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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 67-22

GEOLOGY AND TUNGSTEN DEPOSITS NEAR THE HEADWATERS OF FLAT RIVER, YUKON TERRITORY AND SOUTHWESTERN DISTRICT OF MACKENZIE, CANADA

(Report and 13 figures)

S. L. Blusson

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ABSTRACT

The stratigraphic section consists of more than 20,000 feet of layered sedimentary rocks ranging in age from Upper Proterozoic to Upper Ordovician and (?)younger. It is broken by two prominent unconformities, the first beneath the Middle or Upper Cambrian and the second beneath the Upper Ordovician strata.

The area lies near the western extremity of mio-geosynclinal deposition of the northern Cordillera and was tectonically unstable during much of early Palaeozoic time. Pronounced facies changes, from shallow water carbonates in the east to fine clastics in the west, are present in the Lower Cambrian and Ordovician rocks. Subaerial volcanism occurred in the Lower Cambrian.

Discordant, quartz monzonite plutons of mid-Cretaceous age intrude the older rocks throughout the area and exhibit contact aureoles ranging up to more than a mile in width. These contain rocks as highly metamorphosed as the hornblende hornfels facies.

Except where locally modified by intrusion, the strata are deformed into a series of generally open, upright to moderately overturned folds that trend northwest, approximately parallel with the axis of earlier tectonic disturbance.

Contact metasomatic, scheelite-bearing skarn deposits, in part of ore grade, are emplaced within a Lower Cambrian limestone member (where moderately metamorphosed) in the vicinity of the intrusives.

Frontispiece. View southeast down Upper Flat River valley, showing Watson Lake road heading through Harrison Pass on right and Canada Tungsten townsite (T) in far distance.

GEOLOGY AND TUNGSTEN DEPOSITS NEAR THE HEADWATERS OF FLAT RIVER, YUKON TERRITORY AND SOUTHWESTERN DISTRICT OF MACKENZIE, CANADA

INTRODUCTION

LOCATION AND ACCESS

The area mapped covers almost 300 square miles at the headwaters of Flat River, between latitudes 61°45' and 61°58' north, and longitudes 127° 5' and 128°30' west and lies partly in Yukon Territory and partly in southwestern District of Mackenzie. Access is provided by both wheel- and float-equipped light aircraft and, since the fall of 1962, by an all-weather gravel road extending 200 miles north from Watson Lake, at mile 635 of the Alaska Highway, to the Canada Tungsten mine.

CLIMATE

No meteorological records have been kept for the upper Flat River area but, oral accounts by local inhabitants suggest a typical subarctic climate, with average temperatures of less than 32°F in winter and more than 50°F in summer. White (1963) reports the normal range of winter temperatures at the Canada Tungsten mine to be from +20°F to -40°F. Permafrost occurs in some places, particularly on poorly drained, moss-covered, north-facing slopes.

Precipitation appears to be greater than in most other parts of Yukon Territory and District of Mackenzie, and seems to be spread evenly throughout the year. Maximum snow depths in the lowest valleys commonly exceeds 5 feet. The snow-free season ranges from 3 1/2 to 4 months on floors of major valleys to zero in the perennial snowfields at the heads of alpine glaciers. Showers of rain, sleet and even snow, are common throughout the summer.

PHYSIOGRAPHY

The map-area lies within the rugged southwestern part of the Selwyn Mountains. Northwest-trending mountain ranges with peaks rising to more than 9,000 feet are separated by forested, heavily glaciated, U-shaped

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valleys producing local relief of as much as 6,000 feet. Areas underlain by granitic rocks and hornfels, mainly east of Flat River, are particularly high and rugged and contain many small alpine glaciers. The general northwest topographic trend reflects the regional structure of stratified rocks.

The map-area forms part of the Mackenzie River watershed drained by the South Nahanni, Flat and Hyland Rivers. Rabbitkettle River, a tributary of South Nahanni River, forms the northeast boundary and Little Hyland River the southwest boundary. The upper Flat River divides the area into two nearly equal parts. With the exception of a small area near Flat Lake, all drainage is to the southeast. Flat and Rabbitkettle Rivers drain ice-covered areas and carry milky meltwater throughout the summer. Lakes have formed behind kame deposits and more recently from damming of main streams by alluvial fans of high-gradient tributaries. Numerous smaller rock-basin and moraine-dammed lakes occupy cirques above tree-line.

GLACIATION

During the Pleistocene the area was covered by at least one major ice-sheet that left erratics up to 6,500 feet elevation. Below this level, where not affected by subsequent alpine glaciation, ridges are smoothed. To some degree the ice moved transversely across topographic obstacles but the main flow was down major northwest-trending valleys thus producing marked V-shaped troughs and hanging tributaries.

Features of deglaciation, such as kame terraces and lateral channels, terminate upward at about 4,500 feet showing that ice receded to a valley glacial stage before rapid melting took place. Slopes of terraces and channels indicate that the ice retreated to the northwest.

Topography above 4,500 feet is that characteristically produced by mountain glaciation. Cirques surround most peaks and, by flanking most ridges, form arêtes. Existing cirque glaciers with few exceptions are restricted to the shaded northeast-facing slopes where firn lines average about 6,500 feet elevation. At present they are depositing very little debris and are receding by as much as 50 feet each year. Well-developed, abandoned, lateral and terminal moraines reveal a period of stable, vigorous alpine glaciation when most glaciers were double their present size, about 80 to 150 years ago, judging by present rates of ice recession.

Most of the clastic material that now mantles trunk valleys and major tributaries up to 4,500 feet elevation, was deposited by meltwater flowing around and through stagnant ice during glacial recession. These ice-contact deposits are predominantly kames, kame terraces, kame complexes and eskers. Outwash fans or valley train deposits occur in the extreme southwest part of the map-area. Present stream deposits and slope wash (colluvium) have little modified these fluvioglacial features.

ROCK GLACIERS

Rock glaciers abound throughout the region, flooring cirques and extending in some places to the bottoms of main valleys at less than 3,500 feet elevation. North facing slopes are generally the most rugged and these rock glaciers are most numerous and best developed. Lithology does not seem to be a factor affecting their distribution.

The rock glaciers are distinct, discrete bodies that rise above bordering talus slopes and flow as a continuous mass. The length generally exceeds the width and they would thus be described as tongue-shaped according to Wahrhaftig and Cox (1959). Typically their sides and fronts are oversteepened (exceeding the angle of repose) and their upper surfaces have ridges and furrows indicating flowage of the entire mass (Fig. 1). Most develop in cirques, where they are continuous with the moraines of small alpine glaciers, or join talus slopes at cirque headwalls, though a few form even on open flanks of long ridges as extensions of small talus fans.

That most well-developed rock glaciers are in motion is shown by their lichen-free surfaces and oversteepened fronts, which in some places are advancing into timber. One such rock glacier (Fig. 1) 7 miles southwest of Canada Tungsten mine is readily accessible and was surveyed in detail so that at a future date its rate of flow can be obtained. Comparison of its present form with that on 1949 aerial photographs indicates the front has advanced a few feet per year while surface features such as concentric ridges and furrows have migrated appreciably faster.

GEOLOGICAL WORK

E.F. Roots of the Geological Survey made a reconnaissance trip through the Flat River valley in 1953, and reported the possible mineral potential of the district. In 1959, after five years of exploration by various mining companies, the Canada Tungsten Mining Corporation was formed to develop the high grade scheelite deposit near the headwaters of Flat River. Numerous company geologists have continued the search for new ore deposits and undertaken detailed mapping in the immediate vicinity of the mine. Preliminary regional mapping (4 miles to 1 inch) was carried out near the headwaters of Flat River and in the Nahanni map-area to the north, by L.H. Green and J.A. Roddick (1961). Published reports on the nature and exploration and development history of the scheelite deposit are by Brown (1961), Skinner (1961, 1962), White (1963), Green and Godwin (1963, 1964) and Green (1965, 1966).

Mapping, at a scale of one inch to half a mile, was carried out during the summers of 1962 and part of 1963, by the author and was designed to extend and refine detailed mapping near the Canada Tungsten mine and to

Figure 1. Canada Tungsten rock glacier, veiwed southwest across Flat River valley, showing longitudinal and concentric grooves and furrows, oversteepened sides and front, which is presently overriding timber near the valley floor.

study the stratigraphic, structural and petrologic history of the region. This report embodies part of a Ph.D. thesis submitted to the University of California, Berkeley.

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GENERAL GEOLOGY

The area studied is in the western part of the northern Cordilleran miogeosyncline which is bounded by thin cratonic cover to the east and a broad eugeosynclinal belt to the west. Mesozoic granitic intrusions are widespread west of the miogeosyncline but several isolated stocks and small batholiths extend eastward to this area and beyond.

SEDIMENTARY ROCKS

Exposed sedimentary rocks of the miogeosyncline range in age from Late Precambrian to Devono-Mississippian but are largely Ordovician and older within the area mapped. They include well-sorted sandstones, thick- and thin-bedded carbonates, and light coloured to black, graphitic, cherty shales.

The section is broken by disconformities within the Lower Cambrian strata and by unconformities at the base of the Middle Cambrian and below the Upper Ordovician.

The Lower Cambrian and (?)earlier rocks consist of fine-grained quartzite; the Lower Cambrian of sandstone, dolomite and shale; the Middle Cambrian of platy limestone, siltstone and shale; and the Upper Ordovician of cherty black shale. Near Flat River Lower Cambrian dolomites and sandstones to the north change southwestward into dark brown calcareous shale and argillite.

The Middle Cambrian and Ordovician unconformities account for some marked changes in apparent thickness and omission of strata in Upper Flat River area. Truncation of underlying beds indicates that mild buckling rather than simple regional uplift was related to each unconformity. Pre-Middle Cambrian strata are truncated by the sub-Middle Cambrian unconformity by as much as 1,000 feet per mile. Middle Cambrian beds are truncated by the Ordovician unconformity at more than double that.

History of Sedimentation

In late Proterozoic or earliest Palaeozoic time, fine-grained, non-calcareous clastic sediments accumulated undisturbed over the entire area. They coarsen to the northeast, the probable direction of supply, and reach a maximum thickness of at least 10,000 feet to the southwest.

Throughout much of early Palaeozoic time the region appears to have been relatively unstable. Angular unconformities and major facies changes indicate that gentle buckling took place on northwest-trending axes and that the strandline, with a westward deepening sea, repeatedly shifted

Table I

Table of Formations

Era	Period or epoch	Unit and thickness (feet)	Lithology
Mesozoic	Cretaceous	Unit 11	Quartz monzonite, granodiorite; minor granite.
Intrusive contact			
Palaeozoic	Upper Ordovician	Unit 10 4,000+	Black shale; slate; minor chert, siltstone, and dark limestone.
	Unconformity		
	Middle and (?)Upper Cambrian	Unit 9 4,000+	Intercalated platy impure limestone, siltstone and limestone.
	Unconformity		
	Lower and/or Middle Cambrian	Unit 8 2,000±	Dolomite, silty and sandy dolomite; minor sandstone and shale.
	Lower Cambrian	Unit 7 150±	Bright yellow and orange weathering, silty and sandy dolomite.
		Unit 6 2,000±	Sandstone, sandy and silty dolomite, dolomite; minor quartzite and impure limestone; volcanic flows.
		Unit 5 2,500+	Argillite, shale; minor limestone.
		Unit 4 0 to 300	Dolomite, light grey to white, coarsely crystalline, orange weathering.
		Unit 3 'Ore-limestone' 0 to 300	Blue-grey fine-grained limestone and coarse-grained marble; minor dolomite.
		Unit 2 'Swiss-cheese' limestone 200±	Irregularly interbedded dolomitic siltstone and impure limestone; pods and lenses of limestone.
	Lower Cambrian and (?)earlier	Unit 1 9,000+	Phyllite, slate, siltstone, fine-grained quartzite.

from southwest to northeast across the regional trend. In Early Cambrian time, minor facies changes developed along as well as across this trend.

Following deposition of a widespread calcareous siltstone at the beginning of the Cambrian, the area was divided into two contrasting environments of sedimentation, which produced a marked carbonate-shale transition coinciding approximately with the present Flat River. Apparently the basin deepened southwest of Flat River and there was an extensive shallow water shelf to the northeast over which the strandline shifted repeatedly. The shelf sediments are characterized by coarse, well-rounded, clean quartz sands, thin-bedded dolomites and sandy dolomites. Abrupt minor facies changes and pinchouts occur parallel to and transverse to the regional trend, along with periodic possibly subaerial volcanism. To the southwest a considerable thickness of shales and calcareous muds accumulated in a probably subsiding basin in which restricted carbonates, such as, the 'ore-limestone', were deposited on local highs.

During late Early Cambrian or early Middle Cambrian time uplift and buckling, most intense to the southwest, produced gentle topographic relief and locally much of the Lower Cambrian strata was eroded.

Stable conditions returned in the latest Middle Cambrian and possibly Late Cambrian as thinly intercalated silts and limestone accumulated in a broad basin which as in Lower Cambrian time probably deepened southwestward. Detritus is proportionately more abundant to the northeast and strata become more thickly bedded and more calcareous to the southwest.

A second period of folding, again most intense to the southwest, was followed by deposition in an euxinic basin that extended beyond the map-area to the northeast of black pyritic shales and chert containing a characteristic graptolitic fauna.

Stratigraphy

Lower Cambrian and (?)Earlier

Unit 1 This extensive unit of brown to red-brown-weathering, non-calcareous, fine-grained, clastic sedimentary rocks is characterized by uniform lithology, lack of marker horizons and great thickness. It underlies by far the greater part of the map-area yet nowhere could adequate sections be found. Owing to complexity of structure and lack of stratigraphic control, its thickness is uncertain but probably exceeds 9,000 feet. Such a thickness is exposed immediately east of Glacier Lake, on the steeply dipping west limb of a broad anticline.

Rock types in order of abundance are slate, phyllite, siltstone and fine-grained quartzite. Slate is generally thick-bedded or massive, grey to greenish or brownish grey and typically weathers maroon, red-brown or rusty brown. Stratification, where present, consists mainly of laminations and layers of white siltstone or less commonly of quartzite beds a few inches to several feet thick. Rarely the slate shows colour banding of medium or light and dark grey with no apparent change in lithology. Phyllite and phyllitic slates are commonly lighter grey owing to the development of fine sericite. In thin section many slates are seen to contain appreciable silt and are more correctly designated argillaceous siltstone. Quartzite is characteristically fine to very fine grained, medium to dark grey and commonly covered with green or black lichen. Beds range up to several feet in thickness and most are internally laminated with slate and siltstone that commonly display cross-lamination, ripple-marks and interstratal slump features.

The distribution of quartzite shows a general coarsening of clastics from southwest to northeast. It is common near Flat River and to the northeast but becomes increasingly rare toward Little Hyland River. Accompanying the increase in argillaceous rocks to the southwest is a general increase in the ratio of phyllite to slate.

The base of the unit is not exposed. The upper contact is conformable northeast of Flat River but possibly disconformable to the southwest.

Lower Cambrian

<u>Unit 2</u> A sequence of thinly intercalated siltstone and fine-grained limestone, overlies unit 1 and persists with little change in lithology or thickness throughout the area. Apparently during compaction originally fairly regular 1- to 5-inch layers of limestone commonly were squeezed into ovoid pods and lenses, and enveloped in an anastomosing network or matrix of siltstone. Outcrops characteristically have a strongly corrugated or swiss-cheese appearance owing to differential weathering of the two components and the term 'swiss-cheese' limestone has been informally applied to the unit.

The siltstone contains significant amounts of finely crystalline dolomite, calcite, and/or clay and the limestone is normally dolomitic and/or argillaceous. Representative lithologies are shown in sections 1-2 (<u>see</u> Appendix).

On the basis of one well-preserved fossil, <u>Archaeocyathid</u> sp., the age of this unit was established as Early Cambrian. The fossil was collected from 50 feet above unit 1, a mile northwest of Pyramid Mountain and is the oldest known within the mapped area.

<u>Unit 3</u> Southwest of Flat River near Canada Tungsten mine the 'swiss-cheese' limestone is overlain conformably by a massive limestone

unit, which Brown (1961) has informally termed the 'ore-limestone'. This unit contains the Canada Tungsten orebody and other principal prospects near the mine.

The 'ore-limestone' is present only on the southwest side of Flat River except for a 10-foot thick exposure just east of the townsite and a 3-foot thickness at the base of section 9. It has a maximum thickness of 300 feet, 2 1/2 miles northwest of the orebody and maintains an average thickness of about 200 feet for more than 4 miles to the southeast. The northern limit is well-defined where it pinches out near Harrison Pass and a short distance north and south of section 9, but southward the unit thins gradually to a few feet near the southern limit of the area mapped.

The limestone is mainly dark or vaguely laminated with dark and light grey to white layers up to 1/2 inch thick, and characteristically weathers light bluish grey. Locally it contains argillaceous or silty laminations and rarely floating grains of coarse quartz sand, but in general the unit comprises extremely pure, finely crystalline granular calcite. The light layers in places have bioclasts up to 1 mm across and on the whole are more variable in grain size. Cream-yellow rhombs of dolomite 0.1 to 0.2 mm across are present in accessory amounts mostly in irregularly shaped, orange-brown weathering patches that are localized along certain laminations, especially the light-coloured ones. The dolomite is probably a late mineral as it also fills fractures in the limestone.

Unit 4 For several miles southeast of Canada Tungsten mine the 'ore-limestone' is overlain or completely replaced in the stratigraphic sequence by massive, coarsely crystalline dolomite, unit 4. In a few places the two rock types are separated by several feet of calcareous argillite and might be reported as distinct, separate rock units but the erratic distribution of the dolomite elsewhere suggests it probably is an alteration of the limestone. The dolomite is mostly light grey to white and forms a buff and light grey mottled or less commonly a distinctive pinkish orange weathered surface which is quite unlike any other dolomite in the area.

Unit 5 Unit 5 was previously mapped at Canada Tungsten mine, and first reported on by Brown (1961), as the 'hanging-wall' argillite.

Like the 'ore-limestone', this unit lenses out northward near Harrison Pass, but thickens to more than 2,500 feet in the south part of the area where it is overlain unconformably by unit 9 (Fig. 2). Only two occurrences of possibly correlative strata are known northeast of Flat River: a 10-foot thick bed of dark grey, rusty weathering argillite at the base of section 9, 100 feet above the 'swiss-cheese' limestone; and a 25- to 50-foot thick bed of dark grey laminated slate just southeast of Flat Lakes, 200 feet above unit 2. At both places the argillite thins rapidly and is not traceable laterally. Unit 5 otherwise is restricted to the southwest side of Flat River Valley.

Unit 5 consists mainly of dark brownish grey to black, commonly calcareous argillite, slate and shale, locally banded and thinly bedded with impure limestone. Where black, the argillite characteristically contains fine pyrite-rich laminations and weathers deep rusty brown. The upper part is commonly more calcareous, lighter and less competent than the lower part. At Baker prospect, about 3 miles southeast of Canada Tungsten mine, two distinctive but discontinuous members are recognized; near the top, a unit up to 100 feet thick of buff-grey weathering, medium-grained, crystalline dolomite and near the base as much as 30 feet of thin-bedded, dark grey limestone.

At Canada Tungsten mine, just southeast of the orebody, the 'hanging-wall' argillite contains several carbonate beds up to 10 feet thick. Some are light grey weathering dolomite but most are medium-grained marble that closely resembles the 'ore-limestone'.

An unconformity is suspected at the base of unit 5 on account of the abrupt lithologic change to black, pyritic shales and the rapid thinning and local omission of the underlying carbonates. The upper limit of the unit is a major unconformity beneath unit 9 and possibly a minor one beneath unit 6 near Canada Tungsten mine.

Fossils from unit 5 were examined by B.S. Norford and W.H. Fritz of the Geological Survey who reported as follows:

> GSC locality 53674
> 2.5 miles NW of the mine at end of ridge.
> archaeocyathid sp.
> cf. Olenellus sp.
>
> GSC locality 53673
> 61°52'15"N, 128°07'12"W, in creek southwest of Canada Tungsten sawmill.
> archaeocyathid spp.
>
> Collection No. 53674 is of special interest, as archaeocyathids and Olenellus are rarely found together. Here archaeocyathids are in thin limestone bands intercalated with Olenellus-bearing silty argillite. Both collections are of Early Cambrian age.

Unit 6 — Unit 6 makes up the greater part of the Lower Cambrian succession northeast of Flat River. It is separated from overlying strata of similar lithology by a distinctive orange-weathering marker horizon, unit 7.

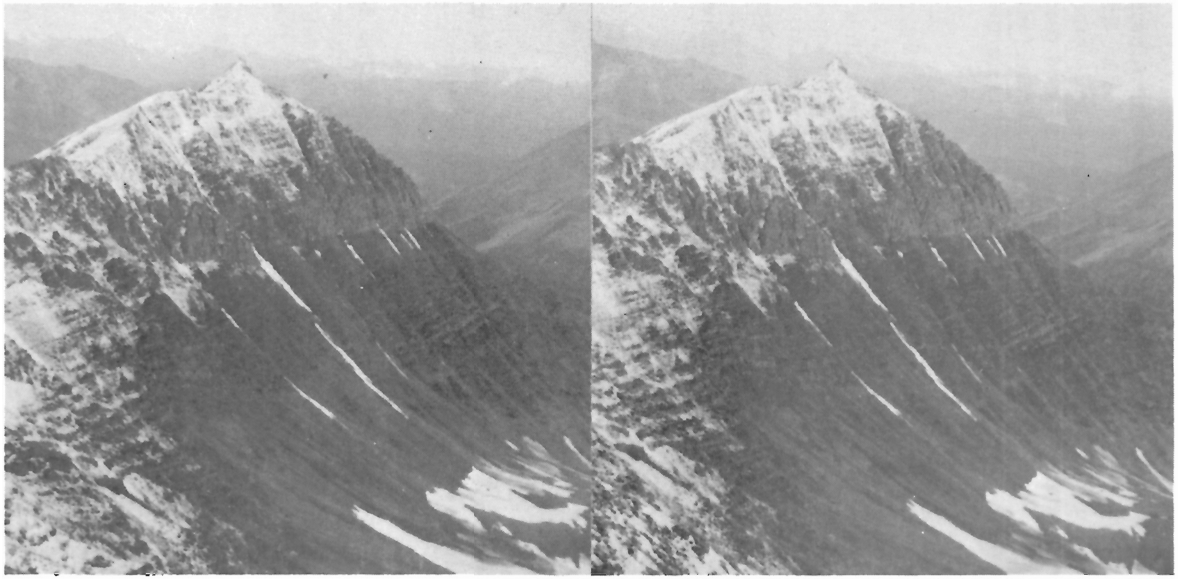


Figure 2. Angular unconformity between units 9 and 5, near southwest corner of map-area. Stereoscopic view, looking southwest toward Hyland River.

Thickness of unit 6 varies from about 500 feet near Rabbitkettle River to more than 3,500 feet southeast of Glacier Lake.

Unit 6 is characterized by an extremely varied lithology comprising, at least in minor amounts, all mixtures of dolomite, sand, silt, limestone and clay. Lensing and interfingering result in abrupt terminations of individual members and beds and as indicated in several places by intraformational breccia, local pinchouts of coarse clastic sediments and volcanism. Diastems appear to be numerous. Representative lithologies and their internal variations are best shown on the reconstructed fence diagram (see Fig. 3). Details of measured stratigraphic sections (Nos. 4-11) are in the Appendix.

Principal lithologies are thin to thick-bedded, light grey, pinkish buff or orange-brown-weathering dolomite, sandstone and quartzite. Dolomite is mostly light grey or white, typically medium-grained, crystalline and massive. Most of the quartz sand is well-rounded, fine- to medium-grained and is cemented by dolomite in sandstones and silica in the quartzites. Quartzite is white where pure, but varies to light brown with increase in silt, clay or rarely limonite. Minor lithologies are platy to thin-bedded, orange-weathering, silty dolomite, argillaceous, commonly bioclastic, dolomitic limestone, and silty or calcareous shale.

Collections of Olenellus were made at two localities near the top of the unit, in platy, dolomitic, silty limestone and silty shale. Unit 6 is accordingly Early Cambrian in age.

Unit 7 This formation outcrops only in the eastern part of the map-area where it forms a distinctive bright orange and yellow weathering marker bed 100 to 200 feet thick.

It is characteristically grey to brown, finely crystalline dolomite with a few per cent of coarse silt and medium to coarse sand, either disseminated or concentrated in laminations. Rarely, as in section 12 (see Appendix), light yellow to buff, finely crystalline dolomite is present at the base.

Unit 7 is unfossiliferous, but as it rests conformably on unit 6, it is thought to be Lower Cambrian.

Lower and/or Middle Cambrian

Unit 8 Unit 8 is divisible into two members with a total thickness as much as 2,300 feet. The lower member consists of thin-bedded to flaggy dolomite, sandy dolomite, silty limestone and dolomitic sandstone, and the upper member is characterized by thick-bedded to massive dolomite.

Section 13, 2.7 miles north of Pyramid Mountain, shows the most characteristic lithologies of the lower member. They include a distinctive, light yellow or pinkish buff-weathering, light to medium grey, fine- to medium-grained, crystalline dolomite and medium grey to light brown-buff to orange-weathering, sandy dolomite with very minor sandstone and quartzite. Northeast and southwest of section 13 the lower member changes facies, becoming less sandy and more calcareous. Near Flat River the base of the lower member contains several hundred feet of silty and dolomitic limestone. The limestone is blue-grey, platy and characteristically banded, commonly very irregularly, with orange-brown-weathering dolomitic siltstone. The upper dolomite is typically light grey to white, medium crystalline and buff weathering. It rarely contains more than a few per cent of fine to coarse sand. North of Canada Tungsten mine unit 8 is apparently cut out by the unconformity at the base of unit 9.

Unit 8 although unfossiliferous is considered of Early Cambrian age on the basis of regional lithologic correlation. Units 6, 7 and 8 in total correlate generally with Lower Cambrian strata to the east and north.

Middle and (?)Upper Cambrian

Unit 9 — Unit 9 consists of intercalated platy beds of limestone, silty limestone and siltstone and rarely beds of limestone a few feet thick. The limestone is medium grey, finely crystalline and in places dolomitic and silty. The siltstone is medium- to coarse-grained. On the whole the unit weathers uniformly light grey or brownish grey.

A distinguishing feature of the unit is its irregular undulatory or wavy layering. The siltstone layers commonly form anastomosing networks that isolate the intervening limestone bands into small lenses. Weathering produces a most characteristic rough, pitted surface. The banding resembles that of unit 2 but is generally more regular and thinner and the limestone lenses smaller.

Unit 9 is bounded below and above by unconformities. It overlies nearly every older formation and varies greatly in thickness throughout the map-area from almost zero near Flat Lake to more than 5,000 feet in the extreme southern part. Near Rabbitkettle River an upper member (9a) is recognized. It is more than 1,000 feet thick and is composed of finely laminated dark grey to black argillaceous limestone and calcareous shale. There the unconformity above the unit is markedly angular and apparently eliminates this upper member within a short distance.

Partial but representative sections of unit 9 are shown in sections 14-16 in the Appendix.

Fossils are extremely rare in unit 9 and are poorly preserved. Trilobite parts collected near the southwest corner of the map-area date the middle part of the unit as Middle or Late Cambrian.

Upper Ordovician

Unit 10 Unit 10 comprises black, graptolitic, argillaceous rocks, chert, and limestone. Exposures are limited to tributary stream courses along Flat River valley and to the core of a large synclinorium near Rabbitkettle River. Folding is generally intense and continuous sections rare. The unit is at least 4,000 feet thick bordering Flat River valley in the southeast, and possibly much more in the synclinorium to the northeast.

Black graphitic shale, slate and argillite forms the major part of the unit. Less commonly these rocks are light to medium or brownish grey and calcareous. The blacker varieties contain appreciable pyrite and weather rusty brown. Gypsum, in tiny crystalline aggregates, forms small veinlets or replaces fossils. Chert as beds a few inches thick varies from light grey to black, is commonly colour-banded on a small scale and normally weathers light grey or white. The limestone is mainly finely crystalline, argillaceous, dark grey to black and thinly bedded or rarely in beds as much as 20 feet thick.

Graptolites collected within the lower 500 feet of the unit and directly above the unconformity at the base are Ordovician (Caradoc). The fossil collections were examined by B.S. Norford of the Geological Survey of Canada who reported as follows:

GSC localities 53670, 53675-53681
Northwest of M.B. Drill Camp, within 500-600 feet above lower contact.
- diplograptid graptolite
- *Dicellograptus* sp.
- *Dicranograptus* sp.
- ?*Leptograptus* sp.
- ?*Glossograptus* sp.
- sponge spicules
- undetermined brachiopods
- Age: Ordovician; Caradoc

GSC locality 53663
Creek bottom at east entrance to Harrison Pass, 20 feet above lower contact.
- diplograptid graptolite spp.
- ?leptograptid graptolite sp.
- cf. *Dicellograptus* sp.
- Age: Ordovician; Caradoc or Ashgill

INTRUSIVE AND PLUTONIC ROCKS

Ultramafic Rocks

Two small bodies of ultramafic rock intrude slates of unit 1, 1 1/2 miles south of Harrison Pass an area north of that shown on Map 4-1967 (in pocket). The enclosing slates show no trace of metamorphism but the border zones are intensely sheared.

The rock is dark green to black, weathers a typical dun colour and is mainly composed of fine-grained, massive serpentine with pyroxene grains up to 1/4 inch long and rare 1/8- to 1/2-inch veins of brittle asbestoform chrysotile. Relict minerals and pseudomorphs indicate that the original composition was about 25 per cent pyroxene and 70 per cent olivine. The olivine, now entirely altered to serpentine, formed anhedral to subhedral crystals 2 to 5 mm across that were enclosed in pale brown to colourless, non-pleochroic, diopsidic augite ($2V_z$=55°-60°). Part of the pyroxene is altered to colourless amphibole, and serpentinized along some cleavage planes but most of it is fresh. In thin section massive serpentine is seen to be of two types - pale yellowish green, where replacing olivine, and apple green with a Berlin-blue birefringence, in the groundmass. Both types form bladed or lamellar grains in a reticulated network, characteristic of antigorite. Rounded to octahedral grains of magnetite and possibly chromite fill interstices between and inclusions within olivine and pyroxene. In addition finer dust-like grains of magnetite, apparently a by-product of serpentinization, outline olivine pseudomorphs and follow cleavage planes in pyroxene.

The sheared margins and lack of contact metamorphism suggests these intrusives reached their present position in a cool solid state.

The age of these ultramafic intrusives is unknown.

Gabbroic Dykes, Sills and Associated Volcanic Rocks

Dykes, sills and minor greenstone intrusions are found sparingly throughout the area in Lower Cambrian and older strata. The original composition is obscured by alteration but relict minerals and pseudomorphs indicates that it was gabbroic. Originally most of the rock was medium-grained, equigranular and consisted of 60 to 90 per cent plagioclase, 10 to 40 per cent pyroxene and minor olivine. Quartz appears to have been absent.

Plagioclase, where determinable, is labradorite (An_{55}-An_{60}) but most is pseudomorphically replaced by albite and epidote. Existing pyroxene is colourless to pale brown, diopsidic augite which forms interstitial poikilitic relic grains enveloping plagioclase, but most of it is now altered to green actinolitic amphibole and in places to fibrous tremolite. Locally fractures and cleavage planes of pyroxene are fringed with serpentine. All of the olivine is altered to serpentine. An aggregate of fine chlorite and minor calcite, with some epidote and apatite, commonly forms an interstitial groundmass.

The larger sills have chilled margins a foot or more wide, but are otherwise uniform in composition and texture, and no layering or other evidence of differentiation was observed. Despite the small size of the intrusions contact metamorphism is pronounced. Impure calcareous rocks contain calc-silicate minerals or are recrystallized for as much as 30 feet from intrusive contacts and slates are commonly chloritized up to 50 feet or more from the contact.

Volcanic flows and tuffaceous beds are present north of Pyramid Mountain, in the upper part of unit 6 (<u>see</u> sections 5, 7, 8, in the Appendix). The flows are similar in composition to the sills but are distinguished by a general aphanitic texture, brecciated oxidized tops with abundant amygdules, and their maintenance of exact stratigraphic position which correlates with tuffaceous beds (Fig. 3). A subaerial origin for the flows is suggested by their reddened, hematite-rich tops and their restricted association to well-sorted and rounded coarse-grained sandstones.

Plutonic Rocks

Granitic plugs and stocks of clearly intrusive origin, unit 11, truncate all strata and regional structures in the area. Similarity of composition, texture and mode of emplacement suggest all belong to one intrusive episode. Contacts with the country rock are sharp, discordant and usually steep (Figs. 4, 5), and inclusions are extremely rare, even in the marginal zones. Apophyses are common, some extending hundreds of feet into the wall-rocks as dykes and sills. Though crosscutting on a regional scale contact details are commonly controlled by planar structures within the wall-rocks such as bedding, slaty cleavage and joints.

The characteristic lithology is non-foliated, medium-grained, biotite quartz monzonite (<u>see</u> Table II and Fig. 6) in which plagioclase and biotite form subhedral to euhedral crystals with interstitial, mostly anhedral, potash feldspar and quartz. The interiors of the larger quartz monzonite stocks contain plagioclase crystals up to 1/2-inch long and much coarser, commonly subhedral megacrysts of potash feldspar, many of which are crowded with inclusions of all other minerals. Potash feldspar is mostly microperthitic microcline, with growth lines representing varying amounts of perthitically intergrown plagioclase and included plagioclase laths. Plagioclase zoning is normal, oscillatory and rarely patchy, with composition ranging in individual grains from An_{35}-An_{18}. Dark greenish brown or red brown biotite is with few exceptions the only mafic mineral. Most grains are altered at least in part to muscovite and pale green chlorite. Besides being an alteration product of biotite, muscovite forms rare, distinct, subhedral

Figure 4. View southeast across MB prospect, showing sharp discordant contact between intrusive rock (gr) and thin bedded calc-silicate marbles of unit 9 overlain unconformably by black slate, argillite and chert of unit 10. Caradoc graptolites are preserved at point F.

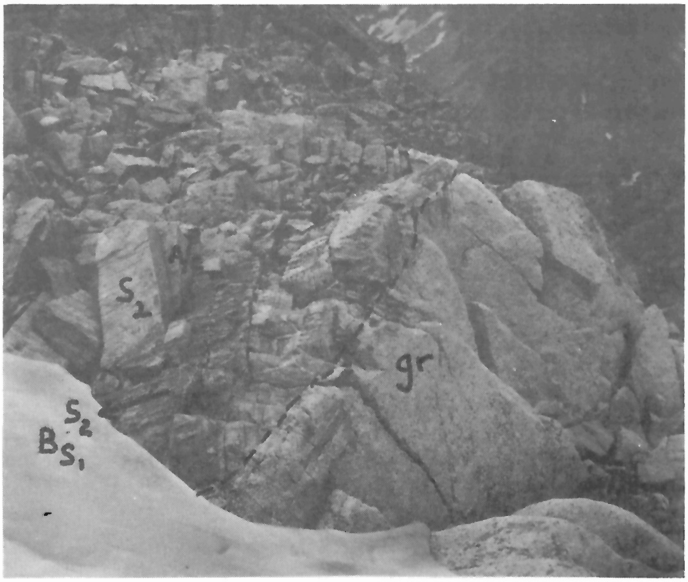
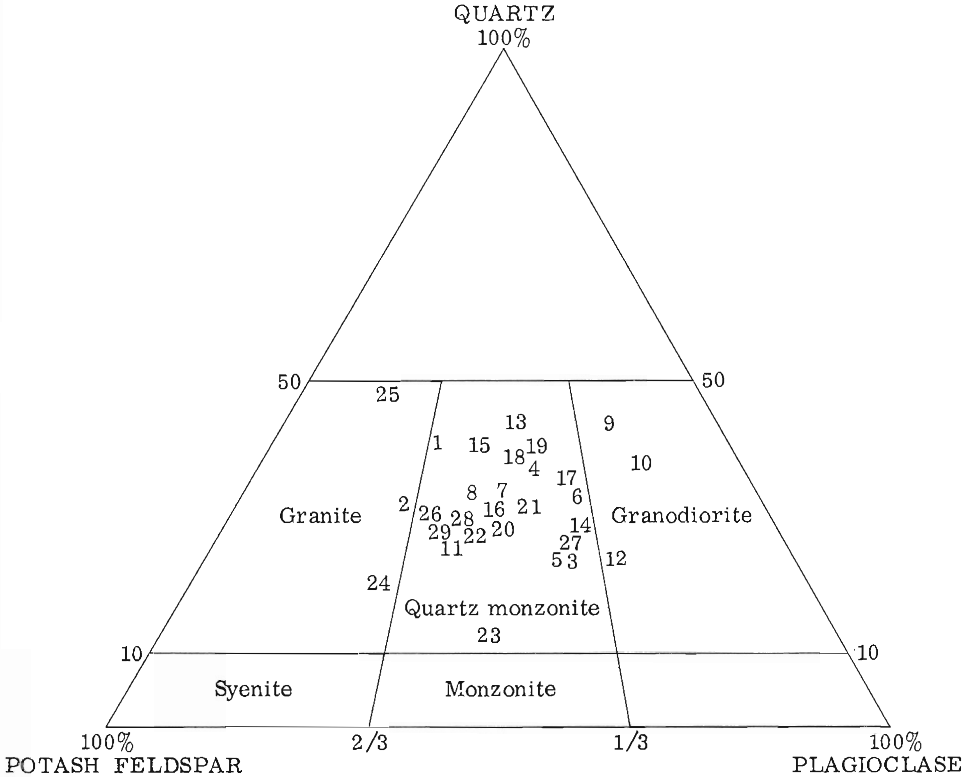


Figure 5. Details of granite contact in hornfelsed slates of unit 1, southwest corner of map-area. Contact transects slaty cleavage and a/c joints produced by regional deformation.



LEGEND

Specimens selected at regular intervals across the small stock northwest of the Canada Tungsten mine . . . . 1 - 14

Specimens of porphyry dykes in the vicinity of the Canada Tungsten mine . . . . 26 - 29

Specimens randomly selected from representative collections of the various stocks . . . . 15 - 25

GSC

Figure 6. Plot of partial mineralogical compositions (volume per cent) of granitic rocks shown in Table II.

Table II

Volume Modes of Granitic Rocks

Specimen	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quartz	39	30	20	35	23	32	30	25	37	34	42	52	24	41	28
Plagioclase	18	19	43	31	39	37	28	50	33	42	30	24	46	26	42
Potash feldspar	35	42	27	25	30	22	30	19	10	8	26	15	20	24	22
Biotite	8	9	8	9	6	9	10	6	20	16	2	9	10	9	8
Hornblende	-	-	2	-	2	-	2	-	-	-	-	-	-	-	-

Specimen	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Quartz	41	31	33	38	37	28	28	26	26	27	12	21	50	30	47
Plagioclase	26	30	36	32	31	32	32	28	43	28	40	24	10	24	11
Potash feldspar	30	33	22	26	26	34	27	37	26	39	42	55	40	43	42
Biotite	-	6	9	4	6	6	13	9	5	6	6	-	-	3	-
Hornblende	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Analyses by point counter 500 to 1,000 counts per slide.

grains that are probably primary. Rarely dark green hornblende forms accessory amounts. Accessory minerals include apatite, zircon, sphene, iron ores and rarely black tourmaline and pink garnet.

Marginal zones are finer grained (Fig. 7) and either equigranular or porphyritic with megacrysts of essential minerals up to 5 mm across in a fine-grained groundmass that is richer in potash feldspar and silica. Large megacrysts are absent.

Contamination of the plutons by wall-rock appears extremely limited and essentially restricted to carbonate rocks. Reaction zones a few inches to a few feet wide are present in which plagioclase becomes more calcic, quartz diminishes and diopside appears as fine disseminated grains.

Age   A specimen of the large stock southwest of Pyramid Mountain yielded a potassium-argon age of 110 million years, equivalent to mid-Cretaceous. This agrees well with that obtained from similar rocks in the Itsi Range to the northwest (Baadsgaard et al., 1959) and is probably representative of all plutonic rocks in the upper Flat River region. Stratigraphic evidence is insufficient for a more precise dating than post-Devonian.

Structures related to intrusion   Folds associated with several granitic stocks differ markedly in orientation and style from regional folds. The regional folds appear to be deflected over the stock just southeast of Canada Tungsten mine. They plunge away from the stock to the northwest and southeast and are more tightly compressed above and to the west of the intrusive. The marked changes in thickness in the vicinity of the plutons are mainly tectonic rather than primary and were probably facilitated by recrystallization accompanying intrusion.

The large circular stock northeast of the mine seems to have deflected structures around its southern margin and strata and cleavage strike east parallel with the contact and dip moderately south away from the granite.

The large intrusive in the southeast part of the area was emplaced along the axis of a broad anticline, which appears to have been opened or spread by the intrusion. The stock transects regional structure at its northwest and southeast ends but elsewhere dips are outward from its contacts. The steeply plunging, highly compressed and overturned Pyramid Mountain syncline (see structure section, Map 4-1967) and the east-trending thrust fault farther north, record northerly compression of the wall-rock which in this area is perpendicular to the contact and evidently a result of expansion of the body.

Felsite and porphyry dykes   Rhyolite, quartz latite and aplite dykes are commonly associated with the granitic stocks (see Fig. 13). The largest are 20 feet or more thick and extend for several hundred feet. Most of the rock consists of a microcrystalline to aphanitic groundmass mosaic of potash feldspar and quartz, commonly myrmekitic or micrographic. Quartz forms conspicuous equant phenocrysts, normally corroded or embayed by the groundmass, and is accompanied by abundant microcline and microperthite in the rhyolite and by plagioclase (albite-oligoclase) phenocrysts in the quartz latite. Biotite, the only mafic mineral, averages less than 2 per cent of the rock and is commonly chloritized. Main accessories are apatite and sphene.

STRUCTURAL GEOLOGY

Regional Structure

The regional structure is dominated by a northwesterly trending syncline along Flat River, separating a complex anticlinorium to the northeast from a terrain of gently overturned more tightly compressed folds to the southwest. Northeast of the river, folds are open upright and cleavage within the argillaceous rocks only weakly developed. Most of the west limb of Flat River syncline is complicated by several smaller folds and farther southwest folds are more closely spaced and cleavage more highly developed.

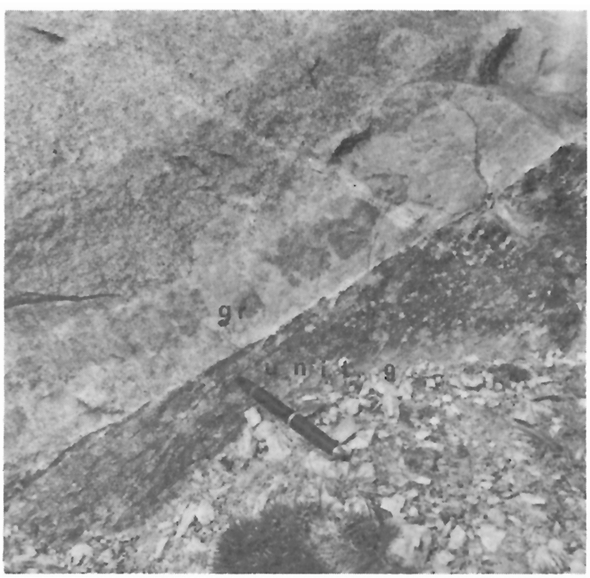


Figure 7. Details of granite contact with 'wavy banded' calc-silicate marbles of unit 9 showing sharpness of contact, here subparallel with bedding, and fine-grained chilled margin less than 1 foot wide.

These structures are considered post-Ordovician, pre-Cretaceous(?) as they involve Upper Ordovician strata and are transected by Cretaceous(?) granitic intrusives.

Structures in the slate and phyllite of unit 1 which underlies most of the area southwest of Flat River are difficult to outline. Owing to the lack of distinctive members and a highly developed cleavage, large scale folds are rarely recognized but must be inferred from fabric elements. A study of cleavages, lineations and minor folds in selected areas showed that the folds have the same general style and orientation as those readily mapped in the younger, well-stratified rocks northeast of Flat River but are on the whole more common and more tightly compressed.

Bedding has been folded upon northwest-trending, sub-horizontal fold-axes, and a strong axial plane slaty cleavage has developed. Most of the folds are symmetrical, upright to moderately overturned, and of the flexural-slip type ranging from a few inches to hundreds of feet across. They are statistically cylindrical over areas of one square mile or more. The slaty cleavage generally dips from near vertical to steeply southwest but moderate dips both northeast and southwest are not uncommon and suggest slight fanning of the cleavage about fold axial planes.

In addition to the pervasive slaty cleavage, the rocks are cut in some areas by a later non-persistent fracture or incipient strain-slip cleavage oriented almost perpendicular to the fold axes. This second cleavage is not discernible in all places, but where best developed, follows axial planes of small symmetrical wrinkles or crenulations, up to an inch or more across, in the slaty cleavage. These crenulations evidently reflect shortening parallel with the regional fold axes but do not appear to have larger scale cross-folds related to them, as the slaty cleavage is remarkedly consistent in orientation throughout the area. Closely parallel to the secondary cleavage is a particularly prominent and widespread joint set, oriented more or less perpendicular to the regional fold axis. The joints, which probably predate the secondary cleavage are readily distinguished as they are non-penetrative and have no relation to minor folds or crenulations in the slaty cleavage.

Faults

Faults developed in at least two, perhaps widely separated, periods: with or closely following regional folding early in the structural history, and during or after granitic intrusion. Some early faults may have had recurrent movement in the later period.

In the east-central part of the map-area, two major transcurrent faults with several subsidiary ones outline a narrow, complex, easterly trending zone of faulting between Flat and Rabbitkettle Rivers. This zone forms a prominent structural break, dividing the region east of Flat River into two areas of differing fold patterns. Both major faults are left-lateral, with a combined horizontal displacement of about 1 1/4 miles on the west side of the anticlinorium and over 4 miles on the east side. The difference in displacement at opposite ends of the zone is attributed to continued independent folding in the areas north of the zone where the three main folds making up the anticlinorium are considerably more closely spaced. The orientation of this fault zone, oblique to the regional structural trend, and the left-lateral sense of movement, suggest that these faults represent a major shear related to regional folding and produced during the same period of shortening in the northeast direction.

Faults near the granitic plutons, such as those radially arranged about the large circular stock in the northern part of the mapped area probably formed during intrusion, as did the few that actually cut the granitic rock.

The east-trending thrust-fault north of Pyramid Mountain appears to have had a complex history. A late period of thrusting, due to movements outward from the large stock to the south, is superimposed on earlier transcurrent movement.

CONTACT METAMORPHISM

For distances of a few hundred feet to more than a mile from the granitic stocks, the country rock is altered in texture and mineralogy by moderate contact metamorphism. These metamorphic zones or aureoles for a given host vary in width more or less with the size of the associated pluton. The highest grade mineral assemblages are typical of the hornblende hornfels facies. Metamorphic effects differ in host rocks of differing composition.

Pelitic Rocks

In the two principal argillaceous units, 1 and 10, the aureoles are broadly divisible into an outer zone of spotted slate and an inner zone (within a few hundred feet of the contact) of more resistant, more massive, fine-grained hornfels. Mineralogy is remarkedly uniform throughout both zones, metamorphic changes being principally a variation in texture and proportion of the constituent minerals which are mainly sericite, biotite and andalusite, rarely cordierite, quartz, graphite and minor opaque minerals. From the zone of spotted slate toward the contact, biotite grades from pale greenish brown to dark red-brown, and along with sericite increases in grain size, whereas andalusite decreases in size. In hornfels andalusite forms clean, fine grains in widely scattered small aggregates in contrast to the spotted slates where it forms erratically distributed, poikilitic porphyroblasts.

Cordierite was observed only in the spotted slates of unit 10, where it forms clear single grains or clots crowded with sericite or graphite and commonly rimmed by biotite. Spots near the margin are formed by accumulations of sericite and fine biotite, or in the blacker slates by aggregates of organic matter and graphite. With increased metamorphism the spots become mostly porphyroblasts of andalusite or cordierite, crowded with sericite and graphite and commonly enveloped by shreds of pale brown biotite.

Calcareous Rocks

'Ore-limestone' The 'ore-limestone' between Canada Tungsten mine and Baker prospect is altered to blue-grey marble containing small amounts of diopside, tremolite, white mica, sphene, zoisite and brucite. Mineralogy is similar throughout but grain-size and proportion of certain minerals vary with distance from the contact. As the intrusives are approached the grain-size of the marble increases from fine to medium, that of the accessories from microcrystalline to fine and the silicates increase in quantity with a corresponding decrease in detrital quartz. Brucite was observed only near intrusive contacts in marbles lacking quartz.

Diopside, the principal accessory, forms colourless equant anhedral grains, commonly disseminated, but mostly in small aggregates with fine needles of grey tremolite clustered near or around detrital quartz. In most places, these two silicates total less than 15 per cent and the other silicates are much less abundant.

Original layering is preserved as a fine, light and dark grey banding up to 1/2 inch thick and a vague colour change of medium grey to bluish-white in beds 6 inches to 1 foot thick. The darker marble is invariably fine-grained and contains a greater amount of accessories including graphite, the principal pigment. Other layers reflect more marked compositional changes. These consist of widely spaced, dark grey to black, more resistant bands and fine laminations commonly disrupted into isolated 'pull aparts' and randomly oriented chips, composed mostly of diopside, dark tremolite, mica and detrital quartz with minor interstitial fine-grained calcite. Apparently, these layers represent original calcareous siltstone bands like those found in unaltered 'ore-limestone'.

Impure limestone Metamorphism has greatly accentuated primary stratification and small scale compaction features of units 2 and 9 by development of contrasting mineral assemblages in the different layers and laminae. The limestone layers are converted to fine-grained marble and the silty layers to dense calc-silicate hornfels. In outcrop a strongly corrugated surface is produced by differential weathering of these two rock types (Figs. 8, 9). In the hornfels highest grade assemblages consist of colourless diopside, tremolite, pink to pale red-brown idocrase, garnet, epidote, and rarely potash feldspar, plagioclase, sphene and biotite, plus interstitial relics of very fine grained calcite and quartz silt. With the exception of garnet and idocrase, which

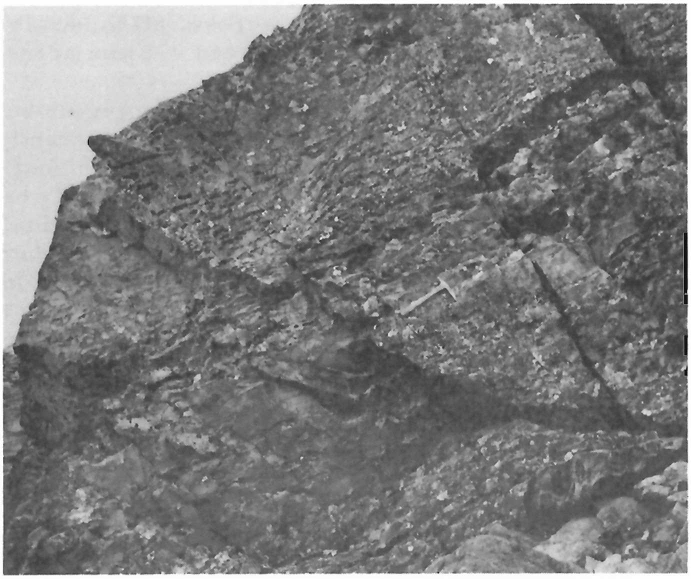


Figure 8. Metamorphosed 'swiss-cheese' limestone about 1,500 feet east of Canada Tungsten mine. Typical pods and lenses of original limestone preserved in more resistant calc-silicate hornfels.

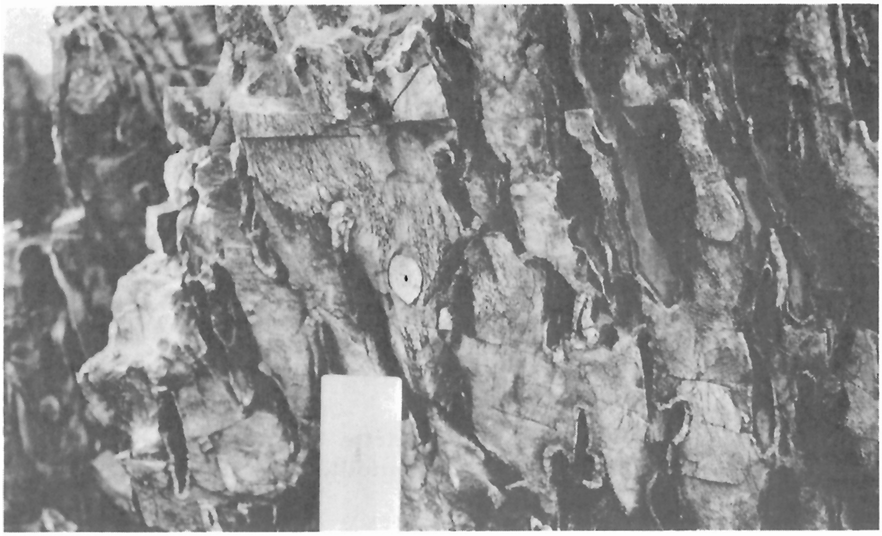


Figure 9. Metamorphosed 'swiss-cheese' limestone 1 mile northwest of Pyramid Mountain, showing well-preserved archeocyathid now replaced by calc-silicates.

commonly form poikiloblasts up to 1/4 inch across, all minerals are microcrystalline to very fine grained and seldom exceed 0.1 mm across.

Most of the calc-silicate bands are not homogenous but are individually laminated with contrasting mineral assemblages, apparently reflecting local equilibrium dependent on original composition. The higher grade silicate layers of the 'swiss-cheese' limestone are conspicuously banded in shades of purplish brown, pale green and white. All bands contain considerable quartz and diopside but are variously coloured by the predominance of biotite, light green actinolite, or, rarely, epidote and quartz. In unit 9 contacts between marble and the diopside-rich bands are commonly transitional, consisting of laminations alternately rich in diopside, idocrase and grossularite. The transitional zone as a whole is richer in aluminum, as are the garnetiferous laminae, apparently reflecting a higher clay content between the original limestone and siltstone bands, a good illustration of how even fine laminae are preserved during the metamorphism.

Siliceous Dolomite

Sandy and silty dolomite and dolomite-cemented sandstones of units 6, 7 and 8 are altered to mixtures of tremolite, diopside, quartz and carbonates, which reflect both primary layering and degree of metamorphism. Stratification of the different hornfels and recrystallized monomineralic rocks (dolomite and quartzite), shows that the various metamorphic assemblages are dependent on original composition. Stratigraphic section 9, measured within the contact aureole, can be correlated in some detail with an unmetamorphosed sequence, section 6, 1 mile to the northwest (see Fig. 3). Textures are also commonly preserved. For example metamorphosed quartz-sand-bearing dolomites, commonly retain their characteristic, sandy textured, weathering surface owing to selective replacement of 'floating' quartz grains by aggregates of fine tremolite.

Degree of metamorphism is shown by an overall change in mineralogy across the aureole, which is broadly divisible into two metamorphic zones. Tremolite defines the outer limit of metamorphism and the first appearance of diopside defines the inner zone. Characteristic mineral assemblages of the two zones are:

A Tremolite zone
1. Quartz, tremolite, calcite
2. Dolomite, quartz, tremolite, calcite

B Diopside zone
1. Diopside, tremolite, quartz, calcite
2. Diopside, tremolite, forsterite, calcite
3. Diopside, tremolite, dolomite

4. Diopside, tremolite, quartz
5. Diopside, tremolite, calcite
6. Diopside, quartz, calcite

Tremolite forms distinctive microcrystalline to medium grained bladed crystals, in places ranging up to 1 inch in length. Diopside is typically colourless and forms equant sugary grains that range from microcrystalline to very fine grained. Both minerals are commonly intergrown in aggregates replacing quartz sand grains in dolomite or, along with secondary quartz and calcite, form cement of some quartzites.

The mineral assemblages are interpreted as being produced by simple metamorphic reactions (dependent mostly on temperature) involving only components of the original rocks, namely: CaO, MgO and SiO_2; with possibly the addition of H_2O. Assuming equilibrium, H_2O must have been irregularly distributed, the distribution being controlled by factors such as original water content or permeability in order to account for some 4-phase assemblages. For instance, in the tremolite zone the association dolomite-quartz would not be stable in the presence of H_2O, nor would the association tremolite-calcite-quartz found in the diopside zone be stable if H_2O was not in excess.

The limit of metamorphism, taken as coinciding with the outer limit of tremolite in these rocks, extends several thousand feet from nearest intrusive contact and up to a maximum of 1.5 miles from the large stock south of Pyramid Mountain. The diopside zone forms roughly the inner half of the aureole and seldom extends more than 4,000 feet from the contact. Near Canada Tungsten mine the diopsidic zone covers a wide area extending from about 2,000 feet southeast of Baker prospect to 2 miles northwest of the mine, on the southwest side of Flat River and to just north of section 9 on the northeast side. Elsewhere the diopside limits are not well known, owing to the difficulty of detecting the fine grained mineral in the field, but the limits may be important in exploration as virtually every contact metamorphic mineral deposit in the map-area occurs within the diopside zone.

TUNGSTEN DEPOSITS

Tungsten deposits of the Flat River area are all of the contact metamorphic or pyrometasomatic type. The tungsten occurs as scheelite associated with skarn in marble near or adjacent to granitic stocks. The bodies are in various structural positions and in limestones of more than one age but the richest are all within one Lower Cambrian massive limestone member, referred to as the 'ore-limestone'. All evidence indicates that the tungsten as well as iron, magnesia and silica came from outside of the limestone, presumably from the plutonic rock, during or after contact metamorphism related to Cretaceous granitic intrusion.

CANADA TUNGSTEN ORE DEPOSIT

The Canada Tungsten ore deposit is exposed on a cirque threshold on the southwest side of Flat River valley, 1,500 feet above the valley floor. It is small by most standards; not more than 600 feet in largest dimension, a maximum of 80 feet thick, and contains little more than 1 1/2 million tons; but as it averages 2.47 per cent WO_3 it is one of the highest grade tungsten orebodies in the world. All the tungsten is in essentially pure scheelite; wolframite has never been reported and molybdenum forms only trace amounts. Copper as chalcopyrite averages about 0.5 per cent.

A skarn of dark green calcium, magnesium and iron silicates developed in coarse-grained marble of the 'ore-limestone' is partly replaced by pyrrhotite, scheelite and chalcopyrite and is cut by scheelite bearing microcline-quartz veins. The body is localized in the massive 'ore-limestone' and in limy bands at the top of the underlying 'swiss-cheese' limestone, several hundred feet from the nearest exposed intrusive contact but within a zone of moderate grade, contact metamorphism.

Mineralogy

Principal minerals of the skarn are dark green diopside-hedenbergite, reddish brown to pink grossularite-andradite, quartz and calcite. Locally the pyroxene and garnet combined form as much as 90 per cent but on the whole average closer to 50 per cent of the skarn. They form medium to coarse, anhedral to subhedral grains commonly with interstitial medium-grained calcite and/or quartz. Quartz forms up to 30 per cent of some thin sections and has extensively corroded and replaced diopside. Most of the calcite is probably relict marble.

Feldspar rarely forms more than a few per cent but is a distinctive feature of the skarn. Fine subhedral grains of plagioclase are commonly corroded or replaced by interstitial microcline and fine-grained calcite. The plagioclase relicts are too few for a determination of composition, but the high refractive index is suggestive of bytownite. The feldspar is often closely associated with scheelite, and except for fluorescence the two are easily confused in hand specimen. Other accessory silicate minerals are actinolite, epidote and sphene.

The ore minerals are closely associated in the skarn-scheelite as disseminated, fine, anhedral grains and sulphides, almost entirely pyrrhotite, as interstitial replacements of the skarn and as tiny veinlets cutting both skarn minerals and scheelite.

Quartz veins Scheelite-bearing quartz veins, some extending more than 100 feet and reaching widths up to 1 foot or more, transect the skarn and underlying 'swiss-cheese' limestone. Within the 'swiss-cheese' limestone the veins follow persistent open fractures, but in the skarn they become less continuous, more irregular and are commonly of the replacement type following relic bedding planes.

Most of the veins are very rich in scheelite which forms coarse, subhedral to euhedral grains up to 1/2 inch across. Additional minerals include microcline, biotite, chlorite, actinolite, garnet, fluorite, apatite, calcite and plagioclase. In most places these minerals are not abundant, except microcline which commonly equals quartz in abundance. Both quartz and microcline are very coarse grained. Quartz is mostly grey to colourless but is also white or milky. Reddish brown, fine-grained biotite forms isolated interstitial shreds and flakes in the quartz. The pale colour and low index (n_y=1.620) are indicative of a low iron content. Much of the biotite is altered to fine-grained pale green chlorite (n_y=1.632). The remaining minerals are present in accessory amounts and are mostly fine grained. A few specks of native bismuth were seen in one specimen.

Locally the quartz is cut by chalcopyrite veinlets lined with fine-grained, wine-purple biotite containing dust-like specks of scheelite (0.1 to 0.2 mm in diameter), clear quartz and, rarely, finely disseminated chalcopyrite and pyrrhotite. This outer biotite-scheelite zone marginally fills interstices and appears to replace quartz.

Most of the veins strike northeast and dip nearly vertically, and are therefore perpendicular to the axes of regional folds.

The close association of quartz veins with the skarn and mineralization suggests that they are genetically related. The veins are found only in the vicinity of the skarn, especially below mineralized areas within it. Some veins terminate in laterally extending replacement masses of skarn, scheelite, and sulphides within the 'ore-limestone' and thicker marble beds of the 'swiss-cheese' limestone.

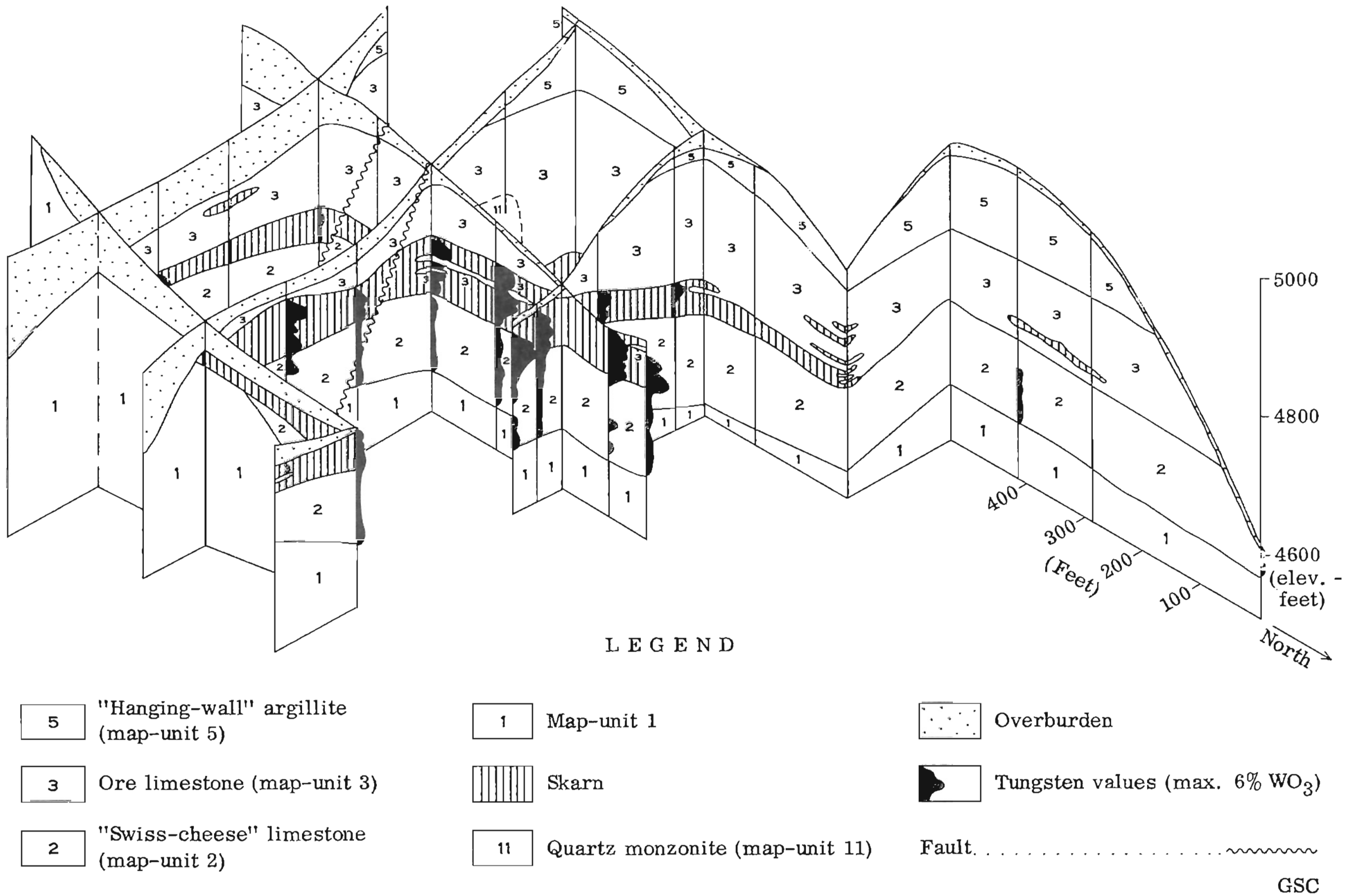


Figure 10. Sectional diagram of Canada Tungsten Ore body (compiled from diamond drill data) after Crawford, 1963.

History of Skarn and Ore Mineralization

The sequence of mineralization is as follows:

1. Replacement of marble by skarn-forming silicates, chiefly diopside.
2. Veining of skarn by feldspar-scheelite-quartz veins and local replacement of diopside by quartz.
3. Restricted veining of previous veins and limited replacement of quartz by aggregates of fine-grained biotite and quartz containing finely disseminated scheelite and sulphide. Locally sulphides, both chalcopyrite and pyrrhotite, are dominant and alone or with biotite vein individual crystals of scheelite in the feldspar-scheelite-quartz veins and diopside in the skarn.

Thus scheelite forms in at least two stages; firstly, as coarse grains in veinlets of quartz and feldspar and, secondly, as fine grains in veinlets of biotite, quartz and sulphide. The bulk of scheelite and sulphide, however, is disseminated in the skarn and evidence is inconclusive as to when this material was emplaced. Probably most scheelite was deposited in the first scheelite stage and most sulphide in the later stage.

Structure

The skarn deposit is on the flat to gently dipping east limb of the prominent northeasterly overturned syncline along the southwest side of Flat River valley (see Map 4-1967). Owing to differing degrees of metamorphism on adjacent limbs and a lack of regional stratigraphic knowledge, this syncline was not recognized in earlier mapping near the mine.

The skarn is tabular in cross-section, roughly circular in plan and transected near the middle by a high-angle fault of small displacement. Figure 10 shows the form of the skarn at the 'ore-limestone'-'swiss-cheese' limestone contact and tungsten values compiled from diamond drill data. The structure contours of Figure 11, drawn at the top of the 'swiss-cheese' limestone, show the position of the fault at depth and indicate a southerly dip of about 70 degrees.

The fault predates mineralization and may have had some influence in localizing the ore deposit. Skarn isopach contours, as shown in Figure 11, are predominantly parallel or subparallel with the fault zone, and drill holes in which skarn is continuous (i.e., not interleaved with relic limestone, but massive throughout), are grouped near the fault (see Fig. 12). Assuming the fault zone is an important ore control, it would at best be a two dimensional one and does not account for the orebody being localized along a particular part of it. Perhaps the proximity of the underlying quartz monzonite, possibly forming a cupola below the skarn deposit, and the extensive development of rhyolite dykes, as shown by diamond drilling (Fig. 12) are the main or, at least, complementary factors.

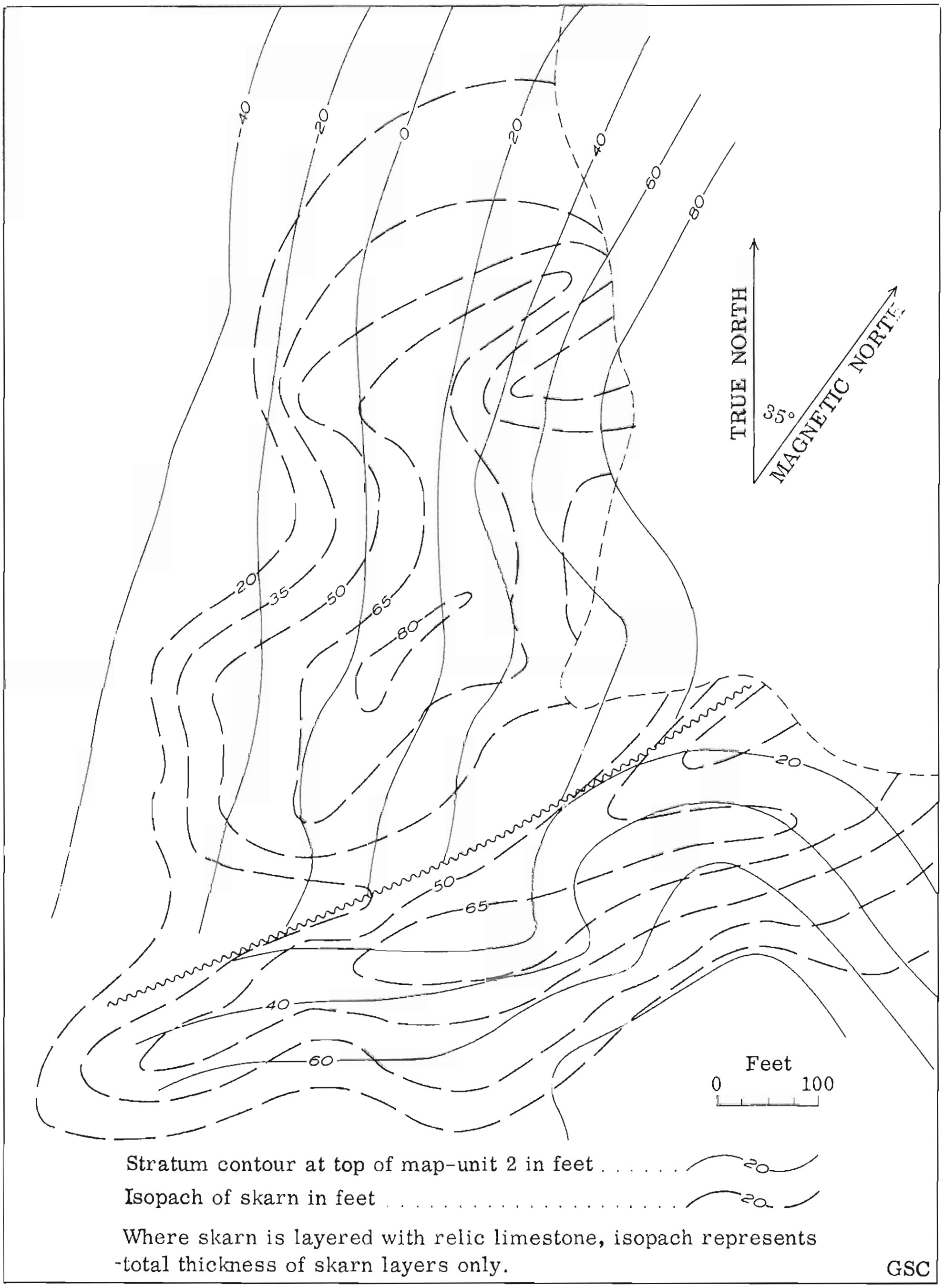


Figure 11. Stratum contours and isopachs of Canada Tungsten skarn.

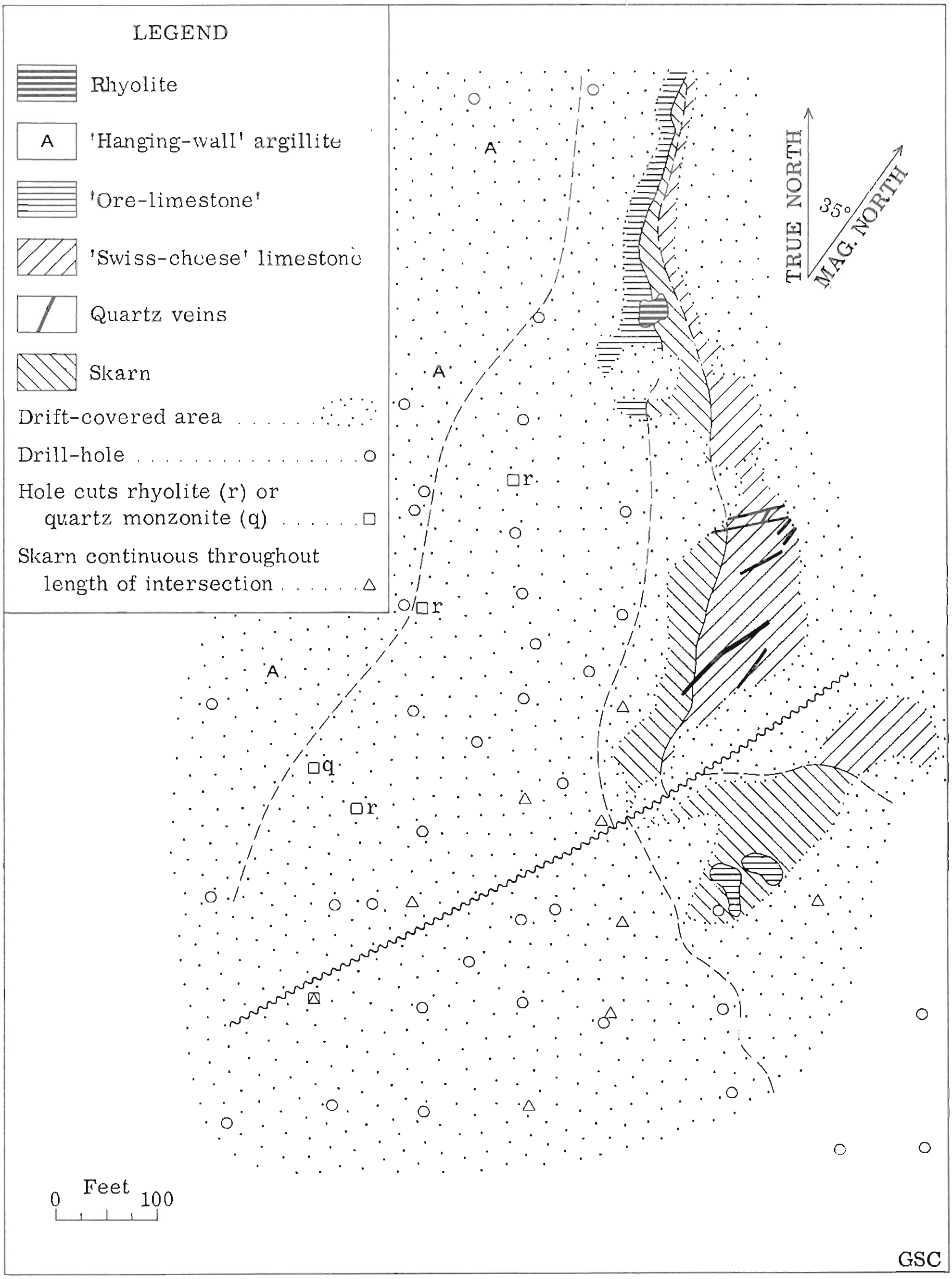


Figure 12. Geology of Canada Tungsten orebody (modified from company records).

BAKER PROSPECT

Baker prospect, located on the southwest side of Flat River, 3 miles southeast of Canada Tungsten mine has the same mineralogy, grade and mode of occurrence as the Canada Tungsten ore deposit. However, due to its much smaller size, it is not considered economic and no exploratory work has been done. Skarn with a maximum thickness of 10 feet is exposed intermittently for about 300 feet at the base of the 'ore-limestone'. Tonnage cannot be estimated without diamond drilling, but it is necessarily limited owing to the proximity of the granite.

The orebody, tabular at the base of the 'ore-limestone', is on a moderately eastward dipping limb near the crest of a gently southeast plunging anticlinal flexure.

Mineralogy The Baker skarn has a more varied mineralogy than the Canada Tungsten ore deposit. Besides pyroxene, garnet, quartz and calcite, idocrase is a principal constituent. Accessories are scheelite, fluorite, sphene, sphalerite, pyrrhotite and chalcopyrite. Fluorite, is colourless to pale purple, medium to coarse grains, forms several per cent of some specimens, and brownish black sphalerite forms up to 10 per cent.

The calc-silicates plus scheelite and fluorite are all intergrown. Quartz replaces idocrase as is shown by sieve texture of quartz. Sphalerite, associated with the other sulphides is poikiloblastic, enclosing all skarn minerals as well as scheelite.

MINOR SKARN OCCURRENCES IN THE 'ORE-LIMESTONE'

Scheelite-bearing skarn is exposed at 5,300 feet elevation 1,000 feet southeast of the Canada Tungsten orebody. The skarn lies along the 'ore-limestone'-'swiss-cheese' limestone contact near the crest of a minor anticline and extends for more than 200 feet with a width of up to 10 feet. Grade is low; a maximum, reported by the Canada Tungsten Company, of 0.74 per cent WO_3 over 10 feet.

Farther southeast, about 1 1/2 miles from the orebody, skarn is developed in 'ore-limestone' adjacent to the intrusive rock. Skarn is not restricted to the favourable basal contact of the limestone but is found as well at the top and at the quartz monzonite contact. Scheelite is present in all skarns but appears most abundant at the base of the 'ore-limestone', where the company reports an average grade of 0.39 per cent WO_3 over an average width of 11.3 feet throughout a length of 160 feet.

Upper skarn near Baker prospect A small, scheelite-bearing, skarn deposit of similar composition to Baker prospect, a short distance south at the top of the 'ore-limestone', appears continuous for several hundred feet but averages 5 feet or less in thickness. This tabular body is overlain by about 20 feet of rusty weathering, thin-bedded, calcareous argillite and weakly hornfelsed slate. Unlike the skarn at Baker prospect, garnet dominates over pyroxene and sulphides are absent. Scheelite grade is considerably lower.

Skarn on dyke contact Near mid-section of the 'ore-limestone' above the Baker prospect, fine-grained, dark green skarn is associated with a 20-foot thick granitic dyke. The skarn forms a 3-foot-wide, rusty weathering zone along both dyke-limestone contacts.

Mineralogy is the same as Baker prospect, except that idocrase is lacking. Minor amounts of scheelite form finely disseminated anhedral grains, mostly associated with fluorite. Calcite, quartz and pyrrhotite fill interstices and minute fractures throughout the skarn.

SCHEELITE-BEARING SKARN DEPOSITS IN UNIT 9

M.B. prospect At the M.B. prospect, situated 18 miles southeast of Canada Tungsten mine, unit 9 is altered to skarn up to a few feet thick over a length of several hundred feet adjacent to an intrusive contact. Scheelite is finely disseminated in the skarn averaging less than 0.5 per cent WO_3. Chief minerals are pyroxene, garnet and idocrase. Chlorite, quartz and calcite are present interstitially with minor wollastonite. Other accessories are clinozoisite and tourmaline. Veinlets of quartz and calcite transect the skarn.

Showings north of Canada Tungsten mine Several small pod-like skarn deposits, about 1 mile north of Canada Tungsten orebody at or within several feet of the granite contact, are all within bands or thin beds of marble in unit 9 and consist of fine-grained pyroxene and garnet, mostly replaced by pyrrhotite and chalcopyrite which weathers to rich brown limonite. Scheelite forms fine disseminated specks and is low grade.

FACTORS RESPONSIBLE FOR LOCALIZATION OF SCHEELITE-BEARING SKARN

Principal factors affecting skarn distribution in the Flat River area appear to be lithology of host rock, type of associated intrusive, and minor folds and faults.

Skarn host rock without exception is marble derived from particularly pure limestone as is found in unit 3 ('ore-limestone') and units 2 and 9. As limestone of units 2 and 9 is thinly intercalated with silty limestone and siltstone sizeable skarn replacement is necessarily limited to the 'ore-limestone'.

Granitic bodies that intrude limestones of the area are the two small stocks near the Canada Tungsten mine and the much larger one southeast of Pyramid Mountain. Although similar in silicate composition (quartz monzonite) it is suggested that the Canada Tungsten stocks, at least at their present structural level are the more favourable source rocks. Pyrrhotite, a principal mineral of the skarn is notably more abundant in these bodies and skarn development is more intense in limestones (units 2 and 9) associated with them.

Although the chief factor seems to be the association of 'ore-limestone' with quartz monzonite stocks, and perhaps in particular those around Canada Tungsten mine, in fact, very little of the marble in this association is actually affected. Localization of skarn within the limestone appears to be governed by a variety of structural factors. All deposits are found on the flat-lying to gently dipping lower limb of the major overturned syncline southwest of Flat River, which is nearest the centre of the intruding stock; but no single local control is common to the individual bodies. The largest and richest skarns, Canada Tungsten and Baker, are on the 'ore-limestone'-'swiss-cheese' limestone contact, at least 50 to 100 feet vertically from granitic rock and near the crests of broad, open, anticlinal flexures. Unique to the Canada Tungsten skarn is a prominent pre-ore fault, mentioned earlier, which may well be an important control. Granitic dykes are likewise associated with these two major skarns, as well as the minor skarn above the Baker prospect. However, as shown by the two remaining minor deposits, at least low-grade skarn may form at the granite contact, or several hundred feet from it, with or without quartz veins, granitic dykes or faults and on either flat-lying or gently dipping beds.

<u>Suggestions for exploration</u> Owing to the limited distribution of the 'ore-limestone' new sizeable scheelite deposits are not likely to be found more than a few miles distant from Canada Tungsten mine. No other formation within the map-area contains sufficiently thick pure limestone to form an orebody of economic size.

For further exploration two main approaches seem justifiable. First to investigate by drilling the 'ore-limestone', with emphasis on the lower limb of the Canada Tungsten syncline both northwest and southeast of the mine and in Flat River valley east of the townsite, and, secondly, to prospect areas of Lower Cambrian strata intruded by granitic rocks between Rabbitkettle and South Nahanni Rivers (<u>see</u> GSC Map 36-1964 'Glacier Lake' 1965).

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APPENDIX

Stratigraphic Sections 1-16

SECTION 1

Unit 2

Location: 3.2 miles north-northwest of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 6.		
	Contact not exposed.		
1	Dolomitic siltstone, argillaceous, fine to medium grained, 15 to 20 per cent finely crystalline dolomite in scattered euhedra, weathers orange-buff, in part has less than 10 per cent dolomite and weathers greenish grey; minor silty limestone: bioclastic, dark grey, very fine to aphanocrystalline, 10 to 15 per cent fine silt, minor clay, forms recessive blue-grey weathering pods, lenses and discontinuous bands.	300	
	Contact rapidly transitional, conformable.		
	Underlying beds - unit 1: interbanded grey slate and minor brown weathering, dark grey, slightly dolomitic siltstone.		

SECTION 2

Unit 2

Location: 2.5 miles north by west of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 6: thinly banded, calcareous, brown-weathering, silty shale and minor silty limestone.		
	Contact gradational, conformable.		

Unit	Lithology	Thickness (feet)	Height above base (feet)
12	Silty limestone, in blue-grey-weathering recessive bands and lenses 1 inch to 2 inches long, interbanded orange-buff weathering dolomitic siltstone.	15	545
11	Silty limestone, argillaceous, finely banded and laminated with medium and light grey silty shale, a few orangish weathering dolomitic laminations, weathers mostly light brown; minor fine to medium grained locally cross-bedded sandstone and buff-brown weathering dolomitic calcareous silt-stone.	91	530
10	Calcareous siltstone, dolomitic, limon-itic, dark grey, massive, orange-brown weathering.	5	439
9	Silty limestone and thinly interbanded, orange-brown weathering, dolomitic siltstone.	4	434
8	Silty limestone, forms recessive blue-grey weathering lenses 1 inch to 3 inches long and discontinuous 2- to 3-inch bands in orange-brown weathering dol-omitic siltstone; minor medium-grained, calcareous sandstone in 2- to 3-foot beds.	50	430
7	Sandstone, light brown, coarse-grained, calcareous cement, massive.	25	380
6	Sandstone, as above, in 2-inch to 2-foot beds, interbanded with buff-orange weathering, brown-grey, silty shale and crudely laminated, dolomitic, calcareous siltstone.	35	355
5	Silty shale, dolomitic, 15 to 20 per cent silt, about 15 per cent finely crystalline cream dolomite, weathers medium brown-grey; thinly banded and laminated with minor silty dolomite: finely		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	crystalline, about 20 per cent coarse silt, weathers orange recessive; a few discontinuous coarse-grained sandy bands up to 4 inches thick.	10	320
4	Silty limestone, dolomitic, thinly inter-banded with minor orange-brown weathering, argillaceous, silty dolomite.	15	310
3	Silty dolomite, dark grey with medium grey laminations, finely crystalline, about 10 per cent medium silt, massive, dark greyish brown weathering.	10	295
2	Silty limestone, dark grey, very finely crystalline, 25 to 30 per cent silt, a few per cent dolomite, forms recessive light buff-grey weathering closely spaced lenses 2 to 3 inches long in minor dol-omitic siltstone: fine to medium grained, 30 to 40 per cent finely crystalline dol-omite as scattered euhedra, minor clay, buff-orange weathering.	250	285
	Covered.	5	35
1	Argillaceous siltstone, and silty mudstone, very fine silt, medium and dark grey, in part laminated; minor limestone: several per cent coarse silt, sericite and argil-laceous matter in ill-defined streaks or fine laminations, forms equant pods and lenses up to 6 inches long, weathers greyish brown; upper part has more silt and limestone.	30	30
	Contact gradational, conformable.		
	Underlying beds - unit 1: thinly banded, dark grey, silty argillite and minor light-grey, fine-grained siltstone.		

SECTION 3

Unit 5

Location: 4.2 miles southwest of Pyramid Mountain. A partial section at the top of unit 5; shows representative lithologies.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 9: calcareous siltstone.		
	Contact sharp, appears unconformable.		
6	Argillite, non-calcareous, dark grey, rusty weathering, in 2- to 3-inch bands alternating with brownish grey weathering silty limestone.	50	512
5	Argillaceous siltstone or silty shale, calcareous medium to dark grey well laminated.	15	462
4	Argillite, non-calcareous dark grey to black, massive cliff-forming, rusty-brown weathering.	52	447
3	Argillite, dark grey to black, pyrite bearing, rusty weathering interbedded medium to dark grey, medium brownish grey weathering, calcareous silty argillite, in part laminated and pyrite bearing.	75	395
2	Silty limestone and calcareous siltstone, dark grey platy to fissile.	80	320
1	Argillaceous siltstone, calcareous, medium and dark grey up to 20 per cent limestone locally, fissile to platy, a few per cent disseminated fine pyrite; thinly banded and laminated with competent black silty argillite; argillite has pyrite laminations, weathers medium brown in part rusty; several 4- to 6-inch beds of light grey limestone: medium crystalline with 20 to 30 per cent scattered coarse-grained silt and very		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	fine sand, minor finely disseminated pyrite, light buff-grey weathering.	240	240
	Contact not exposed.		

SECTION 4

Unit 6

Location: 5.1 miles east of Canada Tungsten mine.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 7.		
	Contact conformable.		
27	Dolomite, light grey, finely crystalline, even grained, massive, mottled weathering buff and medium grey.	50	1178
26	Silty dolomite, medium grey, finely crystalline, fine resistant laminations of coarse silt and very fine sand, cross-laminated in platy beds 1 inch to 6 inches thick, locally silty bands 1/4- to 1/2-inch thick, weathers medium brown grey, locally buff orange with dark silty bands and laminations.	20	1128
25	Dolomite, as above, light grey, finely crystalline, mottled weathering.	25	1108
24	Shale, medium grey and brown with 1/2 inch thick orangish brown weathering dolomitic layers, fissile to platy.	8	1083
23	Dolomite, medium grey, uneven-grained 0.1- to 1-mm, mainly medium crystalline, in beds 1 foot to 2 feet thick, orange rough weathering surface, veinlets of coarse white dolomite.	5	1075

Unit	Lithology	Thickness (feet)	Height above base (feet)
22	Shale, dark grey-brown weathering and medium brown, locally with 1/4- to 1/2-inch thick layers of bioclastic, oolitic, limestone, shell fragments of very finely crystalline calcite and 0.2 mm oolites in part replaced by bright orange-weathering granular very finely crystalline dolomite.	12	1070
21	Dolomite, medium grey, uneven-grained, orange-weathering, in beds 1 foot to 2 feet thick with minor brown shale.	40	1058
20	Sandy dolomite, beds 1 foot to 2 feet thick, massive, brownish grey rough weathering surface.	30	1018
19	Dolomite, medium-grained, mottled weathering, medium grey and buff, minor fine-grained light bluish grey dolomite, gradational over about 5 feet with underlying dolomite.	30	988
18	Dolomite, mottled light grey medium crystalline and dark grey finely crystalline, weathers medium brownish grey and dark grey, a few vugs with coarsely crystalline white calcite.	20	958
17	Dolomite, faintly mottled light and medium grey, even-grained medium to finely crystalline, in beds 1 foot to 5 feet thick.	60	938
16	Dolomite, dark grey, medium to finely crystalline, even-grained, a few per cent clay and very fine silt.	15	878
15	Sandstone, dolomite cemented, coarse-grained, minor very fine sand, about 30 per cent medium crystalline dolomite, in beds 1 foot to 2 feet thick, weathers light buff.	8	863
14	Covered.	10	855

Unit	Lithology	Thickness (feet)	Height above base (feet)
13	Quartzite, pure white, some rusty patches near base, forms prominent cliff, massive.	12	845
12	Quartzite, siltstone and shale; rusty brown weathering quartzite in beds 2 to 3 feet thick with alternating 1- to 2-foot beds of laminated siltstone and recessive brown and grey shale.	75	833
11	Covered.	125	758
10	Quartzite, pure white, coarse grained, in beds 1 foot to 2 feet thick.	20	633
9	Covered.	20	613
8	Dolomitic limestone, oolitic, dark bluish grey, 0.5 mm oolites and matrix consist of coarsely crystalline calcite; light buff grey finely crystalline dolomite forms irregular massive mottles and locally thin films interstitial to calcite; in beds 1 foot to 2 feet thick locally banded, orangish brown weathering.	15	593
7	Shale, silty, medium brown-grey.	5	578
6	Covered.	8	573
5	Quartzite, pure white and pinkish, some limonite specks, beds 1 foot to 4 feet thick, lower part massive.	50	565
4	Quartzite, as above, in beds 1 foot thick.	15	515
3	Sandstone, dolomite cemented and sandy dolomite, white massive, coarse-grained sand and medium crystalline dolomite.	250	500
2	Dolomite, white,, medium crystalline, even-grained, buff weathering.	200	250

Unit	Lithology	Thickness (feet)	Height above base (feet)
1	Sandy dolomite, white, coarsely crystalline, about 30 per cent coarse-grained quartz, dark weathering.	50+	50
	Base not exposed.		

SECTION 5

Unit 6

Location: 3 miles east by north of Baker prospect.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 7: orange-weathering sandy dolomite.		
	Contact conformable.		
16	Sandstone, dolomite-cemented, coarse-grained, finely crystalline dolomite, some interstitial hematite, a few sub-rounded coarse grains of porphyritic volcanic rock, in beds 2 to 6 inches thick, locally purple, minor yellow-orange-weathering dolomite in beds 1 inch to 1 foot thick.	78	1096
15	Volcanic flow, dark green, upper part brecciated and amygdaloidal, centre massive; aphanitic, contains tuffaceous layers composed of several per cent medium- and coarse-grained quartz sand in a dark green chloritized matrix.	57	1018
14	Quartzite, pure white, coarse-grained, beds 2 feet thick, minor sandy dolomite in 1 foot beds.	100	961
13	Dolomite, medium brownish grey, fine to medium crystalline, uneven-grained, fine silty laminations and minor bands of coarse sand, orange weathering.	79	861

Unit	Lithology	Thickness (feet)	Height above base (feet)
12	Silty limestone, blue-grey, in 1 to 2 inch bands with minor intercalated orange-weathering dolomitic siltstone in layers 1/2 to 1 inch thick.	94	782
11	Dolomite, medium and dark grey, medium crystalline, even-grained, weathers medium brown-grey with a few buff patches.	82	688
10	Sandy dolomite, laminated beds 2 to 6 inches thick, crossbedded, orange-brown.	35	606
9	Silty limestone, as above, with intercalated dolomitic siltstone.	21	571
8	Dolomitic argillaceous siltstone and silty dolomite in beds 2 feet thick; a few 1-foot beds of maroon-grey shale.	44	550
7	Silty limestone, argillaceous, well banded, minor dolomitic siltstone.	20	506
6	Dolomite, light grey, finely crystalline, massive, buff weathering.	42	486
5	Dolomite, siltstone, argillaceous, laminated, buff weathering.	5	444
4	Quartzite, pure white, very fine grained massive, upper part light brown, silty.	73	439
3	Sandy dolomite, white, finely crystalline, lower part is dolomite cemented coarse-grained sandstone.	46	366
2	Dolomite, light grey, finely crystalline, mottled weathering buff and light grey.	20	320
1	Sandstone, dolomite cemented, and sandy dolomite; white, coarse grained, weathers light grey-buff to white, forms prominent bluff.	300+	300

Base not exposed.

SECTION 6

Unit 6

Location: 1 mile southeast of Glacier Lake.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 9.		
	Contact not exposed.		
15	Dolomite, cream to white, medium crystalline, a few sandy laminations, massive thick-bedded, weathers light grey with buff patches.	900	3650
14	Sandy dolomite, about 30 per cent coarse-grained sand, 4- to 5-foot beds, buff-grey weathering.	35	2750
13	Dolomite, medium grey, fine to medium crystalline, thin-bedded, weathers brown-grey locally brick red on some parting surfaces.	80	2715
12	Sandy dolomite and interbedded coarse-grained dolomitic sandstone in 2-to 5-foot beds, upper part more thinly bedded mainly dolomite, buff-orange weathering; minor quartzite.	140	2635
11	Sandy dolomite, light grey, fine to medium crystalline, thinly bedded and finely laminated, crossbedded locally, forms prominent cliff, light grey weathering.	200	2495
10	Dolomite, light grey, fine to medium crystalline, massive thick-bedded, light buff-grey weathering.	455	2295
9	Dolomitic sandstone, very coarse grained coarse laminations, crossbedded in part orange and light grey weathering.	40	1840

Unit	Lithology	Thickness (feet)	Height above base (feet)
8	Dolomite, medium grey fine grained, orange weathering, minor coarse-grained dolomitic sandstone.	90	1800
7	Quartzite, medium to coarse grained, upper part slightly dolomitic.	26	1710
6	Dolomite, medium grey, fine to medium crystalline, minor coarse-grained dolomitic sandstone, orange weathering.	64	1684
5	Dolomite, light grey, finely crystalline, irregular quartz nodules up to 1 inch long, mottled weathering light grey and buff.	20	1620
4	Sandy dolomite, laminated 2- to 4-foot beds, minor crossbedded dolomitic sandstone, contains a distinctive 1 foot bed of brown shale.	300	1600
3	Dolomite, dark grey finely crystalline, flaggy.	100	1300
2	Dolomite, light grey to white, medium to coarsely crystalline, massive thick-bedded, mottled weathering buff-cream and light grey, minor medium grey dolomite.	200	1200
1	Covered mainly, outcrops of dolomite as above.	1000	$\pm$1000

Underlying beds: unit 2.

SECTION 7

Unit 6

Location: 2.3 miles north of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds: unit 7.		
	Contact conformable.		
47	Sandstone, buff, dolomite cemented, minor purple, hematite cemented sandstone in 2- to 4-inch beds with purple finely laminated silty mudstone; interbedded sandy dolomite: light brownish yellow, medium and coarse crystalline uneven-grained, with finely crystalline 1/4 inch cream-yellow patches, 30 to 40 per cent medium sand, bright orange and yellow weathering; minor dolomite: silty, light brownish grey, finely crystalline, a few per cent coarse silt, massive, light buff-brown weathering.	205	2227
46	Quartzite, medium and light grey, dark greenish grey weathering.	10	2022
45	Sandstone, dolomite cemented, light tan brown and grey, medium to coarse grained, about 25 per cent dolomite, platy to thin-bedded, orange weathering, minor white coarse-grained quartzite in 3- to 4-foot beds.	70	2012
44	Silty dolomite, cream, finely crystalline, about 25 per cent coarse silt; thin bands and laminations of very fine to aphanocrystalline dolomite with minor silt; more silty in the upper part; bright orange and orange-brown weathering.	20	1942
43	Dolomitic limestone, bioclastic, silty, medium crystalline up to 25 per cent dolomite, irregularly banded and mottled		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	with finely crystalline cream-yellow dolomite, brownish orange weathering, abundant fossils, ?*Salterella* sp., *Olenellus gilberti*.	80	1922
42	Silty limestone, dolomitic, medium grey, 30 to 40 per cent coarse silt, about 10 per cent crystalline dolomite in scattered small aggregates of grains, recessive medium brown-grey weathering, silty finely crystalline dolomite.	50	1842
41	Dolomite, medium to dark grey, fine to medium crystalline, orange and reddish orange weathering, veinlets of white coarsely crystalline dolomite.	10	1792
40	Silty dolomite, dark grey, buff-orange weathering.	5	1782
39	Silty limestone, dark grey 40 per cent coarse silt, massive blue-grey weathering; irregularly interlaminated, in part crossbedded with silty dolomite: cream, finely crystalline, about 10 per cent silt, buff weathering.	10	1777
38	Silty dolomite, calcareous, medium grey, finely crystalline, several per cent interstitial calcite, 30 to 40 per cent coarse silt and very fine sand, finely laminated and crossbedded, a few fine laminations of quartz-cemented siltstone; medium orange-brown weathering.	10	1767
37	Calcareous siltstone, medium brown-grey, coarse silt and very fine sand, about 20 per cent calcite, dark grey weathering; interbanded and laminated with orange weathering dolomitic siltstone.	15	1757
36	Dolomite, flaggy, brown-orange weathering; interbedded brown siltstone.	120	1742

Unit	Lithology	Thickness (feet)	Height above base (feet)
35	Silty limestone, dark grey, finely laminated.	20	1622
34	Dolomite, mottled light grey, medium crystalline and dark grey, finely crystalline, massive, orange weathering, a few white dolomite veinlets.	65	1602
33	Silty dolomite, finely crystalline, buff-orange weathering.	55	1537
32	Dolomite, bioclastic, silicified, dark grey, very finely crystalline, bioclasts replaced by dark grey smoky quartz, massive, orange- weathering.	10	1482
31	Limestone, silty, dark grey, silty laminations, platy.	10	1472
30	Sandstone, dolomite cemented, coarse-grained, laminated.	10	1462
29	Dolomitic siltstone, platy, orange weathering.	5	1452
28	Sandstone, quartz cemented, white, coarse-grained.	10	1447
27	Siltstone, or very fine grained quartz cemented, cream to light brown, laminations and thin bands of dark grey slate.	172	1437
26	Limestone, dark grey, hematitic, olive-grey weathering.	3	1265
25	Limestone, brown, thin-bedded, brown-orange weathering, has medium grey slate chips.	5	1262
24	Limestone, dark grey, very coarsely crystalline, forms lense-shaped patches with anastomosing bands and mottles of orange-brown weathering tan-brown finely crystalline dolomite; limestone has been sheared		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	and re-crystallized; unit grades laterally into orangish brown-grey weathering massive dolomite: mottled dark grey finely crystalline and light grey medium crystalline with a few very coarsely crystalline bioclasts; white dolomite veinlets and calcite lined vugs.	55	1257
23	Quartzite, cream-white, fine to medium grained, 5- to 6-foot massive beds, cliff-forming.	37	1202
22	Silty dolomite, light grey, finely crystalline with some medium crystalline dark grey patches, up to 40 per cent calcite, in part laminated, 5- to 6-foot beds, weathers medium orange-brown to bright orange; interbedded with dolomitic siltstone and sandstone: in part quartz-cemented, medium to light tan-brown, coarse silt and very fine sand, 15 to 40 per cent cream-yellow fine and medium crystalline dolomite, about 5 per cent disseminated fine pyrite, 2- to 4-foot beds, medium orange-brown and brown-grey weathering.	75	1165
21	Silty shale, sandy, light yellowish brown, about 20 per cent coarse silt and 10 per cent medium to coarse sand.	4	1090
20	Sandstone, dolomite cemented, in part quartz cemented, light yellow, fine to very coarse grained, 20 to 25 per cent medium crystalline dolomite, massive upper part finer grained grading to siltstone.	4	1086
19	Dolomite, light grey, coarsely crystalline, even-grained, massive, light buff-orange weathering.	20	1082
18	Dolomite, sandy, white to light grey, medium crystalline, about 10 per cent medium sand, massive, buff-orange weathering;		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	interbedded in lower part with coarse-grained sandstone in 6 inch to 2 foot beds; upper part fine to medium crystalline, buff weathering.	210	1062
17	Sandstone, dolomite cemented, in part quartz cemented, white, coarse grained orangish brown weathering; interbedded in 1- to 2-foot beds with banded and coarsely laminated sandy dolomite: coarsely crystalline, up to 40 per cent medium to very coarse sand mainly in resistant 1/4 inch crude laminations.	180	852
16	Sandstone, dolomite cemented, white, coarse grained, about 40 per cent finely crystalline dolomite, 1/2 inch resistant more sandy layers, buff-orange weathering; upper part grades to medium crystalline light grey dolomite.	75	672
15	Sandstone, dolomite cemented, white, coarse to very coarse grained, a few per cent very fine pebbles, 40 to 50 per cent finely crystalline dolomite, massive dark brownish grey weathering, forms prominent cliff; upper part finer grained.	25	597
14	Sandstone, medium-grained, light grey weathering, in 2- to 5-foot beds, minor interbedded orange weathering, laminated dolomitic sandstone in 2 to 10 foot beds.	65	572
13	Intraformational breccia, sandstone fragments in orange dolomitic matrix.	2	507
12	Sandstone, medium grained, grey weathering; and orange-brown weathering laminated silty dolomite: buff-grey, finely crystalline, 25 to 30 per cent coarse silt, resistant laminations up to 1/4 inch of dark grey to black silty argillite.	10	505

Unit	Lithology	Thickness (feet)	Height above base (feet)
11	Dolomite, silty, finely crystalline, vaguely layered medium to dark grey, darker layers are finer grained, several per cent coarse silt, commonly in laminations, platy, medium orange-brown weathering.	33	495
10	Limestone, silty, dark grey, fine to very finely crystalline, some coarsely crystalline patches, 5 to 10 per cent medium silt, light buff-grey weathering; contains a few per cent of finely crystalline orange weathering dolomite in silty laminations.	40	462
9	Quartzite, fine- to medium-grained, white, massive, a few 1-foot beds of laminated orange-brown weathering dolomitic sandstone and silty medium crystalline medium to dark grey dolomite.	105	422
8	Sandstone, dolomite cemented, light grey, medium grained, 40 to 50 per cent finely crystalline white dolomite; interbedded in 2- to 6-inch beds with argillaceous dolomitic siltstone: dark grey, medium silt with irregular dark grey argillaceous laminations, platy, medium brown weathering.	15	317
7	Quartzite, fine grained, white, 1- to 5-foot beds, in part coarsely laminated, minor recessive brown-orange weathering sandy dolomite layers 2 to 6 inches thick; contains a 2-foot bed of intraformational breccia.	35	302
6	Quartzite, dolomitic, cream, medium to coarse grained about 10 per cent, dolomite, massive, white weathering.	110	267
5	Silty limestone, 1- to 2-inch calcareous siltstone bands.	2	157

Unit	Lithology	Thickness (feet)	Height above base (feet)
4	Calcareous siltstone; medium grey, brown weathering, thinly interbedded with orange buff weathering, calcareous medium-grained dolomitic sandstone.	8	155
3	Siltstone, brown weathering, interbanded blue-grey limestone.	2	147
2	Quartzite, white, medium grained, massive.	10	145
1	Silty shale, calcareous, medium grey, dark grey, argillaceous and orange-brown dolomitic laminations, weathers brown recessive; minor finely interbanded silty limestone.	135	135
	Contact conformable.		
	Underlying beds: unit 2.		

SECTION 8

Unit 6

Location: 3 miles north-northwest of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds: unit 7.		
	Contact conformable.		
35	Dolomitic sandstone, minor quartzite and sandy dolomite, thick-bedded, orange and orange-brown weathering.	300	2120
34	Argillaceous siltstone, with brown and orange weathering silty dolomite.	5	1820
33	Dolomite, sandy, dark grey, medium crystalline, even-grained, massive a few per cent sand, weathers buff-grey veinlets		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	of white calcite and dolomite; upper part is predominantly blue-grey and orangish grey weathering banded silty limestone and calcareous dolomitic siltstone.	200	1815
32	Dolomitic sandstone and sandy dolomite, finely laminated, crossbedded, orange-brown weathering.	25	1615
31	Dolomitic siltstone, quartz cemented, medium to dark grey, coarse silt and very fine sand, 10 to 25 per cent finely crystalline dolomite, laminations of silty dolomite and rarely dark grey shale, brown weathering.	10	1590
30	Shale, silty, limonitic, light yellow-brown, a few fossils composed of fine to very finely crystalline calcite; *Olenellus*.	25	1580
29	Silty limestone, argillaceous, blue-grey, platy, discontinuous light brownish grey, silty laminations.	45	1555
28	Dolomite, dark grey, medium crystalline, some irregular patches of coarse white dolomite, orange weathering, upper part vaguely mottled orange and brown-grey.	110	1510
27	Sandstone, fine-grained, dark weathering; and laminated siltstone.	10	1400
26	Sandy dolomite, orange weathering.	5	1390
25	Quartzite, white, coarse grained.	10	1385
24	Quartzite, siltstone, slate, thinly interbedded; mainly brown weathering, medium-grained quartzite with shale partings, in 2- to 6-inch beds; lesser light grey and brown siltstone and argillaceous siltstone and black slate interlaminated and banded; several thick beds of pure coarse-grained quartzite in mid-part of unit.	120	1375

Unit	Lithology	Thickness (feet)	Height above base (feet)
23	Silty argillite or mudstone, dark grey, about 20 per cent coarse silt in fine orange-brown laminations; minor fine sand in lenticular bands; medium greenish brown weathering.	10	1255
22	Volcanic rock, relics of plagioclase microlites and phenocrysts highly altered to sericite, chlorite and calcite greenish brown weathering, in beds 1 foot to 5 feet thick with orange weathering sandy dolomite, minor black slate.	95	1245
21	Limestone, dark grey, finely crystalline, weak preferred orientation, some irregular white coarsely crystalline patches, minor silt in buff weathering laminations, some pyrite.	10	1150
20	Silty dolomite, dark grey, finely crystalline, about 40 per cent medium to coarse silt, orange weathering; interbanded with argillaceous silty dolomite containing 20 to 30 per cent clay and very fine silt, buff-weathering, recessive.	10	1140
19	Quartzite, white, coarse-grained, massive, in 2- to 5-foot beds.	60	1130
18	Quartzite, cream-yellow, medium to coarse grained, minor silt, in part dolomite-cemented and orangish brown weathering, in 1- to 2-foot beds with silty dolomite: light grey buff, finely crystalline, a few white medium crystalline patches, about 40 per cent silt, weathers medium orange-brown, minor orange, weathering sandy dolomite in 2- to 4-inch bands with crosslaminations.	40	1070
17	Dolomite, pure white, medium crystalline, even-grained, massive faintly mottled weathering buffish brown and pinkish buff.	115	1030

Unit	Lithology	Thickness (feet)	Height above base (feet)
16	Dolomite, sandy, orange-buff weathering, interbanded, laminated dolomitic sandstone.	2	915
15	Intraformational breccia, fragments up to 2 feet long of dark weathering laminated dolomitic sandstone in orange dolomite matrix.	5	913
14	Dolomite, sandy, cream, coarsely crystalline, a few per cent sand, orange-buff weathering; dark weathering medium to coarse-grained dolomite cemented sandstone forms 2 inch to 1 foot beds near base and top and thick massive beds in middle part of unit.	144	908
13	Dolomitic sandstone, coarse grained dark weathering, minor orange weathering sandy dolomite in laminated 2- to 6-foot beds.	70	764
12	Dolomite, pure light grey, medium crystalline, even-grained (0.2 mm) massive, buff weathering, several 1-foot quartzite beds at base.	100	694
11	Quartzite, dolomitic, cream-white, medium to coarse grained about 10 per cent dolomite, thick massive beds, upper few feet has 2- to 4-inch dolomitic sandstone layers.	33	594
10	Quartzite, silty dolomite and dolomite-cemented sandstone; mostly thinly bedded quartzite: dolomitic, cream, fine grained about 15 per cent medium crystalline dolomite, grey-brown weathering; lesser silty dolomite: argillaceous, dark buff-grey, finely crystalline, 20 to 30 per cent silt, laminations of dolomitic siltstone, medium brown weathering; minor interbedded quartzite and orange-brown weathering dolomite-cemented sandstone in 6 inch to 1 foot beds, commonly crossbedded.	73	561

Unit	Lithology	Thickness (feet)	Height above base (feet)
9	Dolomite, light grey, medium crystalline, orange weathering.	15	488
8	Limestone, dolomitic, dark bluish grey, finely crystalline, about 10 per cent finely crystalline dolomite in buff-brown laminations with minor silt.	25	473
7	Silty dolomite, medium grey, finely crystalline, orange weathering.	10	448
6	Limestone, dolomitic, dark grey, finely crystalline, buff dolomitic and silty laminations; interbedded with orange weathering dolomite.	15	438
5	Silty dolomite, orange weathering, in 1 foot beds with bands and laminations of quartzite: cream yellow, mainly coarse sand with light yellow quartz-cemented matrix of silt and very fine sand.	10	423
4	Quartzite, light grey, fine to medium-grained, thick massive beds, light brown weathering.	69	413
3	Intraformational breccia, fragments of fine-grained quartzite up to 2 inches long in matrix of orange weathering dolomite with scattered coarse-grained sand.	4	344
2	Quartzite, light grey, fine grained, in part dolomitic, thick massive beds, light brown weathering; minor dolomite-cemented sandstone: fine grained, banded and laminated, commonly crossbedded, orange weathering.	140	340
1	Covered.	200	200

Underlying beds: unit 2.

SECTION 9

Unit 6

(Metamorphosed)

Location: 3 miles northeast of Canada Tungsten mine.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds: unit 9.		
	Contact unconformable.		
33	Argillite, light and dark grey, laminated, weathers dark rusty brown.	7	2061
32	Dolomite, medium grey, finely crystalline, even-grained, in 2- to 5-foot thick beds, light grey to light buff grey weathering; minor buff-weathering, light grey very finely crystalline dolomite with a few patches of sparry 0.5 mm calcite and a few per cent fine-to medium-grained sand, light buff weathering; in lower part several beds contain 30 to 40 per cent dark weathering tremolite, typically in flat blade-like plates up to 1 inch long, commonly with a few per cent associated calcite; a few beds have finer grained tremolite almost to top of unit.	760	2054
31	Dolomite, orangish buff weathering; minor dolomitic sandstone in alternating recessive and resistant beds 2- to 4-inches thick.	50	1294
30	Dolomitic diopside hornfels, white; diopside forms groundmass of 1/60 mm to cryptocrystalline equant grains, about 15 per cent dolomite in scattered 0.2 mm spots, several per cent interstitial coarsely crystalline calcite and associated tremolite in needles up to 1/10 mm long, minor medium-grained quartz sand; lower part of unit is tremolite hornfels: light grey, very fine to cryptograined		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	groundmass with numerous needles up to 0.3 mm long, about 10 per cent interstitial calcite and minor very fine diopside in 2- to 4-foot beds with tremolitic dolomite: cream, finely crystalline, massive, 20 to 25 per cent massive tremolite in vague scattered 0.5 to 1 mm spots, light buff weathering.	270	1244
29	Diopside hornfels, cream-white, 25 to 30 per cent medium to coarse-grained quartz sand in groundmass of diopside in 0.1 to 2 mm grains.	30	974
28	Tremolite dolomite, white finely crystalline, massive, about 30 per cent tremolite in clots from sand size to 1/2 inch diameter with several per cent interstitial coarsely crystalline calcite, a few scattered diopside grains 1/60 mm diameter, in beds 8 to 10 inches thick, rough medium grey weathering surface; minor cream-white diopside hornfels with tremolite, calcite and quartz sand; minor cream-yellow dolomite with several per cent tremolite and fine diopside and medium grey dolomite with tremolite only; upper part has considerable sand in irregular light and dark grey laminations and bands 1/2 inch to 3 inches thick, more thinly bedded.	180	944
27	Sandstone, white, medium to coarse grained, dolomite cement with minor fine tremolite.	10	764
26	Dolomite, light grey, medium grey and brownish grey, interbedded in 1- to 2-foot beds, finely crystalline, even-grained; a few per cent (locally up to 30 per cent) tremolite as scattered sand-sized clots in larger patches containing minor diopside and as thin films with fine diopside in fractures and bounding argillaceous laminations; locally has		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	sandy laminations and bands up to 1/2 inch thick; buff to light tan rough weathering surface; minor fine to very finely crystalline dolomite, minor 2- to 6-foot beds of orangish weathering sandy dolomite and near base 2-foot beds of dolomite cemented coarse-grained sandstone.	110	754
25	Quartzite, pure white, medium to coarse grained, in beds 1 foot to 3 feet thick, upper part has sandy dolomite bands a few inches thick.	25	644
24	Dolomite, buff weathering, beds 2 to 5 feet thick, interbedded greenish grey weathering dolomite with minor sandy laminations up to 1/4 inch thick.	25	619
23	Quartzite, dolomite cemented, medium grained.	37	594
22	Dolomite, cream, finely crystalline, even-grained, a few laminations and clots of tremolite, in beds 2 to 5 feet thick with medium-grained dolomite cemented quartzite; minor micro- to cryptocrystalline diopside hornfels with several tremolite and interstitial calcite.	20	557
21	Sandstone, light grey, medium to coarse-grained, about 50 per cent quartz in matrix of granular 0.3 mm diopside and minor tremolite with medium crystalline calcite; a few scattered 0.1 mm grains of sphene; in 2- to 5-foot beds with minor 1/4- to 4-inch layers of orange weathering sandy dolomite; a few veinlets of quartz, feathery serpentine and calcite.	30	537
20	Dolomite, light and dark grey, several per cent tremolite in needles and laths up to 1 inch long, in beds 5 to 10 feet thick.	80	507

Unit	Lithology	Thickness (feet)	Height above base (feet)
19	Dolomite, light grey to white, medium crystalline, even-grained, a few per cent fine sand, massive, buff-orange weathering.	10	427
18	Dolomite, tremolitic, medium crystalline, upper part light grey weathering.	12	417
17	Tremolite hornfels, light grey, intergrown tremolite needles about 0.1 mm long with 15 per cent interstitial calcite, appears to contain Archeocyathus, buff to grey rough weathering surface, a few 2 to 4 inch thick bands of crosslaminated sandy, dolomitic, tremolite diopside hornfels.	5	405
16	Diopside hornfels, white, 1/20 mm grains, a few up to 1 mm, minor tremolite in coarser crystals with interstitial calcite.	10	400
15	Dolomite, tremolitic, dark grey, fine-grained, rough weathering surface.	10	390
14	Argillite, hornfelsed, laminated and thinly banded light brown and grey; in thin section mainly sericite with minor recrystallized silt.	7	380
13	Dolomite, dark grey, finely crystalline, about 10 per cent tremolite as dark grey laths up to 1/2 inch long, minor 1 inch thick bands of silty marble: dark grey, finely crystalline, about 15 per cent tremolite, minor siltstone in coarse laminations.	45	373
12	Dolomite, medium grey, medium crystalline, even-grained, flaggy, vaguely laminated, a few per cent tremolite light tan-grey weathering.	44	328
11	Sandstone, medium to coarse grained, about 40 to 50 per cent quartz in matrix of colourless tremolite (0.2 mm long) and diopside (0.05 mm) with a few per		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	cent interstitial calcite; minor interbedded medium grey dolomite; basal part mainly sandstone: light brown, medium to coarse grained, minor very fine sand with some silica cement, light grey to white weathering.	22	284
10	Sandstone, coarse grained, matrix of tremolite, diopside and calcite.	2	262
9	Quartzite, irregular 1- to 2-inch layers of tremolite diopside and minor dolomite.	5	260
8	Quartzite, white, very fine grained.	2	255
7	Limestone, silty, argillaceous, dark grey, recessive.	10	253
6	Dolomite, light grey to white, coarsely crystalline, some medium crystalline irregular patches, minor scattered very coarse crystals, buff to buff-orange weathering.	130	243
5	Dolomite, pure white, sugary, medium crystalline, even-grained, massive.	5	113
4	Argillite, hornfelsed, dark grey, well laminated, pyrite bearing, rusty brown weathering; pinches out a short distance along strike.	10	108
3	Dolomite, calcareous, tremolitic, medium grey, medium crystalline, about 10 per cent each of tremolite in 1-2 mm clots of radiating needles and coarsely crystalline calcite, thin bedded, vaguely laminated, mottled-weathering pink-buff and light buff.	83	98
2	Diopside hornfels, tremolitic, white, mainly 0.5 mm colourless equant diopside with some coarser tremolite laths, very minor 0.2 mm interstitial calcite and a few 1 mm grains of potash feldspar.	11	15

Unit	Lithology	Thickness (feet)	Height above base (feet)
1	Diopsidic marble, sandy, medium brown-grey, coarsely crystalline with some medium crystalline patches, about 15 per cent medium to coarse sand, 30 to 35 per cent 0.1-0.2 mm granular diopside in irregular shaped clusters around the quartz grains, minor tremolite in 2-inch to 1-foot beds, light buffish grey weathering; upper part is dark grey, very fine to medium crystalline marble with several per cent tremolite and fine (1/60 mm) diopside, has discontinuous 1/8 to 1/4 inch layers (pull-aparts) of dark laminated argillaceous siltstone and silty argillite.	4	4
	Contact conformable.		
	Underlying beds - unit 2: 'swiss-cheese' limestone altered to a light green and purplish brown banded calc-silicate rock.		

SECTION 10

Unit 6

Location: 5.9 miles east by north of Canada Tungsten mine.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds: unit 7.		
	Contact conformable.		
14	Dolomite, distinctive pinkish buff weathering in 1-foot beds.	40	731
13	Dolomite, buff weathering in 1-foot beds with minor interbanded dolomitic sandstone.	15	691

Unit	Lithology	Thickness (feet)	Height above base (feet)
12	Sandy dolomite, 2- to 6-inch beds commonly crossbedded.	30	676
11	Dolomite limestone, bioclastic, argillaceous, silty, dark blue-grey with buff-brown dolomite patches, 15 to 20 per cent medium crystalline dolomite as individual scattered grains and irregular patches after bioclasts and as replacement veinlets, medium brown-grey weathering, flaggy, interbedded with calcareous brown shale.	85	646
10	Dolomite, dark grey, medium crystalline even-grained, massive 2- to 3-foot beds, upper part becomes flaggy, buff dark grey weathering.	150	561
9	Quartzite, and sandstone, in part dolomitic, light brown weathering, contains a 5-foot bed of pure white quartzite near top.	33	411
8	Sandy siltstone, medium brown and greenish brown, 15 to 20 per cent medium to coarse silt, dark brown weathering, minor thinly interbedded silty dolomite: oolitic, dark grey, finely crystalline, 30 to 40 per cent coarse silt, minor clay, a few per cent medium-grained sand, oolites average 0.5 mm, are generally confined to vague more argillaceous laminations, orange-brown weathering.	35	378
7	Quartzite, pure white, medium grained, lower 5 feet gradational with underlying beds.	23	343
6	Quartzite, white medium grained, thinly interbanded and laminated with grey quartz-cemented coarse-grained siltstone and minor dark grey silty shale, in upper part siltstone is limonitic and orangish brown weathering.	180	320

Unit	Lithology	Thickness (feet)	Height above base (feet)
5	Dolomite, brownish olive-grey, medium crystalline, some hematitic streaks and laminations, massive, medium orangish brown weathering.	15	140
4	Dolomitic silty limestone, oolitic, limonitic, medium yellow-brown; 0.3 mm oolites in matrix of dark grey medium crystalline limestone and in part coarse silt; thinly banded and laminated, light brownish yellow weathering; lower part is mainly orange weathering, flaggy, medium grey dolomite, with thin bands and laminations of dark brown weathering dark grey dolomitic silty shale.	35	125
3	Shale, silty, brown, contains a 1 foot bed of orange weathering sandy dolomite.	10	90
2	Sandstone, dolomite-cemented, mainly coarse-grained in part fine to very fine grained; minor coarse-grained brown quartzite.	65	80
1	Silty dolomite, cream light grey, finely crystalline, light tan-brown weathering; minor interbedded flaggy brown dolomitic siltstone.	15	15
	Base not exposed.		

SECTION 11

Unit 6

Location: 4.5 miles east-northeast of Canada Tungsten mine.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 7: orange weathering sandy dolomite and dolomitic sandstone.		
	Contact conformable.		

Unit	Lithology	Thickness (feet)	Height above base (feet)
14	Dolomite, light grey, finely crystalline, massive, light buffish grey weathering, cliff forming.	50	965
13	Sandy dolomite, 1/2- to 2-inch bands, flaggy.	15	915
12	Sandy dolomite, medium grey, finely crystalline, massive thick beds, medium grey weathering.	20	900
11	Silty dolomite, laminated 6-inch to 1-foot beds, orange and light buff weathering.	15	880
10	Limestone, silty, argillaceous, dark grey, 2-inch to 1-foot beds: lower part massive; upper part has irregular undulating silty bands; alternates in top few feet with sandy dolomite.	35	865
9	Dolomite dark grey, finely crystalline, 1- to 2-foot beds in part flaggy, upper part silty, brown-grey weathering.	35	830
8	Dolomite, dark grey fine-grained and white medium grained in 5- to 10-foot beds, white dolomite weathers pinky buff.	75	795
7	Quartzite, 1- to 5-foot beds, brown weathering; a pure white quartzite bed in centre; minor brown siltstone; upper few feet is orangish weathering sandy dolomite.	50	720
6	Covered.	15	670
5	Quartzite, white coarse grained, massive 5-foot beds.	20	655
4	Quartzite, impure, medium grained; minor bands of sandy medium grey siltstone, rusty-brown weathering.	10	635

Unit	Lithology	Thickness (feet)	Height above base (feet)
3	Argillaceous limestone, dark grey, flaggy.	25	625
2	Sandy dolomite, white coarsely crystalline, uneven-grained about 10 to 15 per cent medium to coarse sand, massive; minor dolomitic sandstone.	300-	600
1	Covered, mainly, outcrops of dolomite as above.	300	300
	Underlying beds - unit 2.		

SECTION 12

Unit 7

Location: 2.3 miles north by east of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 8: medium and dark grey dolomite.		
	Contact conformable.		
2	Dolomite, silty, dark grey, medium brown-grey and medium brown, finely crystalline, several per cent coarse silt, a few laminations of very fine to coarse sand, thin-bedded, brown-orange to orange weathering; in part thinly banded with resistant fine-grained quartzite and dolomite cemented sandstone, minor bright orange weathering finely crystalline dolomite with a few per cent scattered medium to coarse sand.	125	140
1	Dolomite, light buff-yellow, finely crystalline even-grained, weathers orange recessive, irregular laminations and bands up to 1 inch of dark brown-grey weathering		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	resistant dolomitic coarse-grained siltstone and very fine sandstone.	15	15
	Contact conformable.		
	Underlying beds - unit 6.		

SECTION 13

Unit 8

Location: 2.5 miles north of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Overlying beds - unit 9.		
	Contact covered.		
11	Covered: upper part scattered outcrop of dolomite; light grey, finely crystalline, massive about 5 per cent coarse silt, light pinkish to buff-grey weathering; minor sandy dolomite and tan grey weathering fine-grained dolomitic quartzite.	150	1110
10	Shale, black and brown, minor interbedded silty dolomite and dolomitic sandstone.	50	960
9	Dolomite, medium grey, finely crystalline, well laminated medium and light grey; several 1 foot beds of massive light grey and medium to dark grey dolomite, bright cream to buff-yellow weathering; minor pinkish buff weathering medium crystalline light grey dolomite.	100	910
8	Dolomite, silty, buff, very finely crystalline in 5- to 7-foot beds with interbanded buff silty dolomite, brown-orange weathering sandy dolomite and coarse-grained		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	dolomitic sandstone; minor medium-grained quartzite in beds up to 5 feet.	70	810
7	Dolomite and sandy dolomite, light grey finely crystalline in 1- to 2-foot beds, laminations with 5 to 25 per cent very fine to medium-grained sand, light buff-grey weathering; minor bands of dolomitic sandstone.	220	740
6	Dolomite, light greenish grey, medium crystalline, 1- to 2-foot beds, light buff weathering.	15	520
5	Dolomite, light bluish grey, finely crystalline, buff weathering, lower part sandy.	15	505
4	Sandy dolomite, light grey and light brownish grey, finely crystalline even-grained, coarse laminations with up to 25 per cent silt and fine sand, a few per cent randomly scattered medium and coarse sand, flaggy to thin-bedded, light buff weathering, in part orange; a few 1- to 2-inch bands of dark brown weathering dolomitic sandstone.	75	490
3	Dolomite, light grey, medium crystalline, massive, 1- to 2-foot beds, irregular quartz nodules, light buff weathering.	115	415
2	Sandy dolomite, medium grey, medium crystalline, about 20 per cent fine and medium-grained dark grey smoky quartz sand, orange and dark brown weathering, intercalated in 1/4- to 1/2-inch layers with resistant laminated dolomitic fine-grained sandstone: 40 to 50 per cent finely crystalline dolomite; minor light buff-grey sandy dolomite: finely crystalline, 20 to 25 per cent very fine sand, orange weathering.	200	300

Unit	Lithology	Thickness (feet)	Height above base (feet)
1	Sandy dolomite, light brown-grey, medium crystalline 15 to 20 per cent fine sand, light buff-orange weathering; thinly interbedded with dolomitic siltstone: argillaceous medium brown, medium-grained quartz-cemented about 15 to 20 per cent orange-yellow dolomite, minor limonite.	100	100
	Contact conformable.		
	Underlying beds - unit 7: silty dolomite.		

SECTION 14

Unit 9

Location: 4.7 miles southwest of M.B. prospect.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Middle part of unit.		
	Top not exposed.		
10	Calcareous siltstone, brown-grey, recessive and interbedded light grey weathering limestone in 1- to 3-foot beds.	300+	2495+
9	Silty limestone, argillaceous, interbanded calcareous siltstone in undulating layers 1/4- to 1/2-inch thick, light grey and light brownish grey weathering.	275	2195
8	Dolomite siltstone, orange weathering, forms irregular undulating and anastomosing bands with recessive blue-grey limestone in discontinuous layers and lenses about 1/2 inch thick.	205	1920
7	Siltstone, dark brown-grey, thinly interbanded with light grey weathering limestone; several 3-foot-thick limestone		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	beds; near top contains a 10-foot bed of dark grey recessive calcareous shale and siltstone.	120	1715
6	Limestone, medium grey, finely crystalline, light grey weathering, minor calcareous siltstone, beds up to 10 feet thick.	500	1595
5	Limestone, argillaceous, medium grey, finely crystalline irregular wavy layers 1 inch to 2 inches thick of light brownish grey weathering calcareous siltstone.	155	1095
4	Siltstone, calcareous, finely laminated, brownish grey weathering, interbanded minor limestone.	15	940
3	Limestone and silty limestone, uniformly intercalated in layers 1 inch to 2 inches thick.	25	925
2	Silty limestone and calcareous siltstone; siltstone forms irregular wavy and anastomosing bands; numerous beds several feet thick of light grey weathering finely crystalline medium grey limestone.	440+	900
1	Siltstone, calcareous, dark brown-grey, fine to medium grained, several per cent 1/50 mm cream dolomite, thin bands and laminations of coarse silt with 20 to 25 per cent 1/25 mm dolomite, buff to light weathering grey; minor limestone: light to medium grey, very finely crystalline, 10 to 15 per cent coarse silt, forms uneven bands less than 1 inch thick, veinlets of coarsely crystalline white dolomite; several prominent ribs of limestone, 1 foot to 2 feet thick.	460	460

Base not exposed.

SECTION 15

Unit 9

Location: 4.2 miles west-southwest of M.B. prospect.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Top not exposed.		
3	Silty limestone, silty dolomite and dolomitic siltstone, thinly intercalated; limestone is medium grey, very finely crystalline, has about 25 to 30 per cent coarse silt and a few per cent dolomite, light blue-grey-weathering; silty dolomite is dark brownish grey, finely crystalline, with about 40 per cent coarse silt, slightly calcareous, forms corrugated anastomosing 1/4- to 2-inch layers, light grey-brown to buff-orange weathering; in 5- to 20-foot beds alternating with 1- to 2-foot beds of medium grey finely crystalline limestone; from 1900 to 2200 mainly brownish orange weathering dolomitic siltstone and silty dolomite.	2535	4260
2	Dolomitic siltstone and silty limestone, as below but with greater proportion of buff weathering dolomitic siltstone, thinner bedded and with distinct 2- to 4-foot beds of light grey weathering finely crystalline limestone.	525	1625
1	Silty limestone and dolomitic siltstone, thinly intercalated; limestone forms discontinuous 1/4-to 1-inch layers in corrugated anastomosing 1- to 2-inch layers of dolomitic siltstone; in 15- to 25-foot beds of varying overall composition; limestone is medium grey, very finely crystalline, has a few per cent silt, light blue-grey-weathering; dolomitic siltstone is dark brownish grey, coarse grained, has about 25 per cent finely crystalline		

Unit	Lithology	Thickness (feet)	Height above base (feet)
	cream dolomite as rhombic grains randomly distributed and in faint laminations, buff weathering.	1100	1100
	Base not exposed.		

SECTION 16

Unit 9

Location: 2.7 miles north by east of Pyramid Mountain.

Unit	Lithology	Thickness (feet)	Height above base (feet)
	Basal part of unit.		
3	Silty limestone, medium grey, very finely crystalline, some coarsely crystalline bioclasts, 10 to 40 per cent fine silt, a few per cent dolomite as scattered euhedra in matrix and bioclasts, buff to light grey weathering; thin, waxy and anastomasing bands of argillaceous siltstone: calcareous, medium brownish grey, fine grained, about 10 per cent medium silt, a few per cent dolomite, minor pyrite, massive, light grey weathering.	450+	650+
2	Silty limestone, as above, with two 10- to 15-foot beds of silty dolomite; medium to dark grey, fine to very finely crystalline, massive, bright orange weathering.	50	200
1	Covered.	150	150
	Contact not exposed.		
	Underlying beds - unit 8.		