GEOLOGY OF THE GOOD HOPE – FRENCH MINE AREA, 
SOUTH-CENTRAL BRITISH COLUMBIA* 
(92H/8) 

By G.L. Dawson, C.I. Godwin 
The University of British Columbia; 
G.E. Ray; 
J. Hammack and D. Bordin 
Corona Corporation

KEYWORDS: Economic geology, Hedley, gold skarn, French mine, Good Hope mine, ore controls, mineralogy.

INTRODUCTION

The Good Hope and French mines, in the Hedley mining camp, are gold skarn deposits hosted by French Mine formation limestones of the Upper Triassic Nicola Group. They are located approximately 5 kilometres east of the town of Hedley in south-central British Columbia, about 5 kilometres south of the Nickel Plate open-pit mine. Access to the property is by gravel road off the Nickel Plate mine road. The property is owned by Golden North Resource Corporation and is being explored by Corona Corporation.

This report incorporates regional mapping by Ray and Dawson (1987, 1988), and detailed mapping by Hammack (1988) and Dawson in this study. This work forms the basis of an M.Sc. thesis by Dawson at The University of British Columbia.

REGIONAL GEOLOGY

The Hedley gold camp lies within Quesnellia in the Intermontane Belt of the Canadian Cordillera. The first regional mapping of the area by Bostock (1930, 1940a, b) has recently been updated by Ray and Dawson (1987, 1988).

A sill swarm exposed on the cliffs east of the township of Hedley (Plate 2-6-1) is one of the most visually striking features of the area. Sills of hornblende-porphyritic diorite are part of the Hedley intrusive suite believed to be Late Triassic or Early Jurassic (199 Ma based on U-Pb dates of zircons from the Banbury stock, 3.5 kilometres west of Hedley). In this location the sills, which vary from 1 to 25 metres in thickness, make up almost 50 per cent of the stratigraphic column where they intrude laminated limestone and siltstone of the Hedley formation. They occur both adjacent to the Toronto quartz diorite to gabro stock and as far away as 2 kilometres from it. Auriferous skarn mineralization is spatially and genetically associated with the stock and adjacent diorite sills (Billingsley and Hume, 1941; Dohmage and Brown, 1945; Ray et al., 1986, 1987, 1988). A similar sill swarm is developed within the French Mine formation at the French mine and a single sill is associated with mineralization at the Good Hope mine.

LOCAL GEOLOGY

The Good Hope–French mine area is underlain by sedimentary and volcanic rocks of the Late Triassic Nicola Group and the Middle to Late Paleozoic and Triassic Apex Mountain complex (Figure 2-6-1). The Apex Mountain complex, a deformed ophiolite package, consists of greenstone, chert, argillite, siltstone and minor limestone (Milford, 1984).

Structure within the Good Hope–French mine area is relatively simple with units generally striking to the north-northeast and dipping gently west (Figure 2-6-1). Major faults include the Cahill Creek fracture zone and the Good Hope fault that were important in controlling intrusion of the Cahill Creek pluton. Major folds have not been identified, however, Hammack (1988) mapped numerous small northwest and northeast-trending small-scale flexures.

The Nicola Group has been informally subdivided into three stratigraphically distinct formations within the Good Hope–French mine area (Ray et al., 1987, 1988): a lower volcanic package called the Peachland Creek formation, a middle carbonate package called the French Mine formation, and an upper volcanic package called the Whistle Creek formation. The contact between the Nicola Group and the
## TABLE 2-6-1. TABLE OF FORMATIONS, HEDLEY AREA, SOUTH-CENTRAL BRITISH COLUMBIA.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td>aplite, rhyolite &amp; andesite dikes, granodiorite</td>
<td>basalt flows, pyroclastics</td>
<td>Unconformity</td>
<td>Spences Bridge Group</td>
</tr>
<tr>
<td>Early Cretaceous</td>
<td></td>
<td></td>
<td></td>
<td>Unit 11: andesite - rhyolite pyroclastics, minor sedimentary rocks</td>
</tr>
<tr>
<td>Middle Jurassic</td>
<td></td>
<td></td>
<td></td>
<td>Intrusive contact</td>
</tr>
<tr>
<td>Early Jurassic</td>
<td></td>
<td></td>
<td></td>
<td>Unit 10: Verde Creek stock; granite to microgranite</td>
</tr>
<tr>
<td>Late Triassic(?) - Early Jurassic</td>
<td></td>
<td></td>
<td></td>
<td>Intrusive contact</td>
</tr>
<tr>
<td>Nicola Group</td>
<td></td>
<td></td>
<td></td>
<td>Unit 9: Ashnola Hill formation andesite - dacite pyroclastic rocks</td>
</tr>
<tr>
<td>Late Triassic</td>
<td></td>
<td></td>
<td></td>
<td>Intrusive contact</td>
</tr>
<tr>
<td>Aberdeen formation</td>
<td></td>
<td></td>
<td></td>
<td>Unit 8: Cahill Creek pluton (168 Ma); granodiorite - quartz monzodiorite</td>
</tr>
<tr>
<td>Red Mountain formation</td>
<td></td>
<td></td>
<td></td>
<td>Unit 7: quartz-feldspar rhyolite porphyry dike (171 Ma)</td>
</tr>
<tr>
<td>Nickel Plate formation</td>
<td></td>
<td></td>
<td></td>
<td>Unit 6: Bronney batholith (198 Ma)</td>
</tr>
<tr>
<td>Redtops formation</td>
<td></td>
<td></td>
<td></td>
<td>Unit 5: Hedley intrusive suite; (199 Ma); plagioclase and aphyric quartz diorite - gabbro</td>
</tr>
<tr>
<td>Contact occupied by the Cahill Creek pluton</td>
<td></td>
<td></td>
<td></td>
<td>Unit 3a: French Mine formation (eastern facies); limestone, limestone conglomerate</td>
</tr>
<tr>
<td>Cache Creek Group</td>
<td></td>
<td></td>
<td></td>
<td>Unit 2: Peachland Creek formation; basalt tuff and flows, argillite, chert pebble conglomerate, limestone olistostome</td>
</tr>
</tbody>
</table>

272

*British Columbia Geological Survey Branch*
Figure 2.6.1. Geology of the Good Hope to French mine area, south-central British Columbia. Units on the figure, from oldest to youngest, are: 1 = Apex Mountain complex, 2 = Peachland Creek formation, 3 = French Mine formation, 4 = Whistle Creek formation, 5 = Hedley intrusive suite, 6 = Cahill Creek pluton, 7 = Quartz-feldspar rhyolite dike.
Apex Mountain complex is occupied by the Cahill Creek pluton. Consequently it is unknown whether the original contact was an unconformity or a suture.

The Peachland Creek formation comprises the oldest Nicola Group rocks identified in the study area. It is correlated with, and named after, a volcanioclastic sequence in the Pensusk Mountain area approximately 30 kilometres west of Peachland (Dawson and Ray, 1988).

Massive to poorly bedded, andesitic to basaltic tuffs and volcanic flows with minor argillite and limestone comprise most of the sequence. The tuffs often contain sparse chert and recrystallized quartz grains. Rare, thin chert-pebble conglomerate beds may represent turbidite deposits derived from the Paleozoic Apex Mountain complex farther east. Algal-rich marble blocks, up to 5 metres in diameter and occurring throughout the sequence, are interpreted as olistostromes that were derived from carbonate reefs to the east. Bedding underlying the olistostome is locally disrupted. Spherical argillaceous carbonate mud balls or oncolites, up to 2 centimetres in diameter, are found locally, indicating a shallow depositional environment. The base of the Peachland Creek formation is not exposed in the map area but the unit is at least 400 metres thick.

The French Mine formation stratigraphically overlies the Peachland Creek formation and consists of massive to poorly bedded limestone interlayered with limestone pebble to boulder conglomerate and minor limestone breccia. It has a maximum thickness of 100 metres and tapers westward towards the Cahill Creek fracture zone (Figure 2-6-1).

The limestone pebbles and cobbles in the conglomerates make up 95 per cent of the clasts; they are 5 to 50 centimetres in diameter, subangular to rounded, and both clast and matrix supported. Rare clasts of tuff, argillite and aphyric mafite (?) occur within this unit. The limestone breccia clasts are angular, generally less than 5 centimetres in diameter, and are clast supported. The matrix of the limestone conglomerate and breccia is altered to massive garnet or garnet-diopside reaction skarn, which reflects the variable composition of the matrix and its high porosity. The limestone is invariably recrystallized to marble. This unit probably represents a shallow-water shelf environment of fore-reef or lagoonal facies. It hosts the gold skarn mineralization at the Good Hope and French mines.

Whistle Creek formation stratigraphically overlies the French Mine formation and consists primarily of laminated to massive tuffaceous siltstone and andesite tuff. The lower part of this unit is markedly epiclastic and often exhibits graded beds, flame textures and load casts. These features indicate that the unit is right-way-up and that paleocurrent directions are predominantly from the east. The section grades upwards into more thickly bedded to massive ash, lapilli and tuff breccia that is arc-related and includes both alkaline and subalkaline rocks of andesitic to basaltic composition (Ray and Dawson, in preparation). Biotite + pyroxene + potassium feldspar hornfels is common in the lower sedimentary section of the unit, probably because it is close to Cahill Creek intrusive rocks; higher permeability of the bedded units and the chemical gradients between individual laminations or beds often enhance alteration. The maximum thickness of this unit in the district is 1200 metres (Ray and Dawson, in preparation), but near the Good Hope and French mines it is about 200 metres thick.

Hedley intrusive rocks in the study area form both phryic and aphyric sills, dikes and stocks throughout the Nicola Group rocks, but are absent from the Apex Mountain complex. A U-Pb isotopic age of 199 Ma (Ray and Dawson, in preparation) from the Banbury stock indicates that they are Early Jurassic in age, however contact relationships within the study area suggest they may be as old as Late Triassic.

The phryic Hedley intrusive rocks are commonly calc-alkaline and dioritic in composition (Ray et al., 1988). In hand sample they consist of medium-grained inequigranular feldspar-hornblende diorite and coarse-grained hornblende-porphyritic diorite. In thin section, the hornblende phenocrysts and matrix commonly contain very fine grained felded biotite and oscillatory zoned plagioclase.

Aphyric Hedley intrusive rocks are massive, dark brown to black, biotitic, aphanitic and sulphide rich. They generally occur as small sill and dike-like bodies or as margins to the larger phryic Hedley intrusions. They are interpreted (by the first two authors) as a quenched phase of the Hedley intrusive suite. Peperite-like textures (Plate 2-6-2; cf. Busby-Spera and White, 1987; Kokelaar, 1982) developed along some contacts suggest intrusion into wet sediment. The authors do not concur with this interpretation of the origin for these aphyric, biotite-rich rocks. Further detailed work is planned to investigate their origin and to differentiate them from non-bedded mafic tuffs and argillites in the area.

The Cahill Creek pluton consists of medium-grained biotite-hornblende granodiorite to monzodiorite of calc-alkaline composition (Ray et al., 1988). It is the youngest intrusive suite in the Good Hope–French mine area, and forms a large body with minor apophyses controlled in part by the Cahill Creek fracture zone. Uranium-lead isotopic dates from zircons give a mid-Jurassic age of 168 Ma (Ray and Dawson, in preparation). Minor late aplitic dikes occur both in the pluton and adjacent to it.

Quartz-feldspar rhyolite, the youngest intrusive rock identified in the study area, forms a dike less than 3 metres wide
that cuts mineralization at the French mine. A similar intrusive unit, 11 kilometres southwest of Hedley, returned a U-Pb isotopic zircon age of Middle Jurassic (171 Ma) by Bostock (1940a) and as Early Cretaceous Spences Bridge Group by Ray and Dawson (1987, 1988).

ALTERATION AND MINERALIZATION

The Good Hope mine (MINFILE 92H 060) has produced 178 kilograms of gold, 120 kilograms of silver and 602 kilograms of copper from 11 410 tonnes of ore mined during the period 1946 to 1948 and in 1982. Production was from gold-enriched skarn developed along the contact between the French Mine formation and a Hedley diorite sill (Figure 2-6-2). In general the bedding in the area is gently dipping, but a broad synclinal structure is exposed within the trench area.

The diorite sill is approximately 2 metres thick and is composed of feldspar and hornblende crystals, less than 3 millimetres in diameter, set in a fine-grained matrix. The hornblende crystals and matrix contain fine-grained felted biotite with minor diopside occurring along fractures. Skarn is best developed in the hangingwall of the sill. A distinct mineralogical zonation is recognized from the sill contact upwards into the overlying marble: this consists of a massive garnetite zone adjacent to the sill and up to 2 metres thick followed by a discontinuous zone, less than 0.3 metre thick of large tabular hedenbergite crystals. The garnet crystals are reddish brown to black, subhedral to euhedral, less than 1 centimetre in diameter, anisotropic and exhibit sector twinning. Microprobe analysis of selected garnet grains shows they are $\text{Ad}_{10}$ to $\text{Ad}_{30}$ mole per cent and enriched in man ganese (11%) compared to other skarns in the Hedley area (Ettlinger and Ray, 1989). Tabular euhedral hedenbergite crystals, up to 10 centimetres long, are oriented perpendicular to the marble contact. Microprobe analysis show they range from $\text{Hd}_{90}$ to $\text{Hd}_{100}$ and are also enriched in manganese (10%).

Minor retrograde skarn consisting of calcite, epidote and sulphides occurs interstitial to the hedenbergite crystals. Sulphides consist of finely disseminated and massive pyrrhotite, arsenopyrite, pyrite, marcasite and chalcopyrite with minor native bismuth and hedyelite. Grab samples from the hedenbergite-sulphide skarn assayed up to 94 ppm gold (Ettlinger and Ray, 1989). Local zones of jasperoid are developed along the upper contact of the sill with the marble.

A second period of mineralization crosscuts the auriferous skarn mineralization and consists of north-striking quartz + actinolite + epidote + calcite + molybdenite ± scheelite veins bordering the aplite dikes of the Cahill Creek pluton.

The French mine (MINFILE 92H 059) produced 161 kilograms of gold and 124 kilograms of silver from 79 000 tonnes of ore during the periods 1950 to 1955, 1957 to 1961 and in 1983. Mineralization is confined to a broad anticlin structure within a down-faulted block of the French Mine formation (Figure 2-6-1). Within the area of the mine workings, the French Mine formation consists dominantly of massive limestone with some limestone conglomerate and breccia layers present in the western end of the workings. The anticlinal structure strikes west to northwest and has been worked along two main stopes over a horizontal distance of 225 metres (Figure 2-6-3). Mineralization is terminated against the high-angle French fault on the west and the west dipping Canoeo thrust fault on the east. Other northeast and northwest-striking high-angle faults have been identified underground, however displacements are generally less than 3 metres. The stopes are about 3 metres wide and are believed to be separated by biotite-rich aphyric mafite sills of Hedley diorite (the authors do not concur – the separating unit may be hornfelsed tuffs and argillites).

A distinct skarn mineralogical zonation is developed outwards from aphyric mafite sills and dikes. Zones consist of successive envelopes of: scapolite + potassium feldspar + quartz, followed by garnet + diopside, followed by massive marble. The scapolite + potassium feldspar + quartz envelope is up to 50 centimetres thick. The garnet + diopside envelopes are up to 1 metre thick and are composed of massive, fine-grained reddish brown isotopic garnet with minor diopside. Microprobe analysis of garnets with the ore zone shows that they are enriched in iron and range in composition from $\text{Ad}_{80}$ to $\text{Ad}_{100}$ mole per cent, garnets from the outer margin of the skarn envelope range from $\text{Ad}_{13}$ to 275.

Figure 2-6-2. Sketch map of the Good Hope trench (see Figure 2-6-1 for legend), additional abbreviations are: APLT = aplite, GA = garnet, HD = hedenbergite, QZ = quartz, CA = calcite, AC = actinolite, MO = molybdenite, SC = scapolite.

Geological Fieldwork 1989, Paper 1990-1
Ad_{25}. Pyroxene crystals range from H_{d_{63}} to H_{d_{67}} and have a low (less than 1%) manganese content. Associated skarn minerals include minor epidote, wollastonite and sulphides.

Sulphides average less than 5 per cent by volume throughout most of the deposit, except for the western part that was relatively rich in copper and low in gold. The major sulphides identified are pyrrhotite, chalcopyrite, bornite, covellite, pyrite and arsenopyrite. Minor cobaltite, erythrite, tellurides and native gold have been identified. In the lower stopes visible gold is associated with coarse telluride grains. Recent underground chip sampling by Corona Corporation has outlined zones of high grade gold mineralization over a strike length of 65 metres with several samples returning values over 35 grams per tonne gold over widths of 1 metre (Godfrey, 1989). Down-dip extensions of the ore horizons and the displaced horizons underneath the Cariboo thrust are currently being tested by drilling.

Sporadic coarse scheelite and molybdenite are also reported. A 35-metre chip sample along an underground face averaged 0.68 per cent WO_3 (Ray et al., 1988). The relationship of this mineralization to the major gold-bearing skarns remains uncertain, but it may be related to the underlying Cahill Creek pluton.

**SUMMARY**

The Good Hope-French mine area is underlain by the Upper Triassic Nicola Group consisting of the lower volcanic Peachland Creek formation, the middle carbonate-dominant French Mine formation and the upper volcanioclastic Whistle Creek formation. Calsilicate reaction skarn, widely developed throughout the French Mine formation, may have been formed by the Hedley intrusive suite, the younger Cahill Creek granodiorite, or both. However, auriferous skarn mineralization at the Good Hope and French mines is genetically and spatially related to the Hedley intrusive suite. A second period of mineralization consisting of quartz + actinolite + calcite + molybdenite + scheelite veins crosscuts earlier auriferous skarn mineralization and may be associated with the aplitic phase of the Cahill Creek pluton.

At the Good Hope mine, auriferous skarn is best developed along the upper contact of a feldspar-hornblende-phryic Hedley diorite sill. Successive envelopes of garnet, diopside and hedenbergite skarn are developed outwards into the overlying marble of the French Mine formation. Sulphides and associated gold mineralization are concentrated in the coarse-grained hedenbergite envelope; this suggests iron-rich hydrothermal fluids were important in transporting gold. Jasperoid developed along the sill-marble contact and along pre-intrusion faults might be a late feature of the skarning process (i.e. fluids were not hot enough to produce calc-silicate mineralogy).

At the French mine, scapolite, garnet-diopside and marble envelopes are developed adjacent to numerous small Hedley aphyric mafite sills and dikes which have intruded limestone of the French Mine formation. Mineralogical zoning sug-
gests hydrothermal fluids were confined to areas between individual sills and dikes resulting in multiple “box-like” zones of skarn alteration. Minor calcite + quartz + chlo-
rite + sulphides, and associated gold mineralization, are
found predominantly within the garnet-diopside skarn.

The recognition of possible aphyric mafite intrusions as a
quenched mineralized phase of the Hedley intrusive suite,
formed by intrusion into wet sediment, has important genetic
and economic significance in gold skarn models. Some
implications are: contemporaneous sedimentation and intru-
sive volcanism; shallow depth of intrusion and associated
skarn formation; availability of large quantities of seawater
that might facilitate chlorine complexing and transportation
of metals; and depositional environment within an exten-
tional regime, perhaps related to rifting in a back-arc basin.

Distinguishing barren calc-silicate reaction skarn from eco-
nomic auriferous skarn mineralization is difficult. However,
the presence of iron-rich prograde mineral assemblages such
as andraditic garnet and hedenbergite pyroxene and retro-
grade minerals such as epidote, calcite, quartz, amphibole,
chlorite and sulphides may indicate that the skarn is not
isochemical and therefore has auriferous potential.

The amount of alteration and mineralization developed
appears to be proportional to the number of sills present.
The presence of only one sill at the Good Hope mine may explain
its small size as compared to the Nickel Plate and French
mines where sill swarms are more extensively developed.

ACKNOWLEDGMENTS

Field support was provided by a grant financed by the
Canadian/British Columbia Mineral Development Agreemen-
t. Golden North Resource Corporation and Corona Corpo-
ration granted permission to work on the property and
provided free access to all data and drill core. Field assistance
was provided by Ann Pickering and Ian Webster.

REFERENCES

Billingsley, P. and Hume, C.G. (1941): The Ore Deposits of
Nickel Plate Mountain, Hedley, British Columbia; Cana-
dian Institute of Mining and Metallurgy, Bulletin, Volume
XLIV, pages 524-590.

Bostock, H.S. (1930): Geology and Ore Deposits of Nickel
Plate Mountain, Hedley, British Columbia; Geological
Survey of Canada, Summary Report, 1929, Part A.

——— (1940a): Map of the Hedley Area; Geological
Survey of Canada, Map 568A.

——— (1940b): Map of the Wolfe Creek Area; Geological
Survey of Canada, Map 569A.

Busby-Spera, C.J. and White, J.D.L. (1987): Variations in
Peperite Textures Associated with Differing Host-
sediment Properties; Bulletin of Volcanology, Volume
49, pages 765-775.

Camell, C. (1910): The Geology and Ore Deposits of
Hedley Mining District, British Columbia; Geological
Survey of Canada, Memoir 2.

skisk Mountain Area, 92H16; B.C. Ministry of Energy,

Dolmage, V. and Brown, C.E. (1945): Contact Metamor-
phism at Nickel Plate Mountain, Hedley, British
Columbia; Canadian Institute of Mining and Metall-
urgy, Bulletin, Volume XLVIII, pages 27-68.

Enriched Skarns in British Columbia: An Overview and
Geological Study; B.C. Ministry of Energy, Mines and

Mine; in Stockwatch, J. Woods, Editor; Canjex Publish-
ing Ltd., Vancouver.

— French Area; Corona Corporation, unpublished map

Kokelaar, B.P. (1982): Fluidization of Wet Sediments during
the Emplacement and Cooling of Various Igneous Bodies; Journal of the Geological Society, Volume 139,
pages 21-33.

Milford, J.C. (1984): Geology of the Apex Mountain Croup,
North and East of the Similkameen River, South-central
B.C.; unpublished M.Sc. thesis; The University of
British Columbia.

Occurrences in the Hedley Gold Camp, British Colum-
bia; B.C. Ministry of Energy, Mines and Petroleum
Resources, Open File 1987-10.

——— (1988): Geology and Mineral Occurrences in the
Hedley Gold Camp; B.C. Ministry of Energy, Mines and

——— (in preparation): Geology of the Hedley Gok
Camp, South-central British Columbia; B.C. Ministry
Geology and Controls of Skarn Mineralization in the
Hedley Gold Camp Southern British Columbia; B.C
Ministry of Energy, Mines and Petroleum Resources
Geological Fieldwork 1986, Paper 1987-1, pages
65-79.

——— (1988): Geology, Geochemistry and Metallogenic
Zoning in the Hedley Gold-skarn Camp (92H/8;
82E/5); B.C. Ministry of Energy, Mines and Petroleum
Resources, Geological Fieldwork 1987, Paper 1988-1
pages 59-80.

Project; B.C. Ministry of Energy, Mines and Petroleum
Resources, Geological Fieldwork 1985, Paper 1986-1
pages 101-105.

Geological Fieldwork 1989, Paper 1990-1
NOTES