

	Altered pyritic dikes & sills				Samples from the main pluton						
Sample	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99	GR 99
No.	24	46	47	48	24A	26A	27A	29A	30A	51	52
SI0 2	57.50	57.11	46.61	49.32	49.76	58.12	63.19	49.57	47.07	40.13	55.57
TI02	0.59	0.55	0.81	0.78	1.00	0.83	0.34	0.78	0.61	1.29	0.46
A (20 3	17.46	15.87	15.71	14.74	18.51	16.23	16.61	16.91	4.61	5.25	17.58
Fe20 3	5.66	6.11	9.24	8.36	7.95	7.44	3.73	9,26	10.14	23.47	4.57
M n□	0.06	0.05	0.09	0.12	0.17	0.14	0.09	0.15	0.14	0.19	0.10
M g□	1.92	2.44	5.50	6.24	3.48	2.57	1.21	5.15	14.87	10.06	2.13
C all	5.72	5.14	11.35	10.83	11.71	5.99	3.95	8.02	20.13	16.82	9.28
N a20	4.34	5.40	2.02	3.09	3.89	4.47	4.69	3.69	0.26	0.33	6.05
K 20	2.23	3.84	3.13	2.09	1.09	2.74	4.17	1.77	0.10	0.16	0.75
P205	0.18	0.29	0.35	0.30	0.30	0.21	0.16	0.44	0.03	0.04	0.32
LOI	3.66	1.98	3.83	2.68	1.21	0.60	1.12	2.88	1.05	1.33	2.48
TOTAL	99.32	98.78	98.64	98.55	99.07	99.34	99.26	98.62	99.01	99.07	99.29
K 20 /N o20	0.51	0.71	1.55	0.68	0.28	0.61	0.89	0.48	0.38	0.48	0.12
Вα	1300	1665	1865	1030	310	1 41 5	1890	760	75	1 40	495
Rb	56	66	80	64	28	56	100	46	12	16	18
Sr	588	1040	846	1025	842	650	966	630	38	980	1020
Nb	8	8	2	6	8	10	8	6	4	6	18
Zr	96	111	63	78	84	132	105	60	27	51	90
Υ	20	24	20	18	22	24	20	20	12	8	12
F	270	460	1300	1200	640	300	410	500	50	80	170
Hg (ppb)	50	10	10	<10	10	<10	10	10	<10	<10	<10
Rb/Sr	0.10	0.06	0.09	0.06	0.03	0.09	0.10	0.07	0.32	0.02	0.02
Basr	2.21	1.60	2.20	1.00	0.37	2.18	1.96	1.21	1.97	0.14	0.49

Oxides in percent; Hg in ppb; other elements in ppm
Sample descriptions:
GR99-24 & 46 Moderately silicified, rusty weathering, pyritic and albite-altered intrusion
GR99-47 & 48 Pyritic and carbonate-altered intrusion
GR99-24A Altered, hornblende-microdiorite with minor pyrite
GR99-26A Medium grained gabbro with 60% mafics and 2% pyrite
GR99-27A Felsic diorite with 12% mafics and 1% pyrite. Minor quartz veining
GR99-29A Coarse, hornblende porphyry gabbro with 15% mafics and 1% pyrite
GR99-30A Coarse grained pyroxenite with 5% magnetite & trace pyrite
GR99-51 Coarse grained hornblende-pyroxene ultramafic with 10% magnetite
GR99-52 Pale, feldspathic monzodiorite agmatite cutting ultramafics

Analyses completed at Chemex Labs. Ltd., 212 Brookbank Ave., North Vancouver, B.C.

Ba, Rb, Sr, Nb, Zr, Y=XRF; Hg=Atomic AbsorptionSpecroscopy (AAS); F=Specific Ion Electrode

Methods: Major & minor oxides=XRF; Au=Fire assay and AA finish

Analyses completed at Chemex Labs. Ltd., 212 Brookbank Ave., North Vancouver, B.C. Methods: Au=Fire assay and AA finish; F=Specific Ion Electrode; As=AAS; other elements ICP=MS Sample Descriptions
GR94-217, 219 & ?? Garnetpyroxene-magnetite skarn with pyrite and trace chalcopyrite
GR94-223 & 224 Drill core magnetite-garnet skarn with pyrite and trace chalcopyrite
GR99-19 Pyroxene-magnetite-pyrite skarn; UTM 10 706780E, 5636518N
GR99-25A Magnetie-pyrite-garnet skarn
GR99-27 Garnet-pyroxene skarn with pyrrhotite, pyrite and trace chalcopyrite
GR99-32 & 29 Pyrite-magnetite skarn with trace garnet and chalcopyrite
GR99-32 Magnetite-garnet-pyroxene skarn
GR99-32 Magnetite-pyroxene skarn with pyrite and trace chalcopyrite
GR99-33 Magnetite skarn with trace garnet, pyrite and chalcopyrite
GR99-34 Magnetite vein with minor pyrite
GR99-37 Massive magnetite with pyrite and trace garnet

Au and Hg in ppb; Total S, Al, Ca, Fe, Mg, K, Na & Ti in wt%

GR99-40 Magnetite-garnet-pyrite skarn with minor chalcopyrite

GR99-42 Garnet-pyroxene-pyrite skarn with minor chalcopyrite

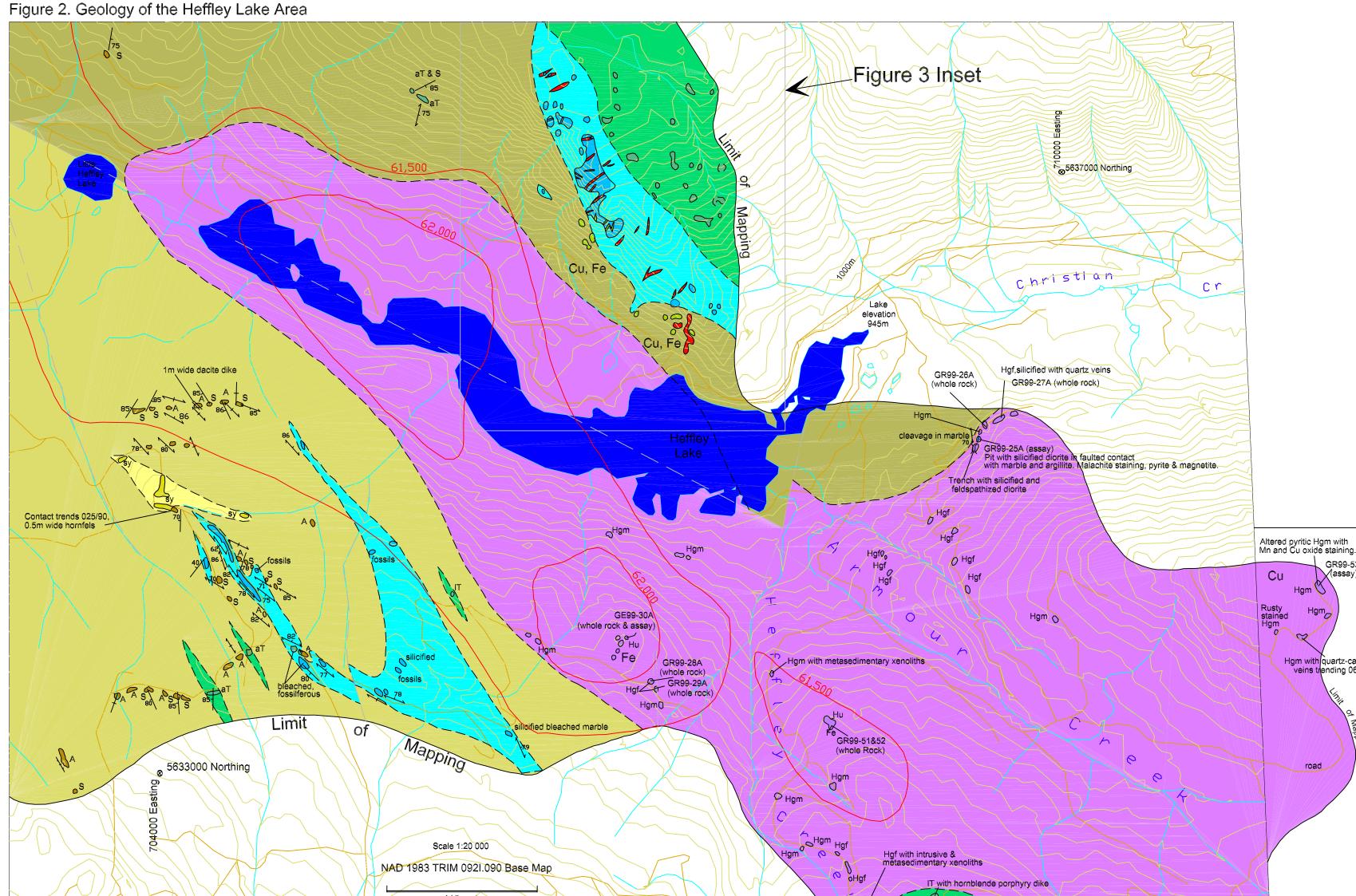
Table 3: Assay results of mineralized intrusive rocks, Heffley Lake, B.C. Altered pyritic dikes & sills 28A 30A 2.55 3.95 1.7 2.08 0.82 0.05 3.25 1.47 0.2 1.43 1.53 3.27 2.06 0.42 0.49 0.32 0.47 0.33 0.2

Au and Hg in ppb; Al, Ca, Fe, Mg, K, Na, & Ti in wt%; other elements in ppm
Analyses completed at Chemex Labs. Ltd., 212 Brookbank Ave., North Vancouver, B.C..

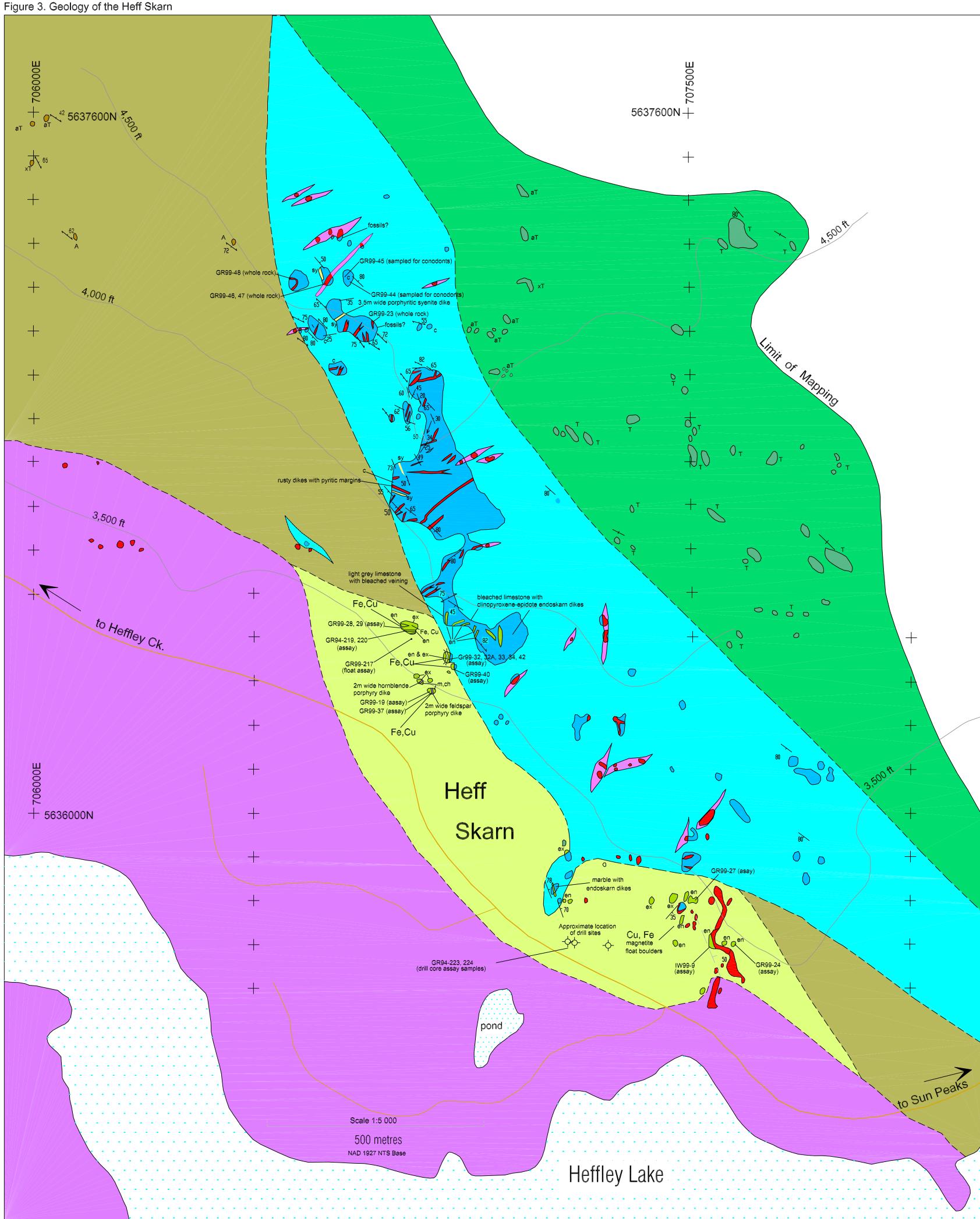
Methods: Au=Fire assay and AA finish; F=Specific Ion Electrode; As=AAS; other elements in ICP-MS
Sample Descriptions:

GR99-23 2m wide pyrite-bearing dike, 7100N-6775E
GR99-24 5m wide pyritic and silicified dike adjacent to garnet-pyroxene skarn, 5700N-7600E
IW99-9 15cm-wide hornblende-pyroxene-porphyry dike with pyrite-pyrrhotite veinlets
GR99-28A Altered, silicified mafic diorite with 10% pyrite and quartz veins
GR99-30A Dark, clinopyroxene with 5% cumulate magnetite and trace pyrite

GR99-53 Silicified, altered and malachite stained gabbro with pyrite and chalcopyrite. UTM 11 289285E; 5634320N



20 metre contour interval







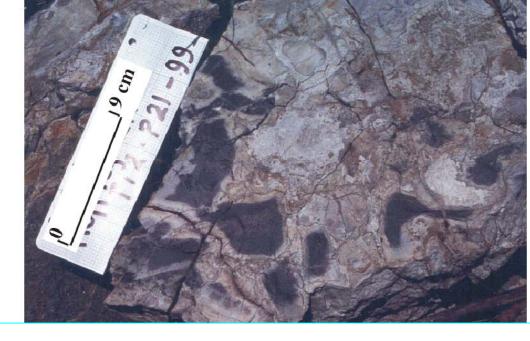


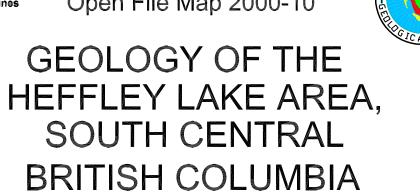
Plate 2. Remnants of dark limestone enclosed by bleached marble. Heff property.



Plate 3.
Coarse grained garnet skarn with pyrite and calcite. Heff property.



Geological Survey Branch
Open File Map 2000-10



Part of NTS 092 I/16 by G.E. Ray and I.C.L. Webster

LEGEND

AREAS OF OUTCROP SHOWN IN DARKER COLOUR

INTRUSIVE ROCKS

Porphyritic syenite - quartz syenite. Massive, pale brown feldspathic rocks with feldspar phenocrysts up to

HEFFLEY CREEK PLUTON

Pyritic, porphyritic and non-porphyritic andesite dikes and sills. Fine to medium grained massive rocks.

Rusty weathering with secondary pyrite, silica, carbonate of feldspar alteration. Local pyroxene ± garnet endoskarn overprinting.

Gabbro, diorite and ultramafics. Massive, coarse grained rocks.

Hu = ultramafic rocks with hornblende ± pyroxene ± magnetite

Hgm = mafic gabbro - diorite (>25% hornblende)

Hgf = felsic gabbro - diorite - quartz diorite (<25% hornblende)

POSSIBLE LATE TRIASSIC - EARLY JURASSIC

ALTERATION

Pyroxene ± garnet ± epidote ± magnetite skarn.
en = endoskarn
ex = exoskarn

STRATIFIED ROCKS

POSSIBLE UPPER TRIASSIC NICOLA GROUP

PACKAGE NORTH OF HEFFLEY LAKE

Upper unit; calcareous tuffs, massive to poorly bedded.

T = undifferentiated, aT = ash tuff, xT = crystal tuff

bleaching by hydrothermal fluids.
C = coarsely clastic to conglomeratic

Lower unit; includes green andesitic to dacitic tuffs, grey to black argillite and bedded siltstone.

Middle unit; limestone, massive to well bedded, loally clastic to conglomeratic; medium to dark grey; local

aT = ash tuff, xT = crystal tuff, IT = lapilli tuff, A = argillite, S = siltstone

POSSIBLE PALEOZOIC HARPER RANCH GROUP

PACKAGE SOUTH OF HEFFLEY LAKE

Limestone and minor marble, locally fossilferous (crinoids), dark blue-grey except where bleached by thermal or hydrothermal overprinting.

Interbedded grey, thin bedded silstone and black, massive, pyritic, slatey argillite.

S = siltstone
A = argillite

Tuffs, green, massive to weakly bedded.
aT= ash tuffs

SYMBOLS

Geological contact, approximate

Fault (with dip)

Bedding with dip

Cleavage with dip

Slickensides

Aeromagnetics (gammas)

Trench
Cu, Fe Chalcopyrite, Magnetite
Roads
Streams

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COMMENTS OR CORRECTIONS:

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Comments concerning this map would be appreciated. Please contact Gerry Ray at (250) 952-0409, Email Gerry.Ray@gems9.gov.bc.ca or lan Webster at (250) 952-0433, Email lan.Webster@gems1.gov.bc.ca, FAX (250) 952-0381

Columbia; B.C. Ministry of Energy and Mines, Open File 2000-10.

DESCRIPTION OF GEOLOGY AND MINERALIZATION

intrusions and the skarns were coeval with the F1 deformation.

INTRODUCTION AND PREVIOUS WORK

The Heffley Lake area lies approximately 26 kilometres northeast of Kamloops and is accessible via the road between the township of Heffley Creek and the Sun Peaks ski resort. It lies within the Intermontane Belt and is underlain by metasediments of the Quesnel Terrane and younger mafic intrusive rocks (Figs. 1 & 2).

Past exploration and drilling have been concentrated on the Heff property which lies at the base of a series of northwest trending limestone cliffs, immediately north of Heffley Lake (Figs. 2 & 3). In 1915, Cu and Fe mineralization were first noted in the area (MMAR, 1916), and in 1966 drilling intersected over 10 metres of massive magnetite and another 4.5 metres thick zone of semi-massive magnetite with chalcopyrite; the latter zone graded 1.67 percent Cu and 0.48 g/t Au (Casselman, 1980).

In 1980, Cominco identified a broad, 600 metres-long Cu soil anomaly (Casselman, 1980); later, a drill-hole intersected 16 metres of semi-massive magnetite, a 6 metre interval of which assayed 25 percent Fe and 0.5 g/t Au (Arseneau, 1997).

Later sampling by Ray and Webster (1997) showed that the Heff magnetite skarn contained moderate anomalous quantities of REE's (up to 570 ppm La and 490 ppm Ce). In 1997, Echo Bay Mines outlined soil anomalies adjacent to the magnetite skarn with values exceeding 1200 ppm Cu and 1000 ppb Au.

Mapping in the district includes early work by Cockfield (1944, 1947) and more recent compilation work by Monger and McMillan (1989). A detailed description of the geology and geochemistry of the Heffley Lake area is given by Ray and Webster (2000).

Stratified rocks

The area is extensively covered with superficial glacio-fluvial deposits. The stratified rocks were originally mapped as Cache Creek Group (Cockfield, 1944, 1947) but more recently they are considered to belong, in part, to the Harper Ranch Group (Monger and McMillan, 1989). They mainly comprise steeply dipping, northwest striking argillites and calcareous siltstones with lesser andesitic ash and lapilli tuff and some limestone. These rocks were folded and overprinted by lower to sub-greenschist metamorphism producing slatey and phyllitic planar fabrics. The magnetite-bearing garnet-pyroxene skarn on the Heff property is hosted by calcareous metasediments and dioritic minor intrusions; it is best exposed in a number of overgrown trenches that lie 200 to 300 metres north of the Heffley Creek-Sun Peaks road (Fig. 3).

The area southwest of Heffley Lake includes units of blue-grey crinoidal limestone and black argillites whilst the coarsely clastic to conglomeratic

limestones in the vicinity of the Heff skarn, north of Heffley Lake, lack crinoids and the argillites are less organic-rich. This and other lithological differences suggest that the supracrustal rocks may be separated into northern and southern packages; these are believed to represent the Nicola and Harper Ranch groups respectively (Fig. 2). Limestone samples from these packages are currently being processed for microfossils that may verify this suggestion. The contact between these packages is thought to pass under the Heffley lakes and continue south-eastwards along Armour Creek. The Heffley Creek Pluton has intruded this presumed stratigraphic contact and has undergone later brittle movement along the Armour Creek Fault (Fig. 2).

Intrusive Rocks

Two intrusive phases are recognised. The oldest and most economically important of these is the Heffley Creek Pluton and its marginal dike-sill swarm (Figs. 2 & 3). This intrusion is probably related to the Heff skarn and was coeval with the district-wide folding. A younger generation, which post-dates the folding, resulted in minor bodies of megacrystic, feldspar-porphyry syenite.

The main Heffley Creek pluton is exposed south and southwest of Heffley Lake, where small, scattered outcrops are traceable over a 10 km2 area. It contains pyroxene-amphibole-bearing ultramafic rocks as well as some gabbros, diorites, quartz diorites and monzodiorite. The ultramafics contain up to 10 percent disseminated magnetite which results in an elongate aeromagnetic anomaly that extends south-east of Little Heffley Lake (Fig. 2).

Major and trace element analytical data for the various rock types in the Heffley Creek Pluton are presented in Table 1. The total alkali content of the gabbroic and dioritic rocks indicates a weak alkalic affinity; however, chemical plots (Ray and Webster, 2000) suggest these rocks were originally calc-alkaline and that their higher alkali content is due to hydrothermal alteration.

The Nicola Group limestones along the northeast margin of the pluton are cut by a swarm of strongly altered, rusty-weathering dioritic sills and dikes (Fig. 3) that are probably related to the Heffley Creek Pluton. Individual bodies are usually less than 10 metres wide; they mostly strike northeast (Fig. 3), but some intrusions are irregular and bifurcating.

A younger phase of porphyritic syenite is best seen south of Heffley Lake, although the Nicola limestones northeast of Heffley Lake are cut by a few dikes up to 3 metres thick. These leucocratic rocks contain up to 7 percent chloritized amphibole and biotite, as well as some minor quartz. They are characterised by abundant elongate feldspar crystals up to 15 cm in length.

STRUCTURE

Only one episode of major folding is recognized (F1); this resulted in the moderately to steeply dipping beds and a southeast trending axial planar slatey cleavage (S1). No fold axial linear features (e.g. mineral lineations) were seen and very few minor F1 folds were identified. However, bedding-cleavage intersections in the Nicola Group limestones north of Heffley Lake reveal the presence of several tight synforms and antiforms.

During the F1 episode, the limestones throughout the area underwent ductile deformation while most of the more competent dikes were disrupted by boudinage and brittle extension. Stereo plots of bedding and S1 cleavage measurements are presented in Figure 4. These suggest that the tight F1 folds in the northern part of the area have sub-horizontal to moderately southeasterly plunging axes and that their axial planes are southeast striking and steeply northeast dipping. Plots of the southern structural data (Fig. 4) also indicates the presence of southeast striking isoclinal folds but their axial planes are more vertical. The large arcuate unit of strongly cleaved limestone exposed southwest of Heffley Lake may represent a major isoclinal F1 structure.

Most of the pyritic sills and dikes on the Heff property strike northeasterly (Fig. 4) and were structurally controlled by a-c fractures developed during the F1 folding. However, some thin sills in the limestones have undergone open to tight F1 folding, and these folded intrusions are invariable overprinted by the S1 slatey cleavage. The folding of some sills together with the a-c joint control of the dikes is supportive evidence that both the

ALTERATION AT THE HEFF SKARN

Most of the Nicola Group limestones north of Heffley Lake show little sign of hydrothermal overprinting, but pyritic, albitic, carbonate and silica alteration are seen throughout the dioritic dike swarm on the Heff property. A progressive southerly change in the intensity and style of alteration in the dikes, and, to a lesser extent, in the limestones is noted. This change reflects increasing proximity to the mineralized Heff skarn occurrences and the northern margin of the Heffley Creek Pluton, which is presumed to either underlie Heffley Lake or its northern shore (Figs. 2 & 3).

In the north part of the Heffley property grid, the sills and dikes are characterised by up to 3 percent by volume pyrite. Further south, however, in the vicinity of line 6700N and 6800E (Fig. 3), the pyrite content increases up to 6 percent; in addition to the disseminated sulphide, the margins of some sills and dikes contain haloes, up to 7 centimetres thick, of massive, coarse grained pyrite. Still further south (close to line 6400N and 6950E), endoskarn alteration is first recognised; the dikes are still pyritic but they also contain trace amounts of magnetite together with pyroxene, epidote and silica. The limestones in this area have also undergone a recognizable colour-change. To the north they are unaltered and dark to medium grey in colour but further south they become pervasively paler. Coinciding with the first southern appearance of pyroxene-endoskarn, the pale grey limestones are cut by irregular veins and stringers, up to 4 centimetres thick, of white marble. These fracture-controlled bleached veins in the limestones represent the more distal effects of hot, metal-poor fluids from the Heff skarn hydrothermal system.

Immediately to the south of this area, on line 6400N and 6850E, outcrops comprising part of the Heff skarn are first seen. These contain abundant coarse grained garnet with massive to semi-massive magnetite, lesser amounts of pyroxene and pyrite and trace chalcopyrite. Some of

coarse grained garnet with massive to semi-massive magnetite, lesser amounts of pyroxene and pyrite and trace chalcopyrite. Some of this garnet-rich alteration appears to be endoskarn. The Heff skarn is only exposed in small widely distributed outcrops that trend southeastwards for 1 kilometre (Figs. 2 & 3). These exposures probably mark the northeastern edge of a large skarn system that is virtually entirely obscured by superficial cover. Adjacent to the skarn, the fracture controlled bleaching in the carbonates is so intense that some rocks comprise mostly white, fine grained marble that enclose small dark relicts of original limestone. In the coarser skarns, the euhedral garnet crystals are intergrown with calcite. Other minerals identified in the skarns include clinopyroxene, epidote, chlorite, quartz, albitic plagioclase, zoisite and ilmenite.

MINERALIZATION AND GEOCHEMISTRY

At least two types of Cu-bearing mineralization are recognized in the area. These are: (1) magnetite-rich chalcopyrite ± Au ± REE garnet-pyroxene

skarns which occur on the Heff property northeast of Heffley Lake, and (2) disseminations and veins of chalcopyrite ± magnetite-pyrite mineralization in the Heffley Creek Pluton south of Heffley Lake (Figs. 2 & 3).

On the Heff property, the pyroxene ± garnet skarn horizons reach up to 50 metres thick but most are generally less than 2 metres wide. Pods and massive lenses of magnetite occur with minor pyrite, lesser pyrrhotite and trace chalcopyrite. Magnetite lenses over 10 metres thick have been intersected by drilling (Casselman, 1980). Mineralization occurs locally in the endoskarn intrusions and in what is believed to be the adjacent exoskarn. On a local scale, many of the calc-silicate layers are mineralogically zoned with a central core of coarser grained garnet-dominant skarn and a wider outer halo of finer grained pyroxene-dominant skarn. Magnetite-sulphide mineralization tends to be better developed in the garnet-dominant skarn.

Assay results of grab samples of mineralised Heff property skarn are shown in Table 2. Some samples are weakly anomalous in Au (up to 445 ppb), Cu (up to 1195 ppm), Co (up to 467 ppm) and Mo (up to 14 ppm) as well as being sporadically enriched in REE's (up to 490 ppm Ce and 570 ppm La) and P (up to 1560 ppm).

Assay data for pyrite-bearing grab samples from the Heffley Creek Pluton and its dike-sill swarm are presented in Table 3. Two samples of magnetite-bearing ultramafic pyroxenite were assayed for PGE's but they contained only 15 ppb Pt and 4 ppb Pd. However, there are unconfirmed reports that Pt geochemical soil anomalies are present in the area (Roed, 1988).

Samples collected from the altered pyritic dike-sill swarm on the Heff property contain no economic quantities of Cu and Au, although one sample (GR99-24; Table 3) is weakly anomalous in Au (145 ppb) and some are moderately anomalous in F (up to 1300 ppm F; Table 1). One chalcopyrite-malachite-K feldspar-bearing occurrence in the pluton was seen in a new road cut at NAD 83, UTM location Zone 11, 2 89 285E; 56 34 320N. A grab sample from this occurrence (sample GR 99-53; Table 3) contained 0.8 percent Cu as well as anomalous Mo, Co and Ag. This sample also contained the highest quantity of Hg (250 ppb) recorded during this survey. The pyritic mineralization in both the pluton and its related dike-sill swarm are weakly anomalous in P and possibly Ce (Table 3).

* The Heffley Lake area contains two types of chalcopyrite-bearing mineralization, namely: (1) magnetite-rich garnet-pyroxene skarns on the Heff property, and (2) pyrite ± magnetite disseminations and veins in the Heffley Creek Pluton south of Heffley Lake.

* The Heff skarn represents an unusual Cu ± Au ± REE ± P-bearing magnetite skarn whose location and distinctive chemistry suggests it differs from the typical Fe skarns occurring along the west coast of British Columbia. It possibly resulted from a Fe-oxide ± Cu ± Au ± REE ± P-bearing hydrothermal system similar to those responsible for deposits in the Ernest Henry-Candelaria-Wernecke Breccias spectrum (Laznicka and Gaboury, 1988; Hitzman et al., 1992; Ryan et al., 1995; Williams, 1999). However, the Heff skarn lacks the extensive brecciation and widespread Na ± K metasomatism that characterizes many deposits of the spectrum. The dominance of pyrite over pyrrhotite and the abundance of magnetite suggests that the Heff skarn formed in an oxidized, low sulphur hydrothermal system.

* The Heff skarn is associated with a swarm of northeast striking sills and dikes that are related to the Heffley Creek Pluton. The intrusions and the skarn are believed to be coeval with an episode of major F1 folding. A southerly change in mineral alteration on the Heff property and the presence of high Au and Cu soil anomalies suggests that economic skarn orebodies may underlie Heffley Lake and its alluvium-covered northern shore. Such orebodies could follow either the southeast striking margin of the Heffley Creek Pluton or the northeast trending a-c fractures related to the F1 event.

orebodies could follow either the southeast striking margin of the Heffley Creek Pluton or the northeast trending a-c fractures related to the F1 event.

* The Heffley Creek Pluton probably represents an Alaskan-type body, similar to the Tulameen and other Triassic-Jurassic complexes in Columbia (Nixon et al., 1997). It has the potential to host Cu, Au, Cr and PGE mineralization, and the immediately adjacent country rocks should be explored for other Cu-Au-REE skarns similar to the Heff property.

* Recognition of a large Alaskan-type pluton indicates that this part of British Columbia needs to be re-evaluated for its skarn, porphyry and PGE-potential.

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