GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES, OTTAWA

PAPER 75-33

GEOLOGY OF FORT GRAHAME E1/2 MAP-AREA, BRITISH COLUMBIA

H. GABRIELSE

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Energy, Mines and Resources Canada
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Price - Canada: $3.00
Other Countries: $3.60

Catalogue No. M44-75-33

Price subject to change without notice

Information Canada
Ottawa
1975

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ABSTRACT

Fort Grahame east-half map-area (94C E½), bounded by latitudes 56° and 57° and longitudes 124° and 125° in north-central British Columbia, embraces parts of Omineca and Rocky mountains and is bisected diagonally by the north-northwesterly trending Rocky Mountain Trench. The floor of the Trench in the map-area is now flooded by Williston Lake created by the W. A. C. Bennett dam on Peace River.

About three-quarters of the map-area is underlain by strata of late Proterozoic age assigned to the Ingenika and Misinchinka groups. These rocks, dominantly clastic in the lower part but containing at least one important carbonate unit in the upper part, are similar to those of the Upper Proterozoic Kaza Group and lower part of the Cariboo Group in Cariboo Mountains. They are regionally metamorphosed to facies ranging from subgreenschist to amphibolite.

Lower Paleozoic strata in Omineca Mountains are relatively thin as they are in Cassiar Mountains farther north. They comprise Lower Cambrian clastic and minor carbonate beds, possible Ordovician calcareous shale and siltstone and silty limestone, and very well bedded, in part laminated Silurian (?) and Devonian dolomite. Overlying rocks consist of late Paleozoic slate, bedded chert, minor limestone and a thick sequence of basic volcanics.

In northern Rocky Mountains a well differentiated and locally highly fossiliferous Cambrian succession, typical of Cambrian sequences farther south in Rocky Mountains, is overlain by a thick unit of Lower Ordovician nodular, silty limestone that forms many of the high peaks in the region. Graptolitic siltstone and shale of mid-Ordovician to early Devonian age is locally capped by a persistent Middle Devonian carbonate unit.

Probable Lower Tertiary conglomerate and finer grained nonmarine clastic rocks outcrop here and there in Rocky Mountain Trench and in the valley occupied by Mesilinka and Omineca rivers.

Structures northeast of Rocky Mountain Trench in general show a northeasterly directed asymmetry whereas those west of the trench are commonly westerly directed. The northern Rocky Mountain Trench is therefore, in this area, a zone of structural divergence.

Several lead-zinc showings have been explored in the Silurian-Devonian carbonates near Osilinka River and mica has been mined on a small scale in the northern part of Butler Range.

RESUME

Fort Grahame, situé dans la moitié est de la carte 94C E½, est compris entre les 56^{e} et 57^{e} degrés de latitude nord et entre les 124^{e} et 125^{e} degrés de longitude ouest, au centre nord de la Colombie-Britannique; la région est encaissée entre les chaînons Ominéca et les Montagnes Rocheuses et est coupée en diagonale par le sillon des Rocheuses qui est orienté vers le nord-nord-ouest. Dans cette partie de la carte, le fond du sillon est aujourd'hui envahi par les eaux du lac Williston, qui s'est formé à la suite de la constuction du barrage W. A. C. Bennett sur la rivière de la Paix.

Des strates datant de la fin du Protérozoïque et attribuées aux groupes d'Ingenika et de Misinchinka recouvrent environ les trois quarts de la région couverte par la carte. Ces roches, surtout clastiques dans la partie inférieure, mais qui comprennent au moins une unité importante de roches carbonatées dans la partie supérieure, sont semblables à celles du groupe de Kaza du Protérozoïque supérieur et à celles du groupe de Cariboo de la partie inférieure des chaînons Cariboo. Elles sont métamorphisées par endroit en faciès qui vont des sous-schistes verts aux amphibolites.

Les strates du Paléozoique inférieur dans les chaînons Oménica sont relativement minces, comme elles le sont dans la chaîne des Cassiars plus au nord. Elles sont composées de roches clastiques et de petits lits de roches carbonatées, peut-être de schistes calcaires, de siltstones et de calcaire limoneux datant tous de l'Ordovicien et, très bien stratifiée et en partie feuilletée, de la dolomie du Silurien (?) et du Dévonien. Les roches qui les recouvrent sont constituées d'ardoise, de schistes siliceux stratifiés, d'un peu de calcaire et d'une épaisse série de roches volcaniques basiques, datant tous de la fin du Paléozoïque.

Dans le nord des Rocheuses, une succession de roches du Cambrien bien distinctive et hautement fossilifère par endroit, exemple type des séries du Cambrien situées plus au sud des Rocheuses, est recouverte d'une épaisse couche de calcaire limoneux et noduleux qui date de l'Ordovicien inférieur et dont sont constitués de nombreux sommets dans cette région. Des siltstones et des schistes graptolitiques dont l'age s'échelonne de l'Ordovicien moyen au début du Dévonien sont couronnés d'une unité continue de roches carbonatées du Dévonien moyen.

On trouve ici et là dans le sillon des Rocheuses et dans la vallée occupée par les rivières Mésilinka et Oménica des conglomérats et des roches clastiques non marines à grain fin probablement du Tertiaire inférieur.

Les structures qui se situent au nord-est du sillon des Rocheuses forment en général un ensemble asymétrique orienté vers le nord-est, tandis que celles qui se trouvent à l'ouest du sillon se dirigent habituellement vers l'ouest. Le nord du sillon des Rocheuses est donc, dans cette région, une zone de divergence structurale.

On a fait l'exploration de plusieurs manifestations de cuivre et de zinc dans les roches carbonatées qui datent du Silurien et du Dévonien près de la rivière Osilinka, et on a extrait du mica sur une petite échelle dans la partie nord de Butler Range.

INTRODUCTION

Fort Grahame east-half map-area in north-central British Columbia (56° to 57°N, 124° to 125°W) embraces parts of Omineca and Rocky mountains, and is bisected diagonally by the north-northwesterly trending Rocky Mountain Trench (Fig. 1). The floor of the Trench in the map-area is now flooded by Williston Lake created by the W. A. C. Bennett dam on Peace River.

As a result of the flooding of Fort Grahame, the former residents have re-settled in several communities one of which is the new village of Ingenika on the west side of Lake Williston, just north of Ingenika Arm. In addition, several logging companies have maintained temporary camps along the lake.

Accessibility

Mackenzie, connected by paved road to the Hart Highway, was used as a base for supplies and communication. Camp equipment and fuel was transported by barge to campsites on Omineca Arm, the mouth of Davis River, and the mouth of Ingenika River. In this regard, the writer acknowledges the excellent service provided by Finlay Navigation Ltd. of Mackenzie. Fixed-wing and rotary-wing aircraft are available at Mackenzie. Two airstrips have been constructed in the map-area, one at Ingenika and one near the mouth of Mesilinka River. During the 1973 field season both were serviced by regularly scheduled flights from Mackenzie. Logging roads on the west side of Lake Williston extend as far north as Omineca Arm.

Although Williston Lake provides an obvious means of access to the map-area, caution should be exercised in the use of small craft. Much debris, resulting from flooding, presents a hazard to boats and winds can very quickly produce high waves. A particularly dangerous part of the lake is opposite and south of Omineca Arm, where very rough water may be encountered from time to time. Because of flooding, there are very few good campsites along the lake.

River boats can be taken up Omineca River and are reported to have been used on Mesilinka River during favourable stages of water. Osilinka River is not generally navigable in the map-area.

Tobin Lake, Carina Lake, and lakes in the valley east of Chowika Mountain have been used by small aircraft equipped with floats. The latter valley, however, is subject to very turbulent air conditions when winds blow strongly from the west.

Previous Geological Work

The earliest geological reconnaissance studies carried out in the map-area were made by R. G. McConnell in 1893 (1896). His report contains descriptions of the geology in the ranges immediately bordering Finlay River (now Williston Lake) and the country bordering Omineca River. Dolmage (1928) made a study of the Finlay River valley and described the rocks of the Butler Range near Mica Peak.

Systematic geological mapping on a scale of 4 miles to one inch was begun in the region by J. E. Armstrong (1946), and was continued by E. F. Roots (1954), who authored a comprehensive memoir on Fort Grahame W$\frac{1}{2}$ (Aiken Lake) map-area. J. E. Armstrong and J. B. Thurber (1945) mapped Manson Creek map-area south of Fort Grahame east-half map-area, and E. J. W. Irish (1970) mapped Halfway River map-area to the east.

Observations of outcrops along Finlay River and the lower part of Ingenika River were made by N. W. Rutter (*see* Rutter and Taylor, 1968) prior to flooding. These localities are included on the map accompanying the present report.

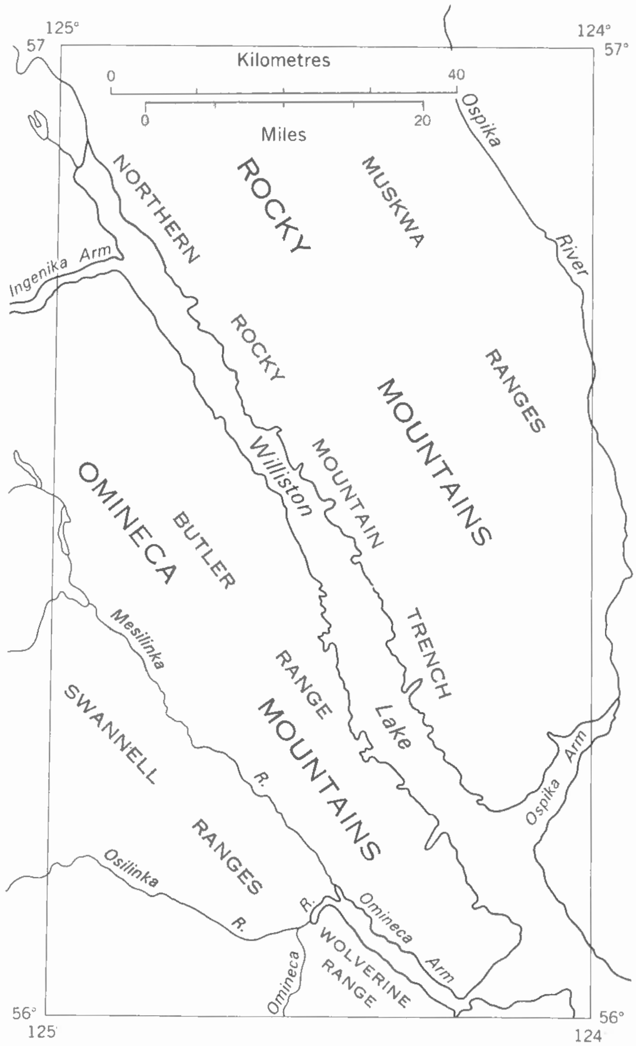


Figure 1. Physiographic regions, Fort Grahame (94 C E$\frac{1}{2}$), map area.

Original manuscript submitted: Nov. 4, 1974
Final version approved for publication: March 11, 1975

Current Field Work

The present study was begun in 1970 and completed in 1973. During 1971 field work consisted mainly of a study of two Cambrian sections by W. H. Fritz of the Geological Survey. No surveys were carried out in 1972, but in 1973 considerable attention was devoted to the northern part of the map-area east of Williston Lake. Observations made by J. W. H. Monger of the Geological Survey in the southwestern part of the area in 1972 are included in the report (*see* also Monger and Paterson, 1974).

Able assistance in the field was provided by K. V. Campbell, G. C. Coughtrey, H. M. Kluyver, F. Lochovsky, J. L. Mansy, W. R. Mullen, R. B. Park and B. C. Read in 1970 and by R. G. Anderson, L. G. Annand, N. N. Blatchford, C. J. Dodds, F. H. Foster, S. P. Gordey, G. D. O'Neil, D. L. Sturrock, R. W. Thompson, and G. J. Woodsworth in 1973. The author gratefully acknowledges the contribution made to the success of the field operations by cooks, Ernest Greyson in 1970 and J. E. Green in 1973. Keom Pierre provided the party with excellent river boat support in 1970.

PHYSICAL FEATURES

Although the area is mountainous, the general topography is not as rugged as many parts of Omineca and northern Rocky Mountains elsewhere. This is especially true for Omineca Mountains where, although local relief may reach a maximum of about 3500 feet, ridge tops are commonly smooth and continuous thus permitting easy travel. Relatively rugged local topography results from development of cirques, mainly on the northern and northeastern sides of mountains, such as near Mount Henri in Butler Range, and southwest of Osilinka River.

A remarkable topographical element of Omineca Mountains is Butler Range flanking northern Rocky Mountain Trench. The range, in the form of a great whaleback, is widest and highest near Mount Henri; its tapering shape becomes narrower and lower to the south-southeast and it disappears at a former Black Canyon on Omineca River. The topography may reflect a south-southeasterly plunging anticlinorium, but definitive stratigraphic evidence is lacking.

Mesilinka River valley and the north-northwest trending part of Omineca River valley form part of Pelly Creek lineament (Roots, 1954), a remarkably linear depression that can be traced northerly for almost 200 miles. In Omineca Mountains it forms the boundary between Finlay and Swannell ranges (Holland, 1964).

Northern Rocky Mountains can be subdivided into two distinct topographical elements. West of a prominent northwesterly trending valley containing parts of Chowika Creek and a tributary of Davis River, is a sombre coloured range with a number of prominent landmarks, such as Chowika Mountain and Deserters Peak. Local relief between Deserters Canyon and Deserters Peak, in the order of 5000 feet, is a maximum for the map-area. Typically the peaks of this range sustain vegetation to high elevations thus enhancing the dark colours resulting from the weathering of dark coloured rocks.

East of the aforementioned valley, light weathering colours, typical of northern Rocky Mountains, reflect the dominantly carbonate bedrock. These mountains are generally rugged and contain numerous cirques. Two prominent northwesterly trending valleys in the northeastern part of the area are occupied by Ospika River and McCusker Creek. Herchmer Pass and the divide at the head of Davis River provide the two most direct low routes through the mountains from Rocky Mountain Trench to the valley of Ospika River.

GLACIATION

According to Roots (1954), the last major movement of Cordilleran ice in Fort Grahame west-half (Aiken Lake) map-area, was toward the northeast, and presumably few, if any, of the higher ridges escaped glaciation. Farther east in Fort Grahame east-half map-area, there is less evidence for direction of movement of high level ice, although it was generally easterly towards Rocky Mountain Trench (*see* Fig. 2). Abundant criteria show, however, that during the waning stages of glaciation, ice filled and flowed down the main valleys such as the Ingenika, Mesilinka, Osilinka, Omineca and Finlay. Thus most of the late stage ice in the valleys west of northern Rocky Mountains eventually joined the main trunk valley glacier that occupied and flowed southeasterly down Finlay River valley.

Evidently the higher ranges of northern Rocky Mountains prevented major ice movement to the east, although low passes at the head of Davis River and the valley of Herchmer Pass must have been filled with ice at maximum stages of glaciation. Mount Grahame, elevation 5663 feet, and the mountain immediately to the northwest (about 6000), were apparently completely covered with ice. Ridges north and south of Herchmer Pass have glacial erratics, derived from the west, at elevations of about 6000 feet. All erratics noted are from Lower Cambrian strata that outcrop immediately to the west. No material clearly derived from west of Rocky Mountain Trench was observed at high levels in northern Rocky Mountains.

Evidence for alpine glaciation is abundant throughout the map-area. Classic examples of cirques and U-shaped valleys occur in the higher ranges, particularly east of Rocky Mountain Trench. Characteristically, cirques have been developed on northern and eastern sides of ridges and as a result, the best rock exposures are commonly observed in southerly views.

Drumlinoid ridges and grooves in bedrock reveal directions of ice movement down major valleys. These features and well developed abandoned drainage channels, locally deeply incised in bedrock, dominate local topography along the sides of the valleys. Abandoned drainage channels mark the lowering levels of retreating ice. Excellent examples can be seen along Mesilinka River and Rocky Mountain Trench where the channels slope southeasterly.

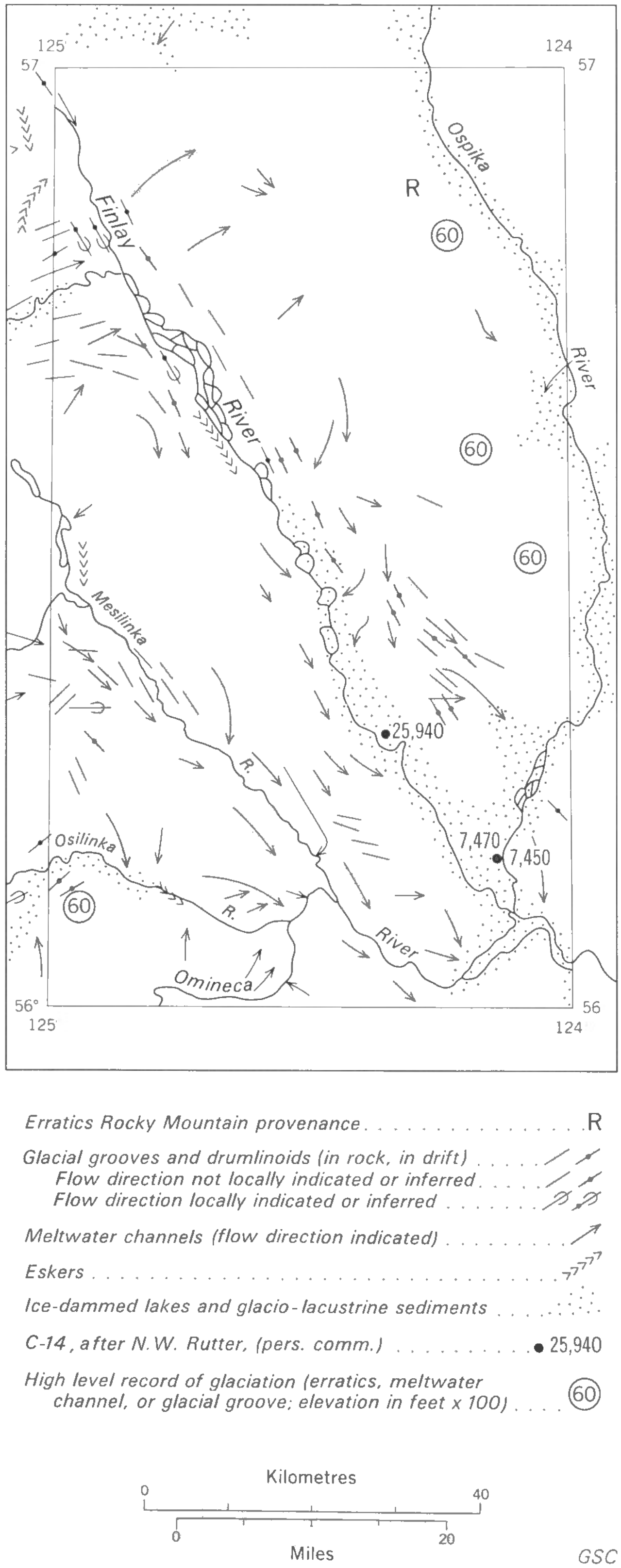


Figure 2. Main glacial features, Fort Grahame (94 C E½), map-area.

Drainage from the east was blocked by ice in the Rocky Mountain Trench at a time when valleys to the east were largely free from ice. This resulted in the impounding of lakes, the most important of which was glacial Lake Ospika. Lake silts extend along Ospika Valley from near the mouth of the river to the northeast corner of the map-area. Smaller areas underlain by glacial silts in northwesterly trending valleys east of Snowtop Peak and Mount Grahame indicate the former presence of lakes.

The last stages of ice retreat are recorded in esker, and kettle and kame deposits consisting of sand, gravel and silt particularly in the valleys of the main streams. The deposits have been partly removed by subsequent stream erosion and are commonly preserved only on higher terraces along stream courses.

On the southwest side of Mount Grahame and elsewhere along the east side of Rocky Mountain Trench, landslide scars and associated hummocky topography are conspicuous in rocks of the Misinchinka Group. Most of the slides appear to be relatively old and possibly they are somehow related to the effects of deglaciation.

GENERAL GEOLOGY

About three-quarters of Fort Grahame east-half map-area is underlain by strata of probable late Proterozoic age. The rocks are dominantly clastic but include important carbonate members in the upper part. They are regionally metamorphosed to facies ranging from subgreenschist to amphibolite. Lower Cambrian clastic and minor carbonate rocks are overlain by dominantly carbonate sequences ranging in age from middle Cambrian to middle Devonian. In the northeastern part of the map-area, graptolitic argillaceous and silty rocks are locally important. Carboniferous and Permian clastic and volcanic rocks occur only southwest of Osilinka River. Upper Cretaceous (?) and Lower Tertiary nonmarine clastic rocks outcrop locally in Rocky Mountain Trench and in the valley occupied by Mesilinka and Omineca rivers.

Upper Proterozoic

Ingenika Group

The name Ingenika Group was applied by Roots (1954) to "an assemblage of interbedded quartz-chlorite schist and phyllite, sericite schist, crystalline limestone, quartzite, quartzitic conglomerate, slate, and argillite, not less than 18 000 feet thick" characteristically developed in the mountains north and south of Ingenika River. Most of the upper Proterozoic strata southwest of Rocky Mountain Trench are herein assigned to the Ingenika Group although some are correlative with rocks assigned by Roots (ibid) to the underlying Tenakihi Group. In Fort Grahame east-half map-area, separation of the two groups is difficult, if not impossible, unless metamorphic grade is used as a definitve parameter of stratigraphic position. Although an increase in metamorphic grade with stratigraphic depth is commonly observed, it can be clearly illustrated in Wolverine Range and near Mount Ferguson in northern Butler Range that, locally, strata relatively high in the Ingenika Group are more highly metamorphosed than elsewhere. Because of this, and in view of the lack of distinctive lithological contrasts between the lower part of the Ingenika Group and the Tenakihi Group, all strata are herein included in the Ingenika Group.

Within the map-area four general subdivisions of the Ingenika Group can be recognized. The lowest comprises several thousand feet of well bedded argillaceous and siliceous clastic strata, commonly metamorphosed to schistose and gneissic assemblages containing micas, garnet, and, in the highest grade varieties, kyanite. The best exposures are in north-central Butler Range and central Swannell Ranges. The most diagnostic lithologies are poorly sorted feldspar-quartz grit and feldspar-quartz conglomerate. Typically, quartz fragments range from 2 to about 5 mm in diameter and display a distinctive bluish opalescence. Feldspar grains include twinned oligoclase and andesine, microcline and perthite in varying proportions. Some samples lack potash feldspar, whereas all seem to contain plagioclase. Quartzite pebbles are the remaining main constituent of the pebbles. Micaceous quartzite and chloritic and micaceous schist are volumetrically more important than conglomeratic rocks. Although bedding is distinct, minor sedimentary structures are scarce.

Regional metamorphism of the stratigraphically lowest unit of the Ingenika Group in Butler and Swannell ranges has produced broad areas of garnet-feldspar-mica-quartz gneiss and schist, micaceous quartzite, and minor amphibolite, silicated limestone, marble, and pegmatite. The more micaceous varieties contain abundant porphyroblastic garnet and, in higher grade rocks, staurolite and kyanite. The largest crystals of kyanite observed, more than 2 cm long, occur in schist near the triangulation station, elevation 2935 feet, two miles northwest of the mouth of Ole Creek. In most cases the schistose rocks are highly crenulated, foliation is generally almost parallel with bedding, and deformation appears to have outlasted crystallization because most metamorphic minerals are bent and/or fractured around the hinges of crenulations

Muscovite-quartz-feldspar pegmatite occurs in Wolverine and Butler ranges and forms lenses of mainly concordant sill-like bodies several feet thick. Near Mica Peak and Mount Henri pegmatite contains coarse books of muscovite greater than 6 inches in diameter. In thin section pegmatite is seen to consist of about equal amounts of plagioclase feldspar, potash feldspar, and quartz with varying amounts of muscovite and biotite. Plagioclase feldspar is mainly sodic andesine, similar in composition to plagioclase in pebble conglomerate of the Ingenika Group. One pegmatite in Butler Range displays marked thinning and thickening and the minerals within it are intensely strained and show well developed cataclastic textures. Elsewhere textures are crystalloblastic and xenoblastic with muscovite showing the best developed crystal form.

Above the gritty and conglomeratic strata, the second subdivision of the Ingenika Group, best exposed south of Mount Ferguson and east of Carina Lake, comprises about 600 feet of lustrous sericitic and chloritic, buff to green weathering, calcareous phyllite, slate, and siltstone. The rocks are thin bedded and commonly highly crumpled. The schist northeast of Carina Lake is distinctive in that it contains abundant zoisite, chloritoid, and tourmaline. Quartz, calcite, and sericite are the dominant minerals.

The third division of the Ingenika Group is a resistant, light grey weathering, coarse grained recrystallized limestone, possibly 400 feet thick near Mesilinka River. It is the best marker unit in the Precambrian assemblage and is critical for elucidation of regional structure. The limestone is well exposed east of Carina Lake, but is highly recrystallized. Less metamorphosed strata occur south of Osilinka River where they may be as much as 750 feet thick. There, distinct beds of limestone range from 1 and 2 feet in thickness to massive units a few tens of feet thick, and are locally interbedded with 3- to 6-inch beds of rusty weathering, cryptograined light green dolomite.

The uppermost subdivision of the Ingenika Group is preserved only in the core of an overturned syncline east of Carina Lake. The thin bedded, tightly folded and crumpled rocks include platy, buff-brown to grey weathering, platy chloritic limestone, slate, and siltstone. The strata appear to be a few hundred feet thick, but a reliable estimate is not possible because of excessive weathering and poor exposures.

The four subdivisions of the Ingenika Group recognizable in the map-area can be traced northerly in Omineca Mountains through northwestern Aiken Lake map-area into eastern Toodoggone and southwestern Ware map-areas where they are less metamorphosed and more easily defined. Farther to the northwest the Good Hope Group in Cassiar Mountains (Gabrielse, 1963) consists mainly of the upper three units. The upper Proterozoic strata can be traced southerly to a structural depression east of Prince George but reappear in Cariboo Mountains. There, the probable correlatives of the four units described above are, in ascending order, the Kaza Group and Isaac, Cunningham, and Yankee Belle formations (Campbell, *et al.*, 1973; Mansy, 1972). Thus there seems to be a remarkable similarity of upper Proterozoic assemblages in a belt west of Rocky Mountain Trench more than 600 miles long.

Precambrian and Paleozoic (Lower Cambrian)

Misinchinka Group

The Misinchinka Group exposed east of Rocky Mountain Trench in Fort Grahame east-half map-area represents a continuation of the northwest trending belt of similar strata exposed in the southwestern part of Halfway River map-area (Irish, 1970). The assemblage has much in common with the Ingenika Group west of the Trench, but nevertheless is distinct in several respects. In particular, the Misinchinka Group appears to include a much greater proportion of fine grained argillaceous rocks in its upper part than does the Ingenika. On the other hand, carbonate seems much less common in the Misinchinka assemblage. The Misinchinka Group is known to include some Lower Cambrian rocks.

The dominant lithology of the Misinchinka Group is thin bedded, highly cleaved, lustrous grey, black and green phyllitic slate. Within the slates precise stratigraphic correlation is almost impossible and for some idea of structure one must rely on the disposition of minor carbonate members which, unfortunately, are discontinuous. Gritty quartzite, impure argillaceous grit, and pebble conglomerate are important locally.

The best exposed sequence of the Misinchinka Group occurs on the ridges northeast of Tobin Lake where three members can be recognized in ascending order as follows:

a. interbedded chloritic slate, impure feldspathic gritty quartzite and pebble conglomerate, more than 500 feet thick, similar to the assemblage that underlies the ridges east of lower Ospika River, although, there, grit and pebble conglomerate are more abundant and the rocks may be generally older than those exposed north of the river.

b. calcareous slate and slaty, platy limestone; green and black phyllite; sandy limestone; includes one conglomerate unit as much as 40 feet thick with cobbles of quartzite and limestone to 1 foot in diameter in a phyllitic matrix; pure white quartzite, possibly 100 feet thick; total thickness of the member is more than 500 feet.

c. a monotonous, highly cleaved sequence of green, grey, and black phyllitic slate; with local beds of limestone and dolomite that may exceed 2000 feet in total thickness; impure carbonates of member b change facies, at least in part, northerly into phyllitic slate comprising the lower part of member c.

On the west flank of Mount Moodie, a sequence of interbedded limestone and phyllite grades westerly, and probably upward in the section, through an increasing proportion of limestone into well bedded, cryptograined to medium grained light grey to dark grey limestone. In the lower phyllitic units, limestone forms beds from less than an inch to more than a foot thick, whereas phyllite generally occurs in beds less than 2 inches thick. In the upper part, limestone beds may be as much as 2 feet thick.

From Pesika Mountain south-southeasterly beyond Chowika Mountain a conspicuous carbonate unit, associated with other less continuous carbonates, can be traced along the east limb of a major anticlinal axis. North of Chowika Creek, the carbonate is about 200 feet thick; the lower half is platy fine grained black limestone and the upper half is medium grained, light cream weathering massive dolomite, about 40 feet thick, overlain by well bedded, dark grey weathering, dark grey, fine grained, platy limestone. In places the dolomite is orange buff weathering and coarse grained. The carbonate thins markedly to the north and disappears on the east side of Pesika Mountain. On the west side of the anticlinal axis on Pesika Mountain, the carbonate interfingers with and pinches out northerly into phyllitic strata.

A thin unit of limestone, east of the main member and north of Chowika Creek, is about 30 feet thick and consists of platy, blue grey weathering limestone with minor sandy, buff weathering limestone. These rocks are enclosed in greenish to silvery grey, pyritic, siliceous phyllite.

The Misinchinka strata are regionally metamorphosed in a belt as much as 8 miles wide flanking Rocky Mountain Trench north of Mount Grahame. The remarkably well defined succession from east to west is as follows:

1. drab, grey to dark grey, phyllitic slate.
2. glossy, green, fine grained, chloritic phyllitic slate.
3. strongly crenulated, coarse grained chloritic schist.
4. garnet-amphibole-sericite and muscovite schist; amphibolite.
5. kyanite-staurolite-garnet-muscovite schist bordered to the west by medium grained granitic gneiss.

This regional metamorphism bears little relation to stratigraphic level as revealed in the major anticline trending through Snowtop Peak and Pesika Mountain.

Granitic gneiss noted above is a grey weathering, buff rock containing about 40 per cent quartz, 30 per cent orthoclase, and 20-25 per cent andesine. Biotite and hornblende comprise the relatively minor mafic constituents. The rock is highly cataclastized and has a maximum grain size of about 5 mm.

From Tobin Lake to the northeast for about two miles, Misinchinka strata contain abundant chlorite as do rocks east of the lower Ospika River. Rocks on Mount Moodie, however, are not chloritic and are less metamorphosed, suggesting perhaps that they are downfaulted relative to those northeast of Tobin Lake.

In Ware east-half map-area, the upper part of the Misinchinka Group includes discontinuous carbonate bodies that contain archeocyathids. In places the carbonates are phyllitic and highly sheared, and the enclosing strata are identical with those of the Misinchinka Group elsewhere in the map-area. The distribution of Lower Cambrian facies clearly demonstrates that the distinctive Lower Cambrian sandstone beds near Herchmer Pass are correlative with silty and shaly rocks in the northwest part of the area, but the latter appear to be gradational with Misinchinka strata, hence no easily mappable boundary between Lower Cambrian and Upper Proterozoic rocks is evident. Thus it seems preferable to include the Lower Cambrian strata in the Misinchinka Group.

The belt of Misinchinka Group narrows to the north and is apparently truncated by a fault in the Rocky Mountain Trench north of Ware. It has been traced a great distance to the south on the east side of the Rocky Mountain Trench (Irish, 1970; Muller, 1961)

Plate 1.

Lower Cambrian strata cut by western splay of Herchmer Fault four miles south-southeast of Herchmer Pass.

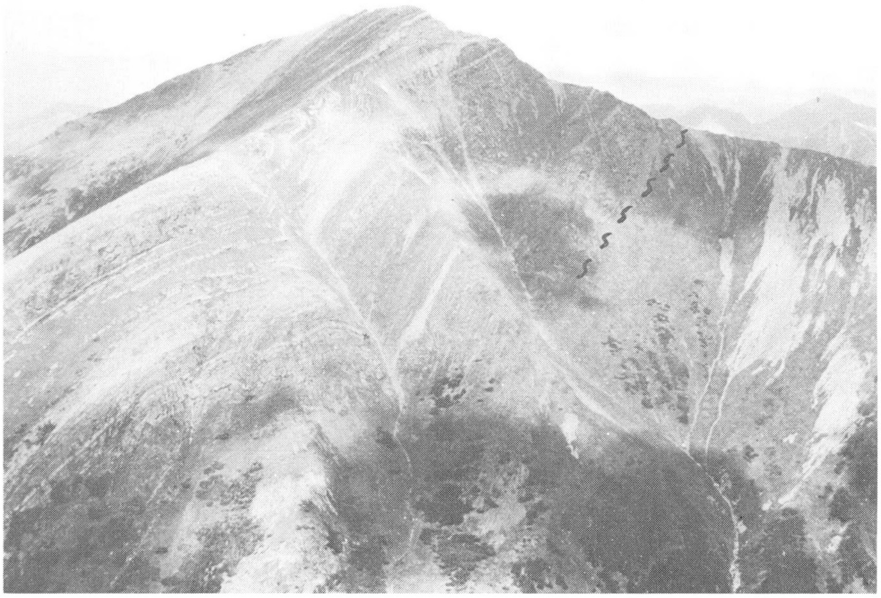


Plate 2.

Overturned lower Cambrian strata in hanging-wall of Herchmer Fault thrust over Cambro-Ordovician carbonates. Note 'reverse' drag-folds in lower Cambrian beds. About three miles south-southeast of Herchmer Pass.

and is probably largely correlative, at least in the lower part, with the Miette Group on the Jasper (Mountjoy, 1962) and McBride (Campbell *et al.*, 1973) areas.

Precise correlations between the Misinchinka and Ingenika groups are not possible although the general similarity of the two assemblages is obvious. It is tempting to correlate the carbonate units because of their similar stratigraphic position relative to Lower Cambrian strata and underlying fine and coarse grained clastic rocks. If, as assumed, the groups are correlative (keeping in mind that the Misinchinka Group includes some Lower Cambrian strata) reconstruction of their paleogeographic setting poses difficult problems. In particular, the thick non-calcareous slate and phyllite overlying the carbonate member of the Misinchinka Group seems to represent a deeper water environment than the homotaxial, thinner, calcareous, and, locally, coarser grained strata of the Ingenika Group. As demonstrated later, this problem assumes much clearer focus when the character and disposition of lower Paleozoic rocks are considered.

Lower Cambrian

Lower Cambrian strata east of Rocky Mountain Trench are exposed in the hanging-walls of the Herchmer and Ospika faults (Pls. 1, 2, 3). The rocks display marked facies changes to the west and northwest, suggesting deposition in a basin trending more northerly than the present structural trend. The stratigraphy of Lower Cambrian rocks south of Osilinka River, less

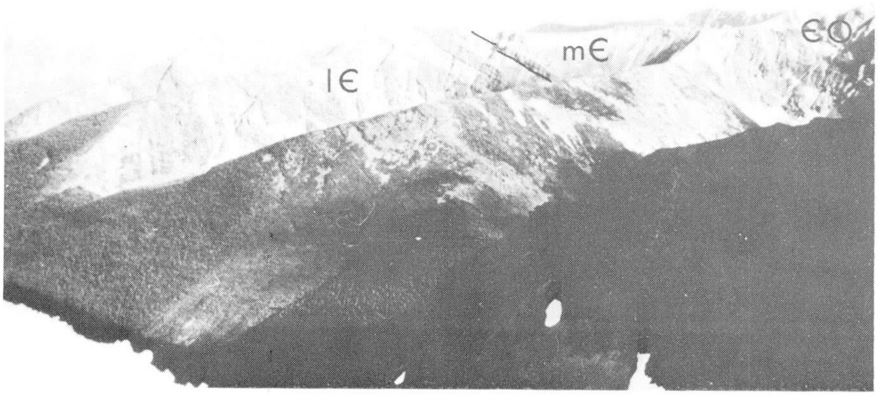


Plate 3.

Well exposed Cambrian sequence in hanging-wall of Ospika Fault southeast of Herchmer Pass.

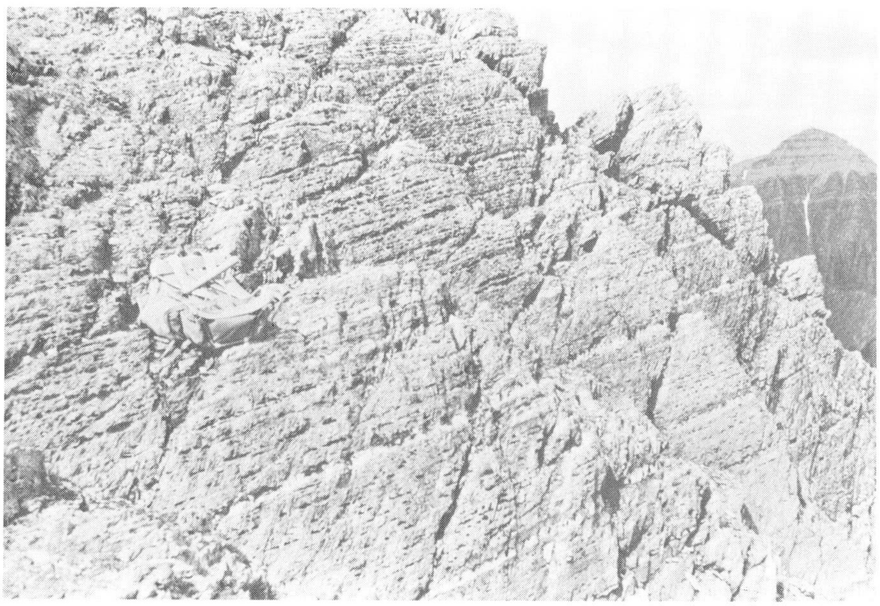


Plate 4.

Nodular, silty, wavy banded limestone of the Cambro-Ordovician Mount April Formation southeast of Herchmer Pass.

well understood than in the Rocky Mountains, has not been studied in enough detail to facilitate separation from older and younger units.

Lower Cambrian rocks were studied in three measured sections near Herchmer Pass (*see* Fig. 3). None, however, reached the base of the sequence or the lowest beds above the Ospika Fault. Another section was examined along the border of Fort Grahame east-half and Ware map-areas.

More than 2000 feet of dominantly clastic, well bedded Lower Cambrian strata are exposed on the hanging-wall of the Ospika Fault (Pl. 3). The lowermost part, of unknown but considerable thickness, consists of moderately recessive weathering, thin bedded and commonly laminated, grey to light greenish grey very fine grained quartzitic sandstone, siltstone and shale. Overlying this sequence and comprising most of the measured sections is an assemblage of rusty brown, grey and silver grey weathering flaggy to thick bedded quartzitic sandstone members interbedded with dark grey weathering siltstone and minor dolomite, limestone and shale. The sandstone is commonly medium to fine grained. Locally, small scale crossbeds are conspicuous.

A few members of dolomite and sandy dolomite with a maximum thickness of about 60 feet characteristically weather buff orange to buff grey. Thin bedded buff to dark grey weathering limestone is interbedded with black and dark grey weathering shale and siltstone in the uppermost and richly fossiliferous part of the Lower Cambrian sequence. In lower beds limestone locally occurs as concretions within shale members.

TABLE 1

TABLE OF FORMATIONS

ERA	PERIOD OR EPOCH	GROUP OR FORMATION	MAP-UNIT	LITHOLOGY	THICKNESS IN FEET
CENOZOIC	Pleistocene and Recent		Qs	Unconsolidated glacial, fluvio-glacial and alluvial deposits	
MESOZOIC	Upper Cretaceous (?) to Eocene (?)	Sifton Formation	KTs	Conglomerate, sandstone, shale, coal	200+
PALEOZOIC	Permian (?)		Pv	Basalt, agglomerate, tuff, diabasic sills	5,000+
	Lower Permian (?) Pennsylvanian and (?) older		PPpt	Argillite, slate, chert; minor limestone and conglomerate	2,000-3,000
	Middle Devonian	Dunedin Formation	DD	Limestone, dark grey, argillaceous	400±
	Lower Devonian and (?) younger		lDpsc	Shale, black graptolitic, locally cherty; crinoidal limestone; quartzite	600+
	Silurian (?) and Devonian		SDc	Dolomite, laminated algal, fetid; platy limestone; minor calcareous shale and dolomite breccia	1,000+
	Ordovician, Silurian and Devonian		OSDp	Siltstone, tan, platy and shale; nodular, platy limestone; argillaceous limestone; minor dolomite and quartzite breccia	1,500±
	Middle (?) Ordovician		mOc	Dolomite, dark grey, locally cherty	500+
	Upper Cambrian and Lower Ordovician	Mount April Formation	ЄOM	Limestone, wavy banded, silty, nodular; argillaceous limestone; calcareous shale	3,000±
	Middle Cambrian		mЄc	Upper part: dolomite, cream to orange, crystalline; Lower part: sandstone and sandy dolomite; orange weathering	1,000±
	Lower Cambrian		lЄs	Sandstone, quartzitic; shale, siltstone; minor pebble conglomerate and limestone	200-2,000+
			lЄp	Shale, grey to green; siltstone	200+
			lЄpcs	Quartzite, phyllite, limestone, shale	400+
PALEOZOIC AND PROTEROZOIC	Upper Proterozoic and Lower Cambrian	Misinchinka Group	HЄM	Slate, phyllitic; chloritic phyllite and schist; garnet-mica schist; calcareous sericite schist; schistose siltstone, grit, and pebble conglomerate; limestone, amphibolite; granitic gneiss	5,000+
PROTEROZOIC	Upper Proterozoic	Ingenika Group	HI	Schist, quartz-chlorite, chloritic-phyllite; crystalline limestone; sericite schist; quartzite, conglomerate, slate, feldspathic quartzite; quartz-mica-feldspar gneiss; migmatite, pegmatite, marble, skarn, amphibolite	5,000+

GSC

Fine grained siltstones weathering grey, olive grey and purple commonly display worm burrows and trilobite tracks.

In contrast to the assemblage described above, Lower Cambrian strata in the hanging-wall of Herchmer Fault (Pls. 2, 7) include much less sandstone, are poorly fossiliferous except for carbonate beds, and are much more folded. The most conspicuous units are several members of silver grey weathering, distinctly bedded, medium to thick bedded quartzitic sandstone a few feet to more than a hundred feet thick, and minor lens shaped bodies of blue grey weathering oolitic limestone and buff orange weathering oolitic dolomite that, in places, contain abundant archeocyathids. The proportion of sandstone decreases northerly from Herchmer Pass and is very minor north of the right-angle bend in Chowika Creek.

A Lower Cambrian section measured along the northern border of the map-area and south of Pesika Creek in southern Ware map-area, comprises essentially fine grained clastic rocks with none of the silvery grey massive sandstone units so typical farther southeast. It seems apparent, therefore, that the facies trends of Lower Cambrian rocks trend more northerly than the northwesterly trending structures and that the more basinal facies lie to the west and northwest.

Clean, well bedded, vitreous, medium grained quartzitic sandstone south of Osilinka River forms a unit about 50-75 feet thick and is overlain by brown to grey weathering shale and siltstone, all believed to be of Lower Cambrian ages. One lens of limestone in the fine grained clastic rocks contains archeocyathids. The stratigraphic succession in this area is poorly known, however, and the sequence between upper Proterozoic limestone and Siluro — Devonian dolomite may include upper Proterozoic clastic rocks that everywhere overlie upper Proterozoic limestone farther north.

The northeastern belt of Lower Cambrian strata contain faunas assigned to the Nevadella and Bonnia — Olenellus zones (*see* Appendix).

Middle Cambrian

Middle Cambrian rocks have been recognized only in the hanging-wall of Ospika Fault where they form a well defined sequence of buff and orange buff weathering dolomite, sandy dolomite, and sandstone, ranging from about 400 to possibly more than 1000 feet thick. The unit is resistant and typically forms ledges or cliffs.

The lowermost part of the Middle Cambrian assemblage, ranging up to 200 feet thick comprises medium to thick bedded, buff orange weathering, medium grained sandstone, variably dolomitic. In places cross-beds are conspicuous. Slump structures were noted in the basal beds southeast of Herchmer Pass. The upper part, more than 500 to possibly more than 1000 feet thick, is dominantly medium to thick bedded buff to cream buff weathering, sugary to fine grained dolomite. Minor members of light yellow brown to brown grey weathering siltstone and mottled, blue grey limestone and dark grey, platy, argillaceous limestone and shale from about 10 to 25 feet thick, contain rich trilobite faunas.

Near the north boundary of the map-area the Middle Cambrian succession is faulted out. In view of the markedly variable thicknesses of Middle Cambrian strata and their absence in the measured section along the north boundary of the map-area, it is probable that the unit was partly or, locally, completely removed by pre-late Cambrian erosion. Thicknesses recorded near Herchmer Pass are probably excessive as a result of repetition by thrust faulting (Fritz, 1972). Thus a true maximum thickness for the unit is thought to be about 1000 feet.

Faunas document the presence of all Middle Cambrian zones except the uppermost, or Bolaspidella Zone (*see* Appendix). The latter zone may be represented, however, by several hundred feet of barren dolomite at the top of the sequence southeast of Herchmer Pass.

Upper Cambrian and Lower Ordovician

Mount April Formation

More than 3000 feet of very well bedded, grey, buff grey, and silver grey weathering, wavy banded, nodular, silty limestone overlies Middle Cambrian, and, locally, Lower Cambrian strata northeast of Herchmer Fault. Near Herchmer Pass the map-unit can be readily subdivided into a lower silver grey, recessive weathering member several hundred feet thick and an overlying darker grey, resistant, cliff-forming member more than 1500 feet thick. This subdivision is difficult to make northwest of the headwaters of Davis River. The entire succession is herein assigned to the Mount April Formation (Jackson *et al.*, 1965), although older strata may be included in the Fort Grahame area.

The silver grey weathering beds comprise a basal unit of thin bedded, slightly nodular, dark grey, fine grained limestone, variably silty and shaly. In places thin partings of ochre weathering silty rock are conspicuous. A few light grey weathering limestone interbeds impart a striped appearance to the lower 200 feet of section. Overlying this unit is a unit of platy, nodular, dark grey to black limestone in beds 2 to 4 inches thick. These beds are relatively fossiliferous.

The upper thick resistant member of the Mount April Formation comprises the classic silty, argillaceous, nodular, wavy banded limestone so typical of Lower Ordovician strata of the carbonate facies the full length of the Cordillera (*see* Pls. 4, 5). Beds of limestone breccia with fragments of blue grey weathering, fine grained limestone as much as 6 inches in diameter occur locally. Some beds of medium to coarse grained limestone from 1 to 2 feet thick in the upper part of the member contain a fossil hash.

Buff weathering argillaceous, phyllitic limestone is abundant northeast of Ospika River and northeast of Herchmer Fault in the northernmost part of the map-area. In the section measured in the latter area, the lower 500 feet of the Mount April Formation consists of dark grey to black, calcareous shale with minor fine grained, dark grey, limestone interbeds.

The lower, recessive member of the Mount April Formation appears to be mainly, or entirely of Late Cambrian age (*see* Appendix). It is at least 1670 feet

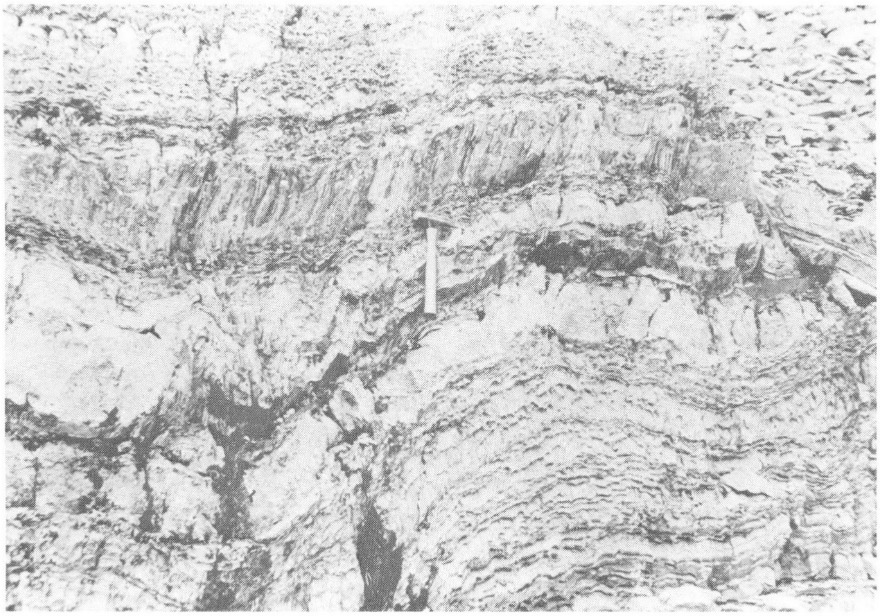


Plate 5.

Same as Plate 4 showing well developed, uniform cleavage in silty beds.

Plate 6.

Well bedded carbonates of Dunedin Formation capping peak and overlying graptolitic shales and siltstones of Silurian and early Devonian age near northern boundary of map-area.

thick in the northern part of the area (*see* Fritz, 1972), but is probably thinner near Herchmer Pass. The upper member is possibly entirely of Early Ordovician age.

Middle(?) Ordovician

Near the headwaters of Davis River, the Mount April Formation is overlain by about 500 feet of dark grey, medium to thick bedded, medium grained, in part cherty dolomite. The age of these rocks is unknown and their suggested mid-Ordovician age is based solely on lithologica similarity to rocks described by Irish (1970) to the southeast in Halfway River map-area.

Lower Ordovician to Lower Devonian

A heterogeneous assemblage of highly folded, generally thin bedded, calcareous, silty, and argillaceous strata occurs mainly in the footwalls of Herchmer and Trident faults and an unnamed fault northeast of Ospika River in the northeastern part of the map-area. The assemblage is of early Ordovician to early Devonian age (*see* Appendix), and is possibly 1500 feet or more thick. Because of structural complexity no complete section of these rocks was examined at a single locality. The main elements comprising the assemblage, each several hundred feet thick, appear to be as follows:

1. A basal unit of platy, dark grey to grey, locally wine-mottled and cherty, limestone contains *Maclurites* sp., in places interbedded with black, graptolitic shale.

2. A middle, tan weathering, very platy, thin bedded and laminated dark grey siltstone unit is of early to middle Silurian age. Within the siltstone sequence are rare lenses of breccia from 5 to 6 feet thick; where examined these contain fragments of light grey dolomite and sandy dolomite up to more than 6 inches long. Locally, overlying a breccia unit is about 2 feet of very fine grained pure quartzitic sandstone.

3. An upper dark weathering unit includes beds of Lower Devonian crinoidal limestone, argillaceous and cherty limestone, and black, graptolitic shale.

The Lower to Middle Silurian siltstone unit seems to be fairly persistent and could probably be mapped separately on a detailed scale. The breccias within the siltstone could represent slide material derived from an easterly or southeasterly shelf margin. A similar source is possible for the beds of crinoidal limestone in graptolitic shale.

Buff and brown weathering; green grey igneous rocks containing conspicuous biotite locally occur as flows or sills northeast of Ospika River. They lie within strata of probable Ordovician age. In accord with older rocks, the Lower Ordovician to Lower Devonian strata represent a more basinal facies than coeval strata exposed to the east and on structural trend to the southeast in Halfway River map-area (Irish, 1970). The assemblage described above is different from that observed in its westernmost outcrops along the northern boundary of the map-area and farther northwest in Ware map-area. There, the sequence is much more homogeneous consisting essentially of black shale or slate and grey to buff siltstone.

The Middle Ordovician to Lower Devonian graptolitic sequence can be traced northerly in a widening belt into Selwyn Basin of Yukon Territory and District of Mackenzie where it is included in the widespread Road River Formation. Fort Grahame map-area contains the southernmost exposures of lower Paleozoic facies typical of the Road River Formation. Farther south near Peace River carbonate facies are exposed only a short distance east of Rocky Mountain Trench.

Silurian(?) and Devonian

A well bedded sequence of carbonate strata as much as 1000 feet thick overlies Lower Cambrian and possibly younger strata south of Osilinka River. The rocks were examined by J.W.H. Monger of the Geological Survey (*see* Monger and Paterson, 1974) who recognized the following five subdivisions in ascending order.

1. Sheared, light grey, locally argillaceous, fine grained limestone includes some dolomite.

2. Thin bedded, black dolomite and dolomitic limestone is about 200 feet thick.

3. Brown to dark grey calcareous phyllite and slaty phyllite is about 80 feet thick.

4. Dark grey and grey, laminated, fetid dolomite is interbedded with repeating units of light grey, fairly massive dolomite containing algal balls with concentric structure from 1 to 2 cm, and dark grey algalaminate dolomite containing rings filled with white crystalline dolomite. The massive beds are from 2 to 6 feet thick, whereas the algalaminate beds average about 6 inches thick. Total thickness of this unit is about 400 feet.

5. Dark grey crinoidal dolomite and sandy dolomite, possibly about 300 feet thick, contains crinoid columnals with twin axial canals. The sandy dolomite contains scattered quartz grains, possibly of windblown origin, in the dolomite matrix. This unit is host to several showings of galena and sphalerite with minor barite and fluorite.

Roots (1954) assigned the carbonate assemblage to the Pennsylvanian(?) and Permian on the basis of fossils collected near Osilinka River. The presence of distinctive two-holed crinoid columnals in the upper beds, however, indicates that the rocks can be no younger than Middle Devonian. In general they resemble strata of late Silurian(?) to Middle Devonian age in the McDame area to the northwest in Cassiar Mountains (Gabrielse, 1963).

Lower Devonian and (?) Younger

On the accompanying geological map, an attempt has been made to separate Lower Devonian and (?) younger strata from older rocks northeast of Ospika River. This has been done only locally because Lower Devonian strata are known to occur in the undivided Lower Ordovician to Lower Devonian map-unit elsewhere.

Three distinct lithologies are recognized — black graptolitic slate and shale; coarse grained crinoidal limestone; and very pure, fine grained, dark grey quartzitic sandstone. The crinoidal limestone is typically grey to light grey weathering and forms beds from 6 inches to several feet thick interbedded with black slate. Crinoid columnals with twin axial canals are abundant. The rocks are highly folded but appear to be a few hundred feet thick. Resistant, dark weathering quartzitic sandstone about 150 feet thick, is believed to overlie the aforementioned strata and may be younger than Early Devonian.

Graptolites, locally abundant in the black slate unit indicate an Early Devonian (Siegenian to Emsian) age (*see* Appendix).

Middle Devonian

Dunedin Formation

Small infolded remnants of well bedded, light grey carbonate are present northeast of the northern trace of Ospika Fault (*see* Pl. 6). The rocks are fine grained, locally cherty, fetid, argillaceous limestone with a maximum preserved thickness of possibly 300 feet. The abundant fauna indicates a Middle Devonian (Givetian) age (*see* Appendix and Taylor and Mackenzie, 1970).

It is clear that strata below the Dunedin Formation in northern Rocky Mountains change facies westerly and northwesterly from carbonate and sandstone to shale and siltstone. The facies changes seem fairly abrupt, at least for Silurian and Devonian rocks, suggesting a shelf margin with significant relief. In any event the westernmost exposures of all lower Paleozoic units east of Rocky Mountain Trench are essentially in shale facies. In contrast, Silurian (?) and Devonian carbonate rocks south of Osilinka River in Omineca Mountains were clearly deposited in shallow water, possibly on a slowly subsiding shelf. Thus, as indicated for upper Proterozoic assemblages, northern Rocky Mountain Trench forms a distinct boundary in terms of depositional environments inferred from the present distribution of the lower Paleozoic strata. Farther north in Ware and Toodoggone map-areas a similar situation is apparent for Lower Cambrian clastic rocks. Work is currently in progress on the sedimentology of the Lower Cambrian formations and preliminary results suggest that the marked facies anomalies are probably the result of major transcurrent displacement along a fault zone coincident with Rocky Mountain Trench.

Lower Permian(?), Pennsylvanian, and (?) Older

Between 2500 and 3500 feet of argillite, slate, chert, minor limestone and conglomerate overlie the Devonian carbonate strata south of Osilinka River. The rocks are sombre weathering and generally recessive, particularly in the lower part.

The lowest beds of the map-unit are dark grey to grey slates, locally about 300 feet thick, with an excellent cleavage facilitating splitting of the rock into flexible sheets less than 2 mm thick. In places the rocks are silver grey weathering. These slates grade upward into cherty lithologies and in the upper part, thin bedded chert predominates. Local conglomerate contains clasts of phyllite, greywacke, limestone, and quartzite. Thin argillaceous limestone beds have yielded Upper Pennsylvanian fusulinids and earliest Permian fusulinids and conodonts (Monger and Paterson, 1974). Thick diabase and gabbro sills, presumably related to the overlying volcanic sequence, are intercalated in the upper part of the sedimentary sequence.

Although part of the map-unit is dated as Pennsylvanian and Permian, the slate member at the base is undated except that it overlies Middle and/or Lower Devonian carbonate. In Cassiar Mountains, similar strata are considered to be of probable late Devonian age.

Permian(?)

Massive, green to brownish green weathering altered basalt flows underlie the rugged terrain in the southwestern corner of the map-area. Diabasic sills presumably related to the volcanics, occur in the upper part of the underlying map-unit. The flows are locally variolitic, fragmental, or pillowed but pillows are poorly preserved (Monger and Paterson, 1974).

In thin section, the coarser grained varieties forming sills are seen to comprise about 50 per cent plagioclase mainly saussuritized, and 50 per cent mafics including pyroxene (partly altered to actinolitic amphibole), amphibole, and chlorite. Ilmenite is an abundant accessory mineral. Diabasic texture is well developed.

Chemical analyses of 10 samples considered representative of the diabasic rocks are given in Table 2. Particularly noteworthy are the very low amounts of K_2O and the relatively high amounts of TiO_2.

Upper Cretaceous(?) to Eocene(?)

Sifton Formation

Clastic, nonmarine strata of the Sifton Formation outcrop locally in and along the valleys of Finlay, Mesilinka, and Omineca rivers (Eisbacher, 1974a). One exposure north of the mouth of Ingenika River and another at the former Black Canyon on the lower part of Omineca River, are now covered by Williston Lake. The rocks form the canyon at Deserters Canyon but part of the succession there is also lost to ready observation because of flooding.

The map-unit comprises lithologies ranging from fine grained, brown to dark grey and carbonaceous shale and micaceous siltstone to grey and buff weathering well bedded sandstone and very coarse, poorly sorted conglomerate. Conglomerate on the west flank of Mount Moodie contains well rounded to subrounded and platy clasts, with a maximum diameter of 2 feet but averaging less than 8 inches, of dark grey limestone and white quartzite in a calcareous limonitic matrix. At one locality white quartzite comprises 55 per cent of the clasts, dark grey limestone 35 per cent, and light grey limestone 10 per cent.

Thick bedded conglomeratic rocks at Deserters Canyon contain clasts of grey limestone, quartzite, and black chert. The rocks are generally poorly sorted. Maximum clast size is about 12 inches but most clasts are less than 3 inches in diameter. A pebble count in one locality revealed the following compositions: blue grey limestone, buff weathering — 75 per cent; black chert — 15 per cent, and white quartzite — 10 per cent. Muscovite is abundant in a few places within beds of gritty sandstone. Yellow brown weathering shale and sandstone beds as much as a foot thick contain a rich flora, especially in the shaly beds.

Very coarse conglomerate east of the confluence of Mesilinka and Ingenika rivers contains clasts to a maximum of 2 feet, but generally averaging about 3 inches in diameter, of green to white micaceous quartzite, grey limestone, quartz, pegmatite, and schist. In places grey limestone is predominant and in one locality green and reddish weathering volcanic clasts were observed.

Based on flora in the map-area and farther north, the age of the Sifton Formation can only be given as late Cretaceous to Eocene, but most probably early Tertiary.

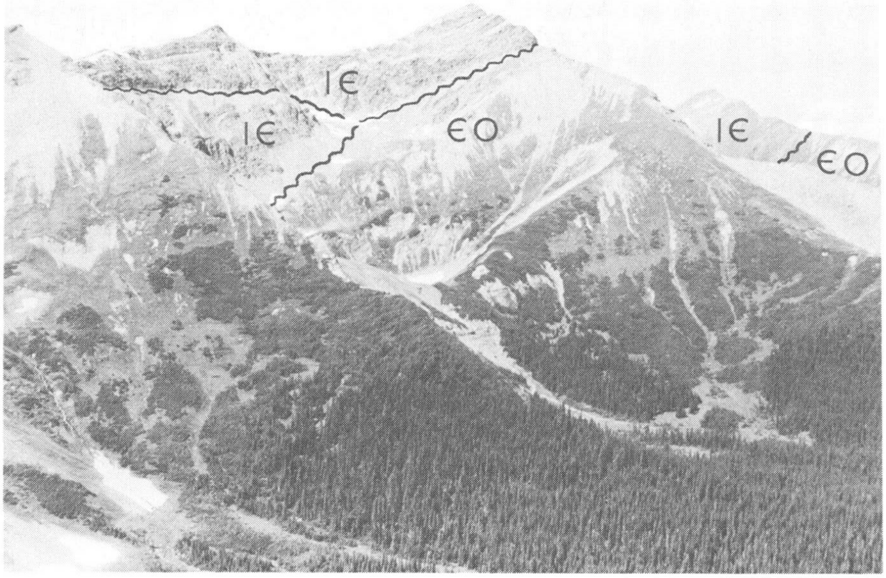


Plate 7.

Relationship of lower Cambrian (lЄ) and Cambro-Ordovician strata (ЄO) along Herchmer Fault southeast of Herchmer Pass.

TABLE 2

Chemical analyses* of diabasic rocks sampled on ridge southwest of Osilinka River near lat. 56°04' and long. 124°54'

G. S. C. SAMPLE NO.

	618	619	620	621	622	623	624	626	627	628
SiO_2	48.0	47.5	44.6	47.2	48.3	49.1	46.9	47.8	48.0	48.3
Al_2O_3	12.2	12.3	14.7	19.8	16.8	15.2	12.8	14.3	15.2	13.7
Fe_2O_3	1.6	0.2	1.0	0.6	1.1	0.6	0.2	1.2	0.4	1.0
FeO	8.6	9.1	10.1	6.5	10.1	9.2	8.7	9.8	9.1	9.2
CaO	12.0	11.6	11.4	10.6	8.3	6.7	8.7	8.9	10.3	9.8
MgO	10.2	11.2	8.3	4.7	4.4	6.8	12.0	8.0	7.1	8.7
Na_2O	2.3	2.5	2.5	4.0	4.5	4.3	2.9	3.2	3.3	3.1
K_2O	0.2	0.1	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1
H_2OT**	3.0	3.2	3.9	3.7	2.9	4.2	4.2	4.2	4.0	2.8
TiO_2	1.36	1.32	1.96	1.35	3.04	1.99	1.08	1.81	1.50	1.48
P_2O_5	0.11	0.12	0.13	0.14	0.34	0.19	0.09	0.17	0.17	0.15
MnO	0.18	0.18	0.19	0.14	0.26	0.18	0.18	0.18	0.18	0.19
CO_2	0.1	0.1	1.1	0.1	0.1	0.2	0.5	0.1	0.3	0.1
Total	99.8	99.4	99.9	99.0	100.1	98.7	98.4	99.7	99.6	98.5

*Analyses by S. Courville, Geological Survey of Canada, rapid method.

**Total water content.

TABLE 3

Potassium-argon age determinations*, Fort Grahame east-half map-area

G.S.C. K-Ar Number	Mineral	Age (m.y.)	Locality
1900	Muscovite	49 ± 4	56°29'N, 120°44'W, Butler Range, 1½ miles southwest of Mount Henri; pegmatite.
1906	Muscovite	45 ± 4	56°03½'N, 124°29'W, Wolverine Range; pegmatite.
1935	Biotite	42 ± 4	56°47'N, 124°45'W, between Chowika and Police creeks; granitic gneiss.
1927 (1)	Hornblende	63 ± 4	56°22'N, 124°39'W,
(2)	Hornblende	64.7 ± 2.4	Butler Range;
(3)	Hornblende	64.9 ± 2.2	amphibolite.
1942 and	Biotite	47 ± 3	56°30½'N, 124°40'W,
1943 (pair)	Muscovite	47 ± 3	Butler Range; gneiss
1953 (2)	Hornblende	53.9 ± 3.0	56°22'N, 124°39'W,
(3)	Hornblende	53.7 ± 2.4	Butler Range;
and			amphibolite.
1954 (pair)	Biotite	40.5 ± 2.2	
1955 (2)	Hornblende	45.4 ± 1.9	56°52½'N, 124°48'W,
(3)	Hornblende	47.9 ± 2.0	Ridge crest south of
and			Ivor Creek; amphibolite.
1956 (pair)	Biotite	40.8 ± 1.9	

*Laboratories of Geological Survey of Canada, Ottawa.

REGIONAL METAMORPHISM

All rocks of the Ingenika and Misinchinka groups have undergone regional metamorphism; the intensity varies from place to place. Much of the latter group has been altered only to the extent that fine grained sericite imparts a glossy sheen to the rocks. Fairly well defined isograds in the range northeast of the mouth of Ingenika River are based on the following key minerals from northeast to southwest: sericite, chlorite, garnet, staurolite, and kyanite. The isograds appear to cut sharply across stratigraphic units, but are offset locally along transverse faults. The highest grade rocks occur near a body of granitic gneiss northwest of Chowika Mountain. North of Tobin Lake and southeast of Ospika River, metamorphic grade increases southwesterly even though younger strata may be involved in that direction. Rocks on Mount Moodie are an exception to this generalization and they may be considerably downdropped relative to strata farther east.

In contrast to the relationship of isograds to stratigraphy described above, a general concordance of isograd surfaces and with stratigraphic level is apparent west of Rocky Mountain Trench. As noted in the discussion on the Ingenika Group, however, the relationship does not hold in detail. Nevertheless, it is remarkable that in Omineca Mountains and, indeed, far to the northwest in Cassiar Mountains, Paleozoic strata show no trace of regional metamorphism and commonly a chlorite isogradic surface does not occur in strata younger than the Upper Proterozoic limestone formation.

K-Ar ages on metamorphic minerals provided by the laboratories of the Geological Survey of Canada (*see* Wanless *et al.*, 1973 and Table 3) presumably indicate cooling dates related to uplift along major longitudinal faults which controlled deposition and preservation of the Sifton Formation.

The distribution of K-Ar ages relative to the minerals hornblende, muscovite, and biotite reveals a remarkable consistency. With but one exception, biotite ages are the lowest and hornblende ages are the highest, with muscovite ages falling between the two extremes. One possible explanation is that the hornblendes contain excess ^{40}Ar. Another, and more intriguing possibility, however, is that the different ages represent different times at which the various minerals cooled to the temperature at which they began retaining ^{40}Ar. This explanation is in accord with the generally accepted view that hornblende and muscovite retain ^{40}Ar at higher temperatures than does biotite.

Interestingly, detrital muscovite from strata of the Sifton Formation at Black Canyon on Omineca River gave a K-Ar age of 117 ± 5 m.y. (Wanless *et al.*, 1973), reflecting earlier uplift of metamorphic terrain, presumably to the west.

Based on regional criteria of the relationship of structure and metamorphism, it seems probable that metamorphism of the Ingenika Group took place mainly during the latter part of the Middle Jurassic. This hypothesis depends on the assumption that the southwesterly and westerly directed structures are correlative with those in Cassiar Mountains to the northwest. There, in Cry Lake map-area, Lower Jurassic strata are involved in the deformation (Gabrielse, 1962a). Upper Jurassic strata in the northeastern part of Bowser Basin display an entirely different style of deformation that may be younger than that of the Lower Jurassic rocks. Rather than reflect a difference in age, however, the contrasting style of deformation may result from the fact that the Bowser rocks are well southwest of the front of the main Cassiar deformation. Nonetheless the Omineca region was a major source area for sedimentation in northeastern Bowser Basin (Eisbacher, 1974b) in late Jurassic time and a tentative model involves metamorphism, deformation and uplift in the Omineca Crystalline Belt during the late Middle Jurassic or early Late Jurassic. Regional isograds are truncated by Lower or mid-Cretaceous granitic rocks in Kechika map-area (Gabrielse, 1962b). Despite the uncertainties in dating regional metamorphism of the Ingenika Group it seems clear that the strata in the Butler Range were metamorphosed much earlier than the K-Ar ages suggest.

If the arguments presented above are valid the K-Ar ages could be explained by at least two different mechanisms. Following regional metamorphism heat flow remained high until early Tertiary time when the rocks cooled to a temperature at which radiogenic argon could be retained; alternatively the rocks cooled soon after regional metamorphism but were sufficiently re-heated in early Tertiary time to drive off any radiogenic argon that had formed previously. In any event, the K-Ar radiometric clock was set or reset in early Tertiary time generally coincident with widespread block faulting in the Omineca and Intermontane belts.

STRUCTURE

The diagrammatic structural cross-sections on the accompanying map illustrate the essentials of structural style. Structures northeast of, and including, Herchmer Fault are directed northeasterly i. e. thrust faults and axial planes of folds dip to the southwest. Fairly open folds characterize the Misinchinka Group. Cleavages of probably more than one generation dip steeply to the southwest or northeast with the former predominant. In Butler Range, the main structure is believed to be an anticlinorium overturned to the southwest, which is flanked by a syncline, also overturned to the southwest, along the Mesilinka River and Carina Lake valleys. To the southwest in Swannell Ranges, structures appear to be upright, open and symmetrical.

The three most important faults in the Rocky Mountains within the map-area, are Herchmer, Ospika, and Trident faults. All are westerly dipping thrust faults with Ospika Fault having, at least locally, the greatest stratigraphic separation of more than 7500 feet.

Trident Fault is best observed just northwest of Trident Peak where it dips southwest at an angle of about 30 degrees. Farther northwest, it is deeper and is characterized by overturned folds in the incompetent strata of the footwall.

Ospika Fault is most clearly defined north of the headwaters of Davis River. Strata in the hanging-wall are little disturbed, but those on the footwall are tightly folded. Smaller thrust faults on the hanging-wall locally repeat Lower and Middle Cambrian strata.

Herchmer Fault is well exposed north and south of Herchmer Pass (Pls. 1, 2). Cleavage to bedding relationships, 'tops' determined by crossbeds and the character of large scale drag-folds indicate that Lower Cambrian strata in the hanging-wall are overturned. Rocks in the footwall are intensely cleaved and folded. About four miles southeast of Herchmer Pass the fault splits into two strands, one cuts structurally upward through the overturned Lower Cambrian strata and extends to the southeast where it juxtaposes Misinchinka over highly folded Lower Cambrian rocks. The other strand continues southeasterly and brings Lower Cambrian rocks against Mount April strata on the northeast.

With the exception of the Lower Cambrian quartzitic sandstone, Middle Cambrian strata and Middle Ordovician (?) dolomite, all rocks northeast of Herchmer Fault have a pervasive southwesterly dipping cleavage. The cleavage is parallel with axial planes of locally developed intense chevron style folds in the Mount April Formation (Pl. 5).

East of the upper reaches of Lafferty Creek, strata of the Misinchinka Group dip uniformly to the southwest. A penetrative slaty cleavage also dips southwest and a well developed northeasterly trending crenulation cleavage dips northwest. Farther northwest, the best defined structure is Deserters Anticline, an open fold with minor subsidiary folds, that can be traced from north of Pesika Mountain to beyond Chowika Mountain. Except near Herchmer Fault slaty cleavage dips more or less symmetrically away from the axis of the anticline. On the southwest flank of the anticline two cleavages are evident and their relationship is shown in Figure 4.

Major steep faults are believed to underlie the northern Rocky Mountain Trench. At Deserters Canyon and on the west flank of Mount Moodie, steep faults bound the east side of exposures of the Sifton Formation. In addition, there is a marked offset of isograds best documented near the mouth of Davis River. Furthermore, the distinctive Upper Proterozoic limestone exposed east of Carina Lake can be traced northwesterly to where it occupies the northeast limb of a major anticlinorium continuous with the Butler Range anticlinorium; the limestone is truncated along the west side of the Trench near the northwest corner of the map-area.

The structure of Butler Range, depicted in the structural cross-section, is known only in a general way. Although minor folds are common the only observed fold of significant amplitude is the tight southwesterly overturned syncline outlined by the limestone unit of the Ingenika Group on the southwest flank of the range.

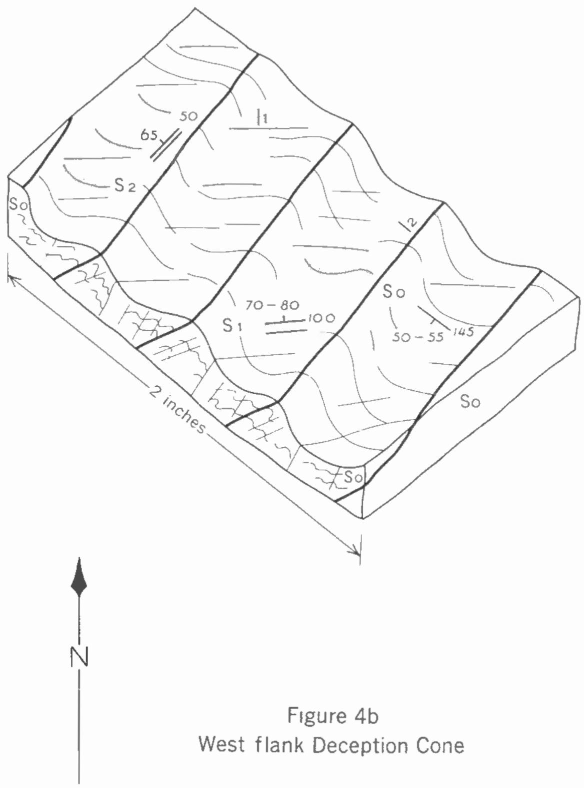
Relatively symmetrical, upright, open folds are typical of Swannell Ranges. An analysis of the structures in Swannell Ranges farther northwest was given by Roots (1954).

As mentioned earlier the time of major deformation in Omineca Mountains is assumed to have been about mid-Jurassic. Whether or not any structures in northern Rocky Mountains are as old is unknown. The age of regional metamorphism and deformation of Misinchinka Group strata west of Herchmer Fault is of critical importance. In Deserters anticline intersecting sets of cleavages indicate more than one phase of deformation but it will be difficult to determine their precise ages. The latest one may be related to early Tertiary faulting in Rocky Mountain Trench. The latest movement on faults within the Trench is believed to be indicated by Eocene K-Ar ages of metamorphic minerals in the Misinchinka Group.

MINERAL DEPOSITS

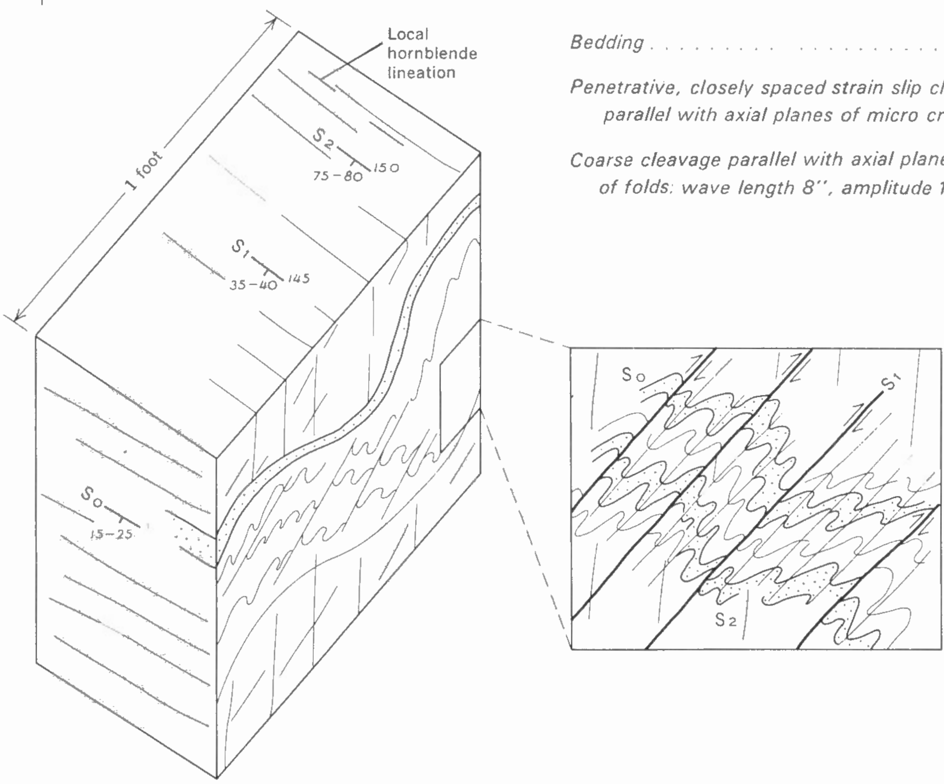
Most of the known mineral occurrences have been found in the Omineca Mountains and they include silver, lead, zinc, gold, and mica. A few copper showings have been reported east of the northern Rocky Mountain Trench in the map-area.

Figure 4a
7 miles north of Tobin Lake



Bedding	S_0
Fine cleavage	S_1
Coarse cleavage	S_2
Fine wrinkle lineation	l_1
Strong lineation and corrugation folds; wave length 6'', amplitude 1''	l_2

Figure 4b
West flank Deception Cone



Bedding	S_0
Penetrative, closely spaced strain slip cleavage parallel with axial planes of micro crenulations	S_1
Coarse cleavage parallel with axial planes of folds; wave length 8'', amplitude 1''–2''	S_2

Figure 4. Typical minor structures in chloritic and micaceous rocks of Misinchinka Group. From field sketches by C. J. Dodds.

Mica: References: Ann. Rep. B.C. Dep. Mines, 1925, p. 145; 1926, p. 153-155; 1927, p. C161; and 1928, p. 183.

During the period between 1925 and 1928 considerable development work was done on muscovite-bearing pegmatite veins in metamorphic rocks of the Ingenika Group north of Mica Peak and near Mount Henri. There, coarse muscovite is found in muscovite-quartz-feldspar pegmatite veins or dykes which are generally parallel to schistosity and range from 2 to more than 14 feet wide. The largest crystals of muscovite up to more than 8 inches across, are apparently concentrated in the marginal parts of the pegmatite bodies. Much difficulty was encountered in obtaining completely unweathered material although the quality of the mica was described as excellent.

Gold - Placer: References: Ann. Rep. B.C. Dep. Mines, 1928, p. C182; 1965, p. 251.

Although placer gold has been mined at Pete Toy's bar on Finlay River just southeast of the map-area, no significant recovery of the metal seems to have been made farther north. Exploration drilling was carried out in 1965 in surficial rocks on the north side of Omineca River just below the mouth of Osilinka River.

Gold - Lode: Reference: Ann. Rep. B.C. Dep. Mines, 1930, p. 152.

Traces of gold and silver were reported from assays of pyrrhotite occurring in basic phases of gneissic rocks in the Ingenika Group on Lorimer Creek about 7½ miles above its mouth. The extent of pyrrhotite-bearing rocks is unknown.

Silver - Lead - Zinc: References: Ann. Rep. B.C. Dep. Mines, 1930, p. 152; 1952, p. A103, A105.

Several silver - lead - zinc prospects have been explored along Osilinka River in the southwest part of the map-area. The property north of the river reveals three zones of mineralized rock in a northerly trending gorge traversing dolomite and limestone of Precambrian or Cambrian age. Three fracture-zones trending east-northeasterly contain galena, sphalerite, and pyrite replacing dolomitic limestone and dolomite. The zones appear to be small and discontinuous.

Trenches, pits, and stripped areas on three properties south of the river expose pyrite, galena, and sphalerite with barite, quartz and calcite in a black, fetid limestone and limestone breccia of Devonian (probably late Lower or early Middle) age. Dolomitization and silicification have occurred locally. Interestingly, a number of silver - lead - zinc occurrences are known in the Osilinka River area west of the map-area in an east-west trending zone that includes lower to mid-Paleozoic rocks.

Copper:

Minor copper occurrences were noted in garnetiferous amphibolite on Rubyred Creek and in Middle Cambrian dolomite near the headwaters of Chowika Creek. In the same general area a showing consisting of narrow stringers of quartz and enargite in limestone has been reported (E. Bronlund, pers. comm.).

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APPENDIX

FOSSIL COLLECTIONS FROM FORT GRAHAME E½ MAP-AREA

Cambrian: Archeocyathids are present in a few small limestone lenses south of Osilinka River. Cambrian strata in the Herchmer Pass area are richly fossiliferous, particularly in the hanging-wall of Ospika Fault. Archeocyathids were noted in carbonate rocks, commonly oolitic, at the following localities in the hanging-wall of Herchmer Fault:

1. 56°48'N, 124°31'W; ridge crest 1.6 miles east of outlet of lake draining northerly into Chowika Creek.
2. 56°38'N, 124°18'W; ridge crest.
3. 56°28½'N, 124°03'W; saddle on ridge crest.

The following collections were made and identified by W.H. Fritz of the Geological Survey from a measured section west of Ospika River at 56°34¾'N, 124°01½-03'W. (*see* Map 2-1975 and Fig. 3).

GSC loc. No.	
	Nevadella Zone
88902	*Kutorgina?* sp. *Nevadella* sp.
	Nevadella Zone
	Bonnia-Olenellus Zone
88903	*Olenellus truemani?* Walcott *Salterella* sp.
88904	*Bonnia caperata* Palmer *Kootenia?* sp. *Zacanthopsina* sp.
88905	*Bonnia* sp. *Ogygopsis* sp. *Onchocephalus* sp. *Syspacephalus?* sp.
88906	*Ogygopsis* sp. *Olenellus* sp. *Piaziella* sp. *Syspacephalus?* sp.
88907	*Ogygopsis* sp.
88908	*Olenellus* sp. cf. *Pelagiella* sp. *Piaziella* sp. *Syspacephalus?* sp.
	Bonnia-Olenellus Zone
	Plagiura-"Poliella" Zone
88909	*Fieldaspis?* sp. *Kochaspis?* sp. *Ogygopsis* sp.
88910	*Fieldaspis?* sp. *Syspacephalus* sp.
	Plagiura-"Poliella" Zone

GSC loc. No.

Albertella Zone

88911	?*Amecephalus laticaudum* (Ressor)
	Hyolithes sp.
	aff. *Luxella* sp. & *Periommella* sp.
	Olenoides sp.
	Pachyaspis sp.
	Pagetia clytia Walcott
	Paterina sp.
	Yohoaspis sp.
	Zacanthoides? sp.
88912	*Yohoaspis* sp.

Albertella Zone?

- -

Albertella or *Glossopleura* Zone

88913	*Amecephalus* sp.
	Caborcella sp.
	Zacanthoides sp.

Albertella or *Glossopleura* Zone

Bathyuriscus-Elrathina Zone

88914	*Elrathina* sp.

Bathyuriscus-Elrathina Zone

Conaspis Zone

88915	*Parabolinoides* sp.
	Pseudagnostus sp.
88916	*Orygmaspis?* sp.
88917	*Pseudagnostus* sp.
	cf. *Quebecaspis* sp.
	Taenicephalus? sp.
	Wilbernia? sp.

Conaspis Zone

____?____?____?____?____?____?____?____?____?____?____?____?____?____?____?____?____?

Ptychaspis-Prosaukia and *Saukia* Zones

88918	*Brabbia* sp.
	dikelocephalid or saukid tail
	Geragnostus? sp.
	Loganellus sp.
	Pseudagnostus clarki? Kobayashi
	Richardsonella sp.
88919	*Drumaspis* sp.
	Hungaia sp.
	Loganellus sp.
	Richardsonella sp.
88920	*Drumaspis* sp.
	Pseudagnostus sp.
	Richardsonella? sp.
	Wilbernia sp.
88921	*Drumaspis* sp.
	Lauzonella? sp.
	Pseudagnostus sp.
	Richardsonella sp.

GSC loc. No.

88922	*Brabbia*? sp. *Drumaspis* sp. *Lauzonella* sp. cf. *Quebecaspis* sp.
88923	*Hungaia* sp. cf. *Levisella* sp. *Pseudagnostus* sp. *Richardsonella* sp.
88924	*Loganellus* sp. *Pseudagnostus* sp.
88925	*Bienvillia* sp. *Bynumiella* sp. *Homagnostus* sp. *Richardsonella* sp.
88926	*Bienvillia* sp. *Homagnostus* sp. *Idiomesus* sp. *Richardsonella* sp.

Ptychaspis-Prosaukia and *Saukia* Zones

The following collections were made by H. M. Kluyver from a measured section west of Ospika River at 56°33'N, 124°00'W (*see* Map 2-1975 and Fig. 3). Identifications and remarks were made by W. H. Fritz of the Geological Survey.

GSC loc No.

85601 *Botsfordia*? sp.
fallotaspid?
Helcionella sp.
Judomia sp.
Nevadella? sp.

Remarks. Lower Cambrian *Nevadella* Zone.
The presence of fragments that are questionably assigned to a fallotaspid trilobite suggests the collection is from the early portion of the *Nevadella* Zone. If this assumption is correct, then the collection approximately correlates with the lower portion of the Sekwi Formation at the site of the type section (June Lake, N. W. T.)

85602 trilobite fragments

Remarks. *Nevadella* Zone? Ornamentation on fragments suggest they may be from *Nevadella* sp. or *Judomia* sp.

85603 archaeocyathid
"*Esmeraldina*"? sp.
Nevadella? sp. (cheek only)

Remarks. *Nevadella* Zone?

85604 archaeocyathids

Remarks. Lower Cambrian.

85605 worm? borings
Remarks. Not diagnostic.

85606 *Olenellus* sp.
Salterella sp.
worm? borings

Remarks. *Bonnia-Olenellus* Zone.

GSC loc. No.

85607 *Salterella* sp.

Remarks. Lower Cambrian.

85608 *Bonnia* sp.
Goldfieldia sp.
Ogygopsis sp.
Olenellus sp.
Piaziella sp.
Syspacephalus? sp.
Zacanthopsis sp.

Remarks. Late *Bonnia-Olenellus* Zone.

85609 *Kootenia* sp.
Ogygopsis sp.
cf. *Olenoides* sp.
Syspacephalus sp.
zacanthoidid trilobite

Remarks. Middle Cambrian?

85610 *Acrothele* sp.
Fieldaspis superba? Rasetti
Ogygopsis sp.
Oryctocephalus sp.
Syspacephalus sp.

Remarks. Early Middle Cambrian, *Plagiura-"Poliella"* Zone.

85611 *Syspacephalus* sp.

Remarks. Early Middle Cambrian.

85612 *Syspacephalus* sp.

Remarks. Early Middle Cambrian.

85613 *Wilbernia* sp.
Pseudagnostus sp.

Remarks. Upper Cambrian. *Ptychaspis-Prosaukia* Zone?

85614 cf. *Eurekia* sp.

Remarks. Late Upper Cambrian. *Saukia?* Zone. This age determination is based on one poorly preserved tail, and is therefore very tentative.

A section measured by H. M. Kluyver west of Ospika River at 56°41'N, and 124°10'W yielded the following fossils: Remarks are by W. H. Fritz of the Geological Suvey.

GSC loc. No.

85616 *Nevadella?* sp.

Remarks. Probably Lower Cambrian *Nevadella* Zone.

85617 *Antagmus?* sp.
Bristolia sp.
Olenellus sp.

Remarks. Lower Cambrian *Bonnia-Olenellus* Zone.

85619 *Chancia* sp.
Kootenia cf. *K. crassa* Fritz
Olenoides sp.
Poliella aff. *P. denticulata* Rasetti
Zacanthoides sp.

Remarks. Middle Cambrian, *Albertella* Zone?

The following fossil collections were made by W. H. Fritz from a section measured south of Pesika Creek at 57°00¼'N, 124°39½'W (*see* Map 2-1975 and Fig. 3).

GSC loc. No.	
	Thrust Plate 1
88883	*Holmia* sp.
88884	*Bradyfallotaspis* sp. *Holmiella* sp. *Nevadella facceta* Fritz
	Thrust Plate 2
88885	*Nevadella?* sp.
88886	*Olenellus* sp.
	Thrust Plate 3
88887	*Bradyfallotaspis* sp. *Nevadella* sp.
88888	*Bradyfallotaspis?* *Nevadella?* sp.
88889	unidentified brachiopod fragments *Nevadella?* sp.
	Nevadella Zone
	Cedaria-Crepicephalus Zone
88890	*Blountia* sp. *Cedaria* cf. *C. prolifica* Walcott *Deiracephalus* sp.
	Zone Unknown
88891	cf. undet. pygidium 2, Rasetti, 1961
88892	cf. *Brabbia* sp. undet. agnostids
	Zone Unknown
	Ptychaspis-Prosaukia Zone and *Saukia* Zone
88893	*Bienvillia* sp. *Drumaspis?* sp. unidentified agnostid
88894	*Bienvillia* sp. *Drumaspis* sp. *Geragnostus* sp. *Loganellus?* sp. *Pseudagnostus* sp.
88895	cf. *Aposolenopleura* sp. *Hungaia* sp. *Loganellus* sp. *Pseudagnostus* sp.
88896	*Brabbia?* sp. *Richardsonella?* sp.
88897	*Geragnostus* sp. *Loganellus?* sp. *Pseudagnostus* sp. *Richardsonella* sp.

GSC loc. No.

88898	*Hungaia* sp. *Loganellus* sp. *Pseudagnostus* sp. *Richardsonella* sp.
88899	*Geragnostus* sp. *Macelloura* sp. *Richardsonella* sp.
88900	*Geragnostus* sp. *Lecanopyge*? sp. *Loganellus*? sp.
88901	*Geragnostus* sp. *Pseudagnostus* sp. *Richardsonella* sp. cf. undet. pygidia No. 2 or 4, Rasetti, 1945.

Ptychaspis-Prosaukia Zone and *Saukia* Zone.

Fritz makes the following comments:

"Localities 88883 and 88884 in thrust plate 1, 88885 in thrust plate 2, and 88887 in thrust plate 3, probably belong to approximately the same stratigraphic horizon. Collection 88886 in thrust plate 2 comes from a horizon that could not be located in thrust plate 3, but is probably around the 5800-foot level.

"An unconformity may exist at the 6344-foot level, with Lower Cambrian strata below and Upper Cambrian strata above. The first locality above the unconformity (88890) belongs to either the late *Cedaria* Zone or to the *Crepicephalus* Zone. The Upper Cambrian fossils are all considered to belong to a deep water environment, and are therefore difficult to correlate with the standard North American zones based upon the shallow water faunal succession."

The following collection was made from blue grey and buff orange mottled limestone with interbeds of phyllitic grey slate. This assemblage, about 12 feet thick, is overlain by 30-40 feet of rusty, platy, dark grey shale and siltstone, presumably of Early Cambrian age, and then a few hundred feet of orange buff weathering dolomite, sandy dolomite and sandstone of probable Middle Cambrian age.

GSC loc. No.

C-27702 — Small saddle in ridge crest southeast of Chowika Creek at $56^{\circ}33'$N, $124^{\circ}28'$W.

Bonnia sp.
Ogygopsis sp.
Paterina sp.
Piaziella sp.

W. H. Fritz assigns this fauna to the Late *Bonnia-Olenellus* Zone.

Lower Ordovician: Two fossil collections were made from strata assigned to the Mount April Formation. They were determined by B. S. Norford.

GSC loc. No.

C-8687 — West of Ospika River in Mount Trident area, $56^{\circ}45'$N, $124^{\circ}08'$W.

gastropods
undetermined leptellid brachiopod
Diparelasma sp.
Hesperonomia sp.
Leptella sp.
Tritoechia sp.

Age: Early Ordovician, latest Canadian, *Hesperonomia* Zone.

GSC loc. No.

C-8697 At elevation 7300 feet, on crest of ridge about 3½ miles southeast of Herchmer Pass; 56°31½'N, 124°04½'W.

inarticulate brachiopod
undetermined trilobites
Highgatella sp.
Symphysurina? sp.

Age: Early Ordovician, Early Canadian Zone A.

Middle Ordovician: Several collections of Middle Ordovician fossils were made in the undivided Ordovician to Devonian map-unit. The lithology of the carbonate facies and their contained fauna closely resembles some facies of the Sunblood Formation in southeastern Mackenzie Mountains. Identifications are by B. S. Norford.

GSC loc. No.

C-8675 On northeast end of northeast-southwest trending ridge 1.6 miles W of Ospika River on southerly fork of ridge at elevation 5500 feet, 56°50'N, 124°12'W.

echinoderms
undetermined gastropods
Maclurites sp.
straight cephalopod
undetermined brachiopods
Ingria sp.
Orthambonites sp.
Orthidiella sp.
Polytoechia? sp.
Syntrophopsis sp.

Age: early Middle Ordovician, Whiterock, *Orthidiella* Zone.

C-8676 Same locality as for C-8675

echinoderm debris
cephalopods
Maclurites sp.
Palliseria? sp.

Age: Middle or Late Ordovician, probably early Middle Ordovician, Whiterock

C-8684 Northern end of Mount Trident massif, west of Ospika River, 56°49'N, 124°11'W.

Climacograptus aff. *C. bicornis* (Hall)

Age: late Middle Ordovician, probably *Climacograptus bicornis* Zone or *Orthograptus truncatus intermedius* Zone

C-8685 Same locality as for C-8684

echinoderm fragments
undetermined brachiopods
Orthambonites sp.
"*Plectorthis?*" aff. "*P?*" *sinuatis* Wilson

Age: Early Middle Ordovician, Whiterock, probably *Orthidiella* Zone.

Silurian: All Silurian fossils collected occur in siltstone, commonly very platy and flaggy.

GSC loc. No.

C-8674 — Headwaters of Chowika Creek about 200 feet east of saddle in an east-west trending ridge, 56°54'N, 124°26'W.

Cyrtograptus sp.
Monograptus? sp.

Age: (assigned by B.S. Norford) Early or Middle Silurian, latest Llandovery or Wenlock.

The following collections were identified by D.E. Jackson.

GSC loc. No.

C-27706 — Just east of saddle on ridge southeast of Chowika Creek, 56°54'N, 124°25'W.

Crytograptus canadensis Jackson and Etherington
Monograptus sp. indet.

Age: latest Llandovery to early Wenlock.

C-27707 — On slope east of saddle on ridge southeast of Chowika Creek, 56°54'N, 124°25'W.

Monograptus cf. *M. priodon* Bronn

Age: Wenlockian or Llandoverian

Lower Devonian: Graptolitic shales of Early Devonian age are present in the northeastern part of the map-area where they are interbedded with beds of crinoidal limestone containing abundant crinoid columnals with twin axial canals. The following collection was examined by D.E. Jackson.

GSC loc. No.

C-27705 — On north-trending ridge north of quartzite-capped peak, 3 miles east of Ospika River.

M. hercynicus Perner
Monograptus thomasi Jaeger
M. telleri? Lenz and Jackson
M. ex gr. *M. yukonensis* Jackson and Lenz

Age: Early Devonian

Jackson comments that "Rocks of more than one age are represented........ *M. hercynicus* incidates an early — middle Siegenian age, whereas, *M. telleri* and *M.* ex gr. *M. yukonensis* suggest early Emsian."

Another collection from the same locality was examined by William B.N. Berry who made the following identifications.

Monograptus aequabilis? notoaequabilis Jaeger and Stein
Monograptus yukonensis Jackson and Lenz

Berry comments that "Early Devonian *Monograptus yukonensis* Zone of Jaeger (1970) which Jaeger correlates with the Pragian and which Jaeger suggests is approximately correlative with the Siegen — Emsian."

Distinctive 'two-holder' crinoid columnals were noted in crinoidal limestone at the localities listed below: Identifications and comments are by A.W. Norris of the Geological Survey.

<u>GSC loc. No.</u>

C-8696	Ridge crest 9 miles west of Ospika River. $56^{\circ}58'$N, $124^{\circ}30'$W. cf. *Gasterocoma? bicaula* Johnson and Lane small echinoderm ossicle with single axial canal *Thamnapora* sp. undetermined brachiopod fragments Age: late Early Devonian (Emsian)
C-8666	East-West ridge east of Ospika River at $57^{\circ}00'$N, $124^{\circ}08'$W. *Coenites* sp. favositid fragments echinoderm fragments
C-8667	On west side of saddle east of Ospika River on east-west ridge at $56^{\circ}57'$N, $124^{\circ}09'$W. *Gasterocoma? bicaula* Johnson and Lane Age: late Early Devonian (Emsian)
C-8689 and C-8691	On northeast trending ridge east of Ospika River at $56^{\circ}55'$N, $124^{\circ}07'$ – $124^{\circ}08'$W. *Gasterocoma? bicaula* Johnson and Lane very large circular echinoderm ossicle with single axial canal five-sided echinoderm ossicle with single axial canal favositid impression Age: late Early Devonian
C-8668	North of headwaters of Chowika Creek on north-south ridge, $56^{\circ}53'$N, $124^{\circ}23'$W. cf. *Coenites rectilineatus* (Simpson) Age: Early Devonian

Norris comments that "The presence of the 'two-holder' echinoderm cirral fragments, *Gasterocoma? bicaula,* in samples C-8667, C-8679, C-8689, C-8691 and C-8696 indicate that the containing beds are probably of late Emsian (late Early Devonian) age. In the northern Yukon Territory Arctic Archipelago, Hudson Platform, and elsewhere this form ranges in age from about mid Emsian (late Early Devonian) to early Eifelian (early Middle Devonian). However, its zone of maximum abundance where dated by conodonts appears to be in beds of late Emsian (late Early Devonian) age."

The identifications and comments by A.W. Norris raises the question of the age or range of age represented by the remnants of infolded carbonate herein included in the Dunedin Formation (GSC loc. Nos. C-8696 and C-8668, also see following section). Possibly carbonates of more than one age are present. The work of Taylor and MacKenzie (1970), however, suggests there is a range from Emsian to Givetian in the Dunedin Formation.

<u>Middle Devonian:</u> Dunedin Formation

<u>GSC loc. No.</u>

C-8662	North of headwaters of Chowika Creek, $56^{\circ}53'$N, $124^{\circ}25'$W. algal ? structures *Coenites* sp. large diameter form Age: Devonian, possibly Middle Devonian (identified by A.W. Norris)

The following collections listed below were identified by A. E. H. Pedder of the Geological Survey.

GSC loc. No.

85629 — Carbonate cap on ridge between headwaters of Davis River and Chowika Creek, 56°23'N, 124°22'W.

Amphipora ramosa (Phillips)
Thamnopora sp.

85630 — Near locality 85629, about 0.4 mile southwest on crest of ridge

Amphipora ramosa (Phillips)

85632 — Nine miles west of Ospika River on ridge crest, conspicuous carbonate cap at 57°00'N, 124°30½'W.

Thamnopora sp.
Disphyllum caespitosum (Goldfuss) subsp. nov.
Moravophyllum sp.

Pedder comments that "As far as is known species of the *Disphyllum caespitosum* type range from Givetian to early Frasnian; the genus *Moravophyllum* occurs in Eifelian and Givetian beds in western Canada. Thus the age of 85632 is likely to be Givetian.

Based on stratigraphic position it also appears likely that 85629 and 85630 are of Givetian age. Taylor and MacKenzie (1970) state that the top of the Dunedin Formation is diachronous and ranges in age from Eifelian in the north (near the Yukon Territory - B. C. boundary), to late Givetian in the south (just north of Fort Grahame E½ map-area). They state further that the base is probably of about the same age everywhere and is of either Early Devonian or early Middle Devonian age.

Upper Cretaceous or Tertiary: (Microfloras) from the Sifton Formation were examined by William S. Hopkins, Jr. of the Geological Survey.

GSC loc. No.

C-8680 — West side of Finlay River in Deserters Canyon opposite mouth of Deserters Creek, 56°57'N, 124°59'W.

cf. Taxodiaceae
cf. *Pinus* sp.
Spiny inaperturate (? Pollen grain)
Tricolpites sp.

Age: Upper Cretaceous or Tertiary

C-8681 — East side of Finlay River in Deserters Canyon, down stream 100 yards from mouth of Deserters Creek.

cf. Taxodiaceae
Tricolpites sp.
Triporites sp.
cf. *Pterocarya* sp.
cf. *Alnus* sp.

Age: Probably Tertiary

Hopkins points out that "Considerable organic material is present in these samples, but palynomorphs are rare and poorly preserved. They appear to be corroded to, or past, the point of recognition, either during the process of deposition, or during diagenesis. The plant megafossil remains, especially *Metasequoia*, suggest an Eocene age."