Greenwood
883705

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GEOLOGICAL FIELD TOUR - GREENWOOD AREA
NOVEMBER 3, 1987 - JIM FYLES

The attached notes are taken from my private report to Kettle River Resources and Noranda Exploration, dated December 1986. They outline the principles of the regional geology of the Greenwood area forming an introduction to the mineral deposits.

It is hoped that the weather conditions at the time of the field trip will permit us to see typical parts of the stratigraphy and structure and one of the skarn deposits. Possible routes and field stops are given at the end of the notes.

NOTES ON THE GREENWOOD GEOLOGICAL MAP 1986

INTRODUCTION

SEE P9

This map clarifies the distribution of the rock units defined by previous workers, particularly H.W. Little (1983) and B.N. Church (1985). The general geology is clearly described by Little (p. 4-6) and the current work has produced only a few significant changes. The map symbols describing the units follow those used by Little with a few modifications. His description of the general geology is as follows:

> "Metamorphic, sedimentary, and intrusive and extrusive igneous rock units, ranging in age from possible late Proterozoic to Middle Eocene are summarized in the Table of Formations. They can be grouped into seven assemblages, separated by intervals of deformation and/or regional metamorphism. The oldest (?) of these is the granitoid gneiss unit Pml of which part may represent the widespread late Proterozoic-early Paleozoic succession of southeastern British Columbia, but some of these gneissic rocks may be as late as Permian, metamorphosed by granitic intrusions of Jura-Cretaceous age.
>
> The relationship of the granitoid gneisses to the amphibolite unit Pa and the schist unit Pm is not known. These units differ lithologically and are in general more highly metamorphosed than the Attwood Formation and Knob Hill Group. The metamorphism and deformation of map units Pa and Pm is believed to predate the Attwood and Knob Hill; it is, however, possible that units Pa and Pm, though more highly metamorphosed, are different facies of the Knob Hill Group.
>
> The second assemblage comprises the Attwood Formation and the Knob Hill Group, both of which have yielded fossils of Carboniferous or Permian age. It may contain a disrupted ophiolite suite with which some or all of the ultramafic rocks may be associated. This assemblage was deformed and apparently eroded before deposition of Early Mesozoic rocks.
>
> The third assemblage, the Brooklyn Formation, rests unconformably upon the Knob Hill Group. The lower part consists of the sharpstone and Rawhide members, of Middle and possibly Lower, Triassic age. The underlying unconformity is widespread in the Western Cordillera.
>
> The fourth assemblage, map-unit uTsv, is limited in extent and includes limestone, shale, and some pyroclastic rocks of Upper Triassic age. It is believed to overlie unconformably the Brooklyn Formation.
>
> The fifth assemblage, the volcanic map unit Jv, is correlated lithologically with the Jurassic Rossland Group to the east. It rests upon other units ranging from pre-Permo-Carboniferous (?) to Upper Triassic.

All these assemblages were affected by the widespread Jura-Cretaceous orogeny during which ultramafic, and Nelson and Valhalla intrusions were emplaced. It is possible that the ultramafic bodies were empleced by a process of cold intrusion.

The sixth assemblage clearly rests unconformably upon Mesozoic and older formations. It consists of the basal Kettle River and the Marron formations of Middle Eocene age. Contemporaneous intrusions include numerous small bodies of syenitic to dioritic composition and plutonic bodies of the Coryell.

The youngest assemblage is of limited extent within the map area. It is an epiclastic breccia (recently defined in the literature as an "olistostrome") resulting from a landslide, it rests upon the Marron Formation and is also of Middle Eocene age."

New data a. observations respecting t. s general geology are the following:

1) Structural studies of the schist unit, Pm, within the present map area confirm Little's observations that these rocks are more highly deformed than the Knob Hill and Attwood assemblages. Rocks of the schist unit have more than one cleavage and an insipient pervasive lineation, structures which are not found in the other assemblages. The Knob Hill Group and Attwood Formations are everywhere in fault contact with the schist unit except on the West Kootenay powerline 3 Km south east of Greenwood, in an area of poor outcrops where the contact is either a fault or an unconformity. Pm is intruded by serpentinite and more significantly by the old diorite which has recently been dated, and probably is Permian.

2) Little's map unit Pa is described by Church (1985 a, 1985 b) as old diorite or the old diorite complex and this terminology is used in these notes and on the map. These rocks, which form bold bluffs and open outcrops, are spectacular, coarse grained diorites crisscrossed by white discontinuous veinlets of feldspar, calcite and epidote. They grade into medium and finegrained varieties of the same rock and into crackled calcareous greenstone. They form an easterly trending belt, associated with serpentinite, extending from west of Boundary Creek near the Skomac Mine to Hardy Mountain.

Old diorite, with or without serpentinite is found at only a few places away from this belt. A cobble of old diorite is reported by Church (1985) in middle Triassic conglomerate of the Brooklyn Formation. A recent (August 1986) potassium argon date on a sample of drill core of old diorite from the Winnepeg Mine gave dates ranging from 214 ± 1 to 258 ± 10 Ma.

The main belt of serpentinite and old diorite dips to the north above the Lind Creek fault and beneath rocks of the Knob Hill Group with which the relationships are conflicting - old diorite intrudes and apparently also grades into greenstone of the Knob Hill. Old diorite forms very irregular masses within and adjacent to the lower part of the Knob Hill group which is a mixed group of volcanic and sedimentary rocks.

3) The Knob Hill group which occurs only north of the Lind Creek fault consists of a complicated group of grey, buff, and white chert, calcareous greenstone (some of which shows pillow structures), cherty siltstone, grey to black argillite, chert breccia, conglomerate, greenstone conglomerate, and minor limestone. This mixed succession passes upward into a less varied succession of greenstone and chert with minor pyroclastics and limestone extending as far north as Jewel Lake. This whole group dips at low to moderate angles to the north and northeast. Probably it contains several disconformities and has a total estimated thickness of more than 5 km. The only fossils reported from the Knob Hill are from the lowest

part within 200 meters of a tongue of old diorite and greenstone (Little P.12 F7 locality). They are described as carboniferous or Permian. It is suggested here that the old diorite and serpentinite are the subcrust forming the base of the Knob Hill succession. Old diorite intrudes only the lower parts of the Knob Hill group and the older (?) schist unit whereas serpentinite intruded these two units extensively forming sill-like sheets in the schist units. These older serpentinite intrusions were periodically remobilized during deformation as late as the Tertiary in the form of "cold intrusions" as referred to by Little or merely as ductile zones followed by or spread out along faults.

4) The stratigraphic and tectonic relationships between the Knob Hill group and the Attwood formation are still not known. The Attwood formation of grey siltstone, cherty siltstone, greywacke, chert pebble conglomerate with lenses of limestone and minor andesitic volcanics has provided several fossil collections which give a Permian and/or Mississipian age. The Attwood formation overlies probably unconformably the schist unit (Pm) at the head of McCarren Creek and eastward to the head of May Creek in an area of poor outcrops. In the same area and on the west and southwest slopes of Hardy Mountain it is unconformably overlain by the Brooklyn formation. The Knob Hill group and the Attwood formation occur in different fault slices and so far no place has been found at which the normal stratigraphic relationship can be seen. The internal stratigraphy of the Attwood formation has not been worked out.

5) The Brooklyn formation unconformably overlies all the older assemblages. The formation has three main lithological components; chert breccia - the sharpstone conglomerate of Seraphim (1956), limestone, and intrusive and extrusive microdiorite and greenstone. All the components are highly lenticular and change rapidly through lateral and vertical transition zones containing sandstone, siltstone, calcareous sandstone siltstone and conglomerate and various volcaniclastic rocks. The main components are referred to as members, some of which have been named in the past (Brooklyn, Stemwinder, Bluebell, and BC limestones. Rawhide shale, Providence Lake microdiorite, Eholt formation, etc.) The main lithologies are repeated at several levels throughout the Brooklyn succession. Diagrammatic stratigraphic columns based on mapping at scales of 1:12,000 and greater, and representing the rock types and their relationships within a small area are given in the following tables.

STRUCTUAL FRAMEWORK

INTRODUCTION

The regional distribution of the rock units in the Greenwood area is controlled by faults. The pre-Tertiary rocks are on the northern flank of a pre-Cambian gneiss complex exposed in northern Washington and in the Grand Forks area to the east. They are contained in a series of north dipping, discontinuous fault slices which, for discripture purposes, I have numbered upward from 3 along the International Border (anticipating that a couple more may be found south of the border) to 7 in the Greenwood-Phoenix- Eholt part of the area. The bounding faults, many of which follow or are followed by serpentinite are probably pre-Tertiary in origin but are highly modified and form an integral part of the Tertiary extensional fault regime.

Tertiary stratiform rocks in the Greenwood area are contained in fault bounded blocks which form the northern extensions of the Toroda Creek and Republic grabens identified in northern Washington. The Tertiary strata dip in general to the east. The pattern of the bounding faults, though complex in detail, consists of low east dipping faults offset by low west and north dipping faults both of which are offset by steeply dipping faults trending 020 degrees to 035 degrees which form the graben structures mapped by previous workers. Map patterns of the Tertiary rocks are complicated by irregular intrusions only the largest of which are shown on the map.

Identification of faults and the major fault slices has been one of the main components of this field review. Some of the faults have already been named by Little and by Church. In this review faults have been identified "on the ground " by tracing contacts, identifying fault features, mapping major sheets of serpentinite and searching for pods of serpentinite along fault contacts, and by mapping geology on both sides of contacts to determine transgression. Faults shown on previous maps have been evaluated on the ground, and although it is difficult to prove that a feature is not a fault, many have been dropped from the present map. The faults shown are well documented but it is certain that many more exist which have not been identified.

The following descriptions are based on data collected between 1982 and 1986 and extrapolations beyond using the maps of Little and Preto (1970). To completely document the structure requires more data long the Granby River valley in the valley of May Creek and along the International border in the vicinity of Mt. McLaren and to the northwest of Greenwood.

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GREENWOOD AGE TABLE

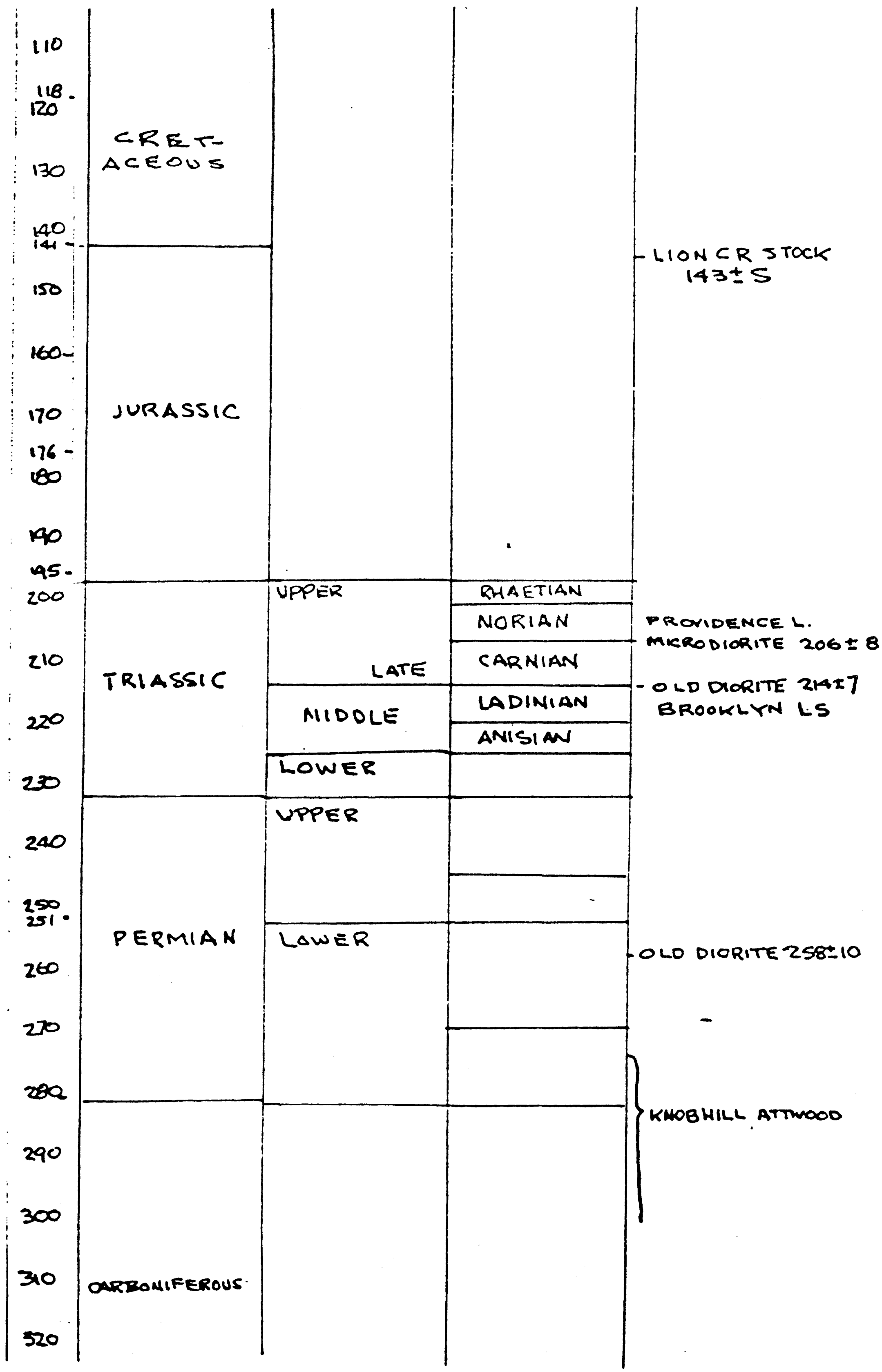

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TABLE OF FORMATIONS

ERA	PERIOD OR EPOCH	GROUP OR FORMATION	MAP UNIT SYMBOL	LITHOLOGY	THICKNESS (metres)
CENOZOIC	PLEISTOCENE AND RECENT			Till, sand, gravel, silt	
	EOCENE Middle	Klondike Mountain Formation	Ekm	Heterogeneous epiclastic breccia of pre-Permian to Middle Eocene rocks	900+
		NON-EROSIONAL UNCONFORMITY WITH MARRON FORMATION			
		Coryell Intrusions	Ec	Syenite, quartz monzonite; minor granite and pulaskite	
		Intrusive equivalents of Marron Formation	Emi	Alkaline syenite, syenite, diorite, and diorite porphyry	
		INTRUSIVE CONTACT			
		Marron Formation	Emv	Soda trachyte, andesite, trachyandesite; minor phonolite and tuff	1525±
		Kettle River Formation	Ekrs	Feldspathic volcanic sandstone, lithic volcanic sandstone, shale, conglomerate	90 to 1200
		UNCONFORMITY			
MESOZOIC	CRETACEOUS OR TERTIARY	Map-unit KTi	KTi	Quartz-feldspar porphyry, quartz porphyry, felsite	
		RELATIONSHIP UNKNOWN			
	CRETACEOUS (?)	Valhalla Intrusions	Kvqm	Granite and quartz monzonite, mainly porphyritic; some pegmatite	
		INTRUSIVE CONTACT			
	JURASSIC AND/OR CRETACEOUS	Nelson Intrusions	JKgd	Granodiorite; minor quartz diorite and diorite	
		INTRUSIVE CONTACT (?)			
	JURASSIC (?)	Ultramafic Intrusions	Jum	Peridotite, pyroxenite, dunite, serpentinite	
		INTRUSIVE CONTACT WITH MAP UNIT Jv (?)			
		Map-unit Js	Js	Siltstone; minor phyllite, sandstone, and conglomerate	300−
		Map-unit Jph	Jph	Black phyllite	500−
		Map-unit Jv	Jv	Flow breccia and massive greenstone; basal (?) conglomerate with limestone clasts; flow breccia with minor interbedded limestone	330+
		UNCONFORMITY			
	TRIASSIC Upper	Map-unit uTsv	uTsv	White limestone, black limestone, grey, black, and buff shale, limestone breccia, purple to maroon agglomerate, minor green cherty argillite	330+
		UNCONFORMITY			
	Middle	Brooklyn Formation	mTl	Limestone, containing some chert grains, skarn; minor chert and sharpstone conglomerate, siltstone, and shale	660
	Middle and (?) Lower	Brooklyn Formation	mTs	Sharpstone conglomerate with mainly chert clasts; local chert sandstone; minor black argillite and green argillite	760
		INTERBEDDED WITH RAWHIDE FORMATION; UNCONFORMABLE WITH KNOB HILL GROUP			
	Middle	Rawhide Formation	mTr	Black siltstone; minor black argillite and chert sharpstone conglomerate	120−
PALEOZOIC	CARBONIFEROUS OR PERMIAN	Knob Hill Group	CPkh	Massive chert, greenstone, and amphibolite; minor limestone or marble; locally tan or black argillite, fine grained quartzite, conglomerate	?
		Attwood Formation	CPa	Black to grey bedded argillite; locally some grey chert and cherty siltstone; minor chert sharpstone conglomerate; limestone, with some thin chert interbeds	1000+
		UNCONFORMITY (?)			
	PRE-CARBONIFEROUS (?)	Map-unit Pm	Pm	Quartz-chlorite schist, quartz-biotite-muscovite schist, greenstone, bedded chert with argillaceous partings; minor limestone or marble	?
		RELATIONSHIPS UNKNOWN			
		Map-unit Pa	Pa	Amphibolite; minor greenstone, and bedded chert	?
		RELATIONSHIPS UNKNOWN			
PRECAMBRIAN		Map-unit Pm	Pm	Paragneiss, migmatite; some amphibolite with pegmatite or aplite	?

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FIELD TRIP ROUTE WEST FROM GRAND FORKS

STOP 1 HARDY MOUNTAIN AND RESERVOIR ROADS

Views to the north show the trace of the Granby River fault and part of the Eagle Mountain fault.

STOP 2 NEAR SPENCER ON HIGHWAY 3

From south to north rock cuts expose:

(a) flaggy grey limestone from which Ladinian chonodonts have been identified - Brooklyn limestone.

(b) Fragmental greenstones, (Lahars) which are interbedded with the limestone referred to by Little as Jurassic Volcanics, (JV).

STOP 3 HIGHWAY 3 ON JULY CREEK

Half a kilometer south of the Athelstan-Hardford road. Rock cuts, from north to south expose:

(a) Green limestone cobble conglomerate and chert breccia at the base of the Brooklyn formation unconformably overlying -

(b) Permian limestone and grey cherty siltstone of the Attwood formation which in turn is separated from -

(c) Greenstone of the Brooklyn formation by the Eagle Mountain fault (not exposed).

STOP 4 HIGHWAY 3 SOUTH AND NORTH OF THE SON RANCH ROAD

(a) Serpentinite
(b) Meff creek Fault (not exposed)
(c) Basal Brooklyn green chert breccia
(d) Overlying maroon limestone cobble conglomerate.
(e) Other overlying maroon siltstone sandstones conglomerates and limestone as far as the Phoenix turnoff (as time permits).

SKARN DEPOSITS

OPTION 1

ORO DENARO - EMMA

Stop 1 Railway function - Emma shaft outcrop of quartz monzonite of the Lion creek stock.

Stop 2 Old Oro Denaro Workings - Skarn and relationships with the quartz monzonite.

Stop 3 Brooklyn limestone - skarn transition.

Stop 4 Emma open stopes - magnetite chalcophyrite skarn mineralization.

OPTION 2

GREYHOUND-SUNSET-MOTHER LODE

Stop 1 Mother lode pit - limestone skarn contact area, granodiorite-skarn relationships, pulaskite dyke and skarnified chert breccia.

Stop 2 Sunset pit - Copper skarn cut by many faults and pink feldspar porphyry dykes.

Stop 3 Mother lode fault and copper bearing quartz monzonite beneath it.

Stop 4 Old railway grade - shattered quartzite (metachert).

Stop 5 Greyhound pit - shattered hematitic skarn.

OPTION 3

PHOENIX COPPER SKARN AND GOLD-PYRITE AREA

Stop 1 Phoenix lookout - general view of the pit. Outcrops of Tertiary monzonite and upper members of the Brooklyn formation-upper volcanics, Stemwinder limestone and upper sharpstone.

Stop 2 Sylvester K zone - massive gold bearing pyrite and pyrrhotite.

Stop 3 Footwall rocks, faults and copper skarn mineralization, upper henches of the Ironsides. Knob Hill part of the open pit.

Stop 4 Any other parts of the pits as time permits.

3 Ages of faults incl. #2 - shallow dipping (thrust) faults - assoc. with mineralization - west-dipping

~~Stage~~ Age 3 faults are 'post' N-S

Brooklyn fmn. in Upper Plate

- Tectonic 'transport' to the west (listric - normal)
- Incl. serpentine slices (ductile)
- Some faults are folded.

Deformed 'Ophiolites'

Pre-Tertiary thrusts are stacking the stratigraphy.

Phoenix skarn has been 'moved' + thus no 'granitic' bodies nearby but they were the source!
(i.e. à la Motherlode).