HYDROTHERMAL ALTERATION MAP OF THE HIGH-SULFIDATION HOPE BROOK GOLD DEPOSIT, NEWFOUNDLAND [1-2-3]

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2 Contribution to the Canada-Newfoundland Agreement on Mineral Development
3 This map is based on detail mapping by B. Dubé and K. Lauzière and compilation of work by Stewart (1992), O'Brien (1990), O'Brien et al. (1991) and several unpublished maps, sections and reports by BP-Selco Division, Hope Brook Gold Inc. and Royal Oak Mines.

Digital compilation and cartography by Eric Boisvert, Ruth Boivin and Nicolas Léonard, Geological Survey of Canada (GSC-Québec)

LEGEND

MASSIVE SILICIC ALTERATION

Sl_1 - Buff silicic alteration (First stage of massive silicic alteration)
Buff-beige to light grey colour, massive silicic rocks (up to 99% SiO_2), no sulfide to 2-3% pyrite, commonly barren to anomalous in gold. Becomes more pyritic towards the deposit area. Typically cut by quartz-tourmaline vein/breccia and local pyrite veinlets. Regional in extent. Intruded by various proportions of mafic-intermediate dikes and sills.

Sl_2 -Grey silicic alteration (Second stage of massive silicic alteration)
Sl_{2a} - CORE ZONE: Light grey to dark grey, massive silicic rocks with several percent pyrite and/or chalcopyrite + bornite either as disseminations, impregnations or veinlets. Auriferous (≥2-2.5 g/t Au) and commonly vuggy. Host of Hope Brook gold deposit. Locally contains high-grade (up to 285 g/t Au) quartz chalcopyrite and quartz-pyrite veins. Intruded by up to 25% unmineralized mafic-intermediate dikes and sills.

Sl_{2b} -Light grey to dark grey, massive silicic rocks with traces to a few percent pyrite as disseminations or impregnations. Anomalous in gold to weakly auriferous (≤ 1 - 1.5 g/t Au). Defines hangingwall and footwall margins to the ore zone. Locally mixed with minor advanced argillic alteration zones on NW side of the deposit. Intruded by mafic-intermediate dikes and sills.

Sl_{2c} -Pyrite-rich grey silicic stage ("PYRITE CAP"): Dark grey, massive silicic rocks characterized by up to 15-20% pyrite as massive/vuggy veinlets and semi-massive mm- to cm-wide bands and disseminations. Contains several metres-wide zones characterized by various compositions and sizes of sub-angular to sub-rounded fragments altered by the buff (first) and less commonly grey (second) silicic stages in a matrix of second stage, dark grey, silicic altered rocks. Both the matrix and the fragments are cut by pyrite veinlets. Gold content varies from several tens of ppb to up to 1 ppm. Constitutes the structural footwall of the deposit. Intruded by various proportions of mafic-intermediate dikes and sills.

Sl_S -Zone A of Swinden (1984)
Lenses of highly strained silicic rocks and advanced argillic alteration adjacent to the Cinq Cerf Fault Zone. Comprises both buff (first) and grey (second) stages of silicic alteration. Anomalous to weakly auriferous. Host of the Chetwynd and Copper shafts showings. Locally contains several percent Cu, As, Hg and up to 2.8 g/t Au (Copper shaft). Intruded by various proportions of mafic-intermediate dikes and sills.

ADVANCED ARGILLIC ALTERATION

AA_1 -Advanced argillic: Various proportions of sericite, quartz, pyrophyllite and kaolinite within quartz-sericite ± chlorite schists. Commonly contains disseminated pyrite (1-3%) and rutile. Minor interbands of grey hematitic schists (altered mafic dikes) and some local hydrothermal magnetite. The pyrophyllite content increases towards the northwest. Anomalous in gold (up to few hundreds ppb). Intruded by various proportions of mafic-intermediate dikes and sills which are not shown.

AA_2 -Advanced argillic with silicic lenses: Quartz-pyrophyllite-andalusite-kaolinite-white micas schists. Locally characterized by well preserved primary mottled texture. Contains patchy cm- to several metres-wide zones of grey, or less commonly buff massive silicic stages, increasing in abundance towards the NW. Contains 1-5% pyrite, rutile, and minor fluorite, barite, topaz and/or specular hematite. The NW limits of the unit is commonly characterized, in the deposit area, by up to tens of metres of hematite-rich schists, derived from mafic-intermediate dikes, with local specular hematite and pyrite-rich mm- to cm-wide veins (≤1.5 g/t Au). Anomalous in gold (≤ hundreds of ppb). Intruded by various proportion of mafic-intermediate dikes and sills which are not shown.

AA_3 -Advanced argillic with alunite: Zone characterized by alunite-quartz-muscovite schists with rutile and up to 5% pyrite. Recognizable by its pinkish hue. Anomalous in gold (up to few hundreds ppb). Mixed with AA_2 zone. Contains zones of grey silicic alteration (Sl_2). Intruded by various proportions of mafic-intermediate dikes and sills which are not shown. Based on surface mapping, interpreted/assumed in drill holes.

PROPYLITIC ALTERATION

PR -Poorly defined multistage alteration zones with chlorite-epidote-calcite-magnetite and some potassic-alteration. Their distribution, composition, chronology and geometry are not well defined.

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0 100 m
Scale 1:2500

GEOLOGICAL SYMBOLS

- Mapped outcrops
- Trench
- Prospect
- Mine grid E11500 / N 4600
- Open pit wall
- Surface projection of Drill Holes* (Colour according to intersected alteration zones. For simplification mafic-intermediate dikes-sills are not shown. Based on drill core logs by BP-Selco and re-logged by B. Dubé. DW0260 and CE0291 are drill hole numbers.)

*Drill Hole sections were plotted at ± 50 m on the nearest 100 meters space mine grid.

a) Bedding (S_0) a) inclined, b) vertical
Foliation (S_1-S_2) a) inclined, b) vertical
Main foliation (S_2) a) inclined, b) vertical
Stretching or mineral lineation (L_2)
Crenulation cleavage (S_3) a) inclined, b) vertical
Fold axis (F_3)
Intersection lineation (L_3)
Mafic dike a) inclined, b) vertical
Joint a) inclined, b) vertical
Brittle fault a) inclined, b) vertical
Striations
Geological contact (defined, approximate, assumed, transitional, compiled and interpreted)
Major brittle strike-slip fault
Major high angle reverse-oblique fault

COMPILATION OF THE MAIN STRUCTURAL ELEMENTS ON EQUAL-AREA PROJECTIONS (LOWER HEMISPHERE) OF STRUCTURES MEASURED ON SURFACE AND UNDERGROUND

A-Late Proterozoic rocks: Mean S_2: 052/77; Mean S_2-S_3: 043/49; Mean L_3: 184/63; ☐ S_2-S_3 Solution in Medium strain (poles) n = 57; ■ S_3Solution (pole) n = 545; ▲ Stretching lineation n = 18; ● S_3 cleavage (pole) n = 23; Mean S_3: 190/88

B-Silurian La Poile Group: Mean S_2: 046/60; Mean S_3: 014/85; Mean L_3: 187/30; ■ S_2 foliation (pole) n = 144; ▲ Stretching lineation n = 26; ● S_3 cleavage (pole) n = 19

C- Brittle faults (poles) n = 134

D- Brittle faults with striations and related sense of motion: 51A Fault; 51A Fault; 51A Fault; striations

E- Mafic dykes (poles) n = 76

F- Mineralized veinlets (poles): ▲ Pyrite veinlets n = 83; ● Quartz-chalcopyrite veins and veinlets n = 8

ABSTRACT

The Hope Brook gold mine (45 t Au) is a high-sulfidation epithermal gold deposit hosted by Late Proterozoic rocks of the Northern Appalachian Avalon Zone, Newfoundland (Dubé et al., 1998).

HYDROTHERMAL ALTERATION AND MINERALIZATION

The Hope Brook deposit is enclosed within an extensive acidic hydrothermal alteration zone which strikes NE and dips steeply to the SE (Stewart, 1992; Dubé et al., 1998). This zone is ≥3 km long, up to 400 m wide and thins out to the SW. The zone is bounded to the north by unaltered but mylonitized Whittle Hill Sandstone rocks, whereas the southeastern limit is rather gradual. To the northwest, the alteration zone is truncated at depth by the Chetwynd Granite and is in contact with associated hornfels on surface (Stewart, 1992). The alteration zone is characterized by two main types of alteration, each with a number of sub-zones: 1) an extensive zone of advanced argillic alteration and 2) a massive silicic alteration of more restricted extent (McKenzie, 1986; Yule et al., 1990; Stewart, 1992; Dubé et al., 1998). A much smaller zone of advanced argillic alteration, known as the "A Zone", occurs to the northwest of the main acidic alteration zone and hosts the Chetwynd and Copper Shaft showings (Swinden, 1984; McKenzie, 1986). This "A Zone" is strongly deformed by the Cinq Cerf Fault Zone and consists of silicic lenses within quartz-sericite-pyrite-pyrophyllite schists derived from advanced-argillic altered rocks. The Copper Shaft showing is locally auriferous (up to 2.8 g/t Au) and is enriched in Cu, As, Hg and Sb (Dubé et al., 1998).

Several generations of barren mafic-intermediate dike-sills from Late Proterozoic to Silurian age are present within the acidic alteration zone and are especially abundant within the siliceous rocks due to their competency. A detailed study of these dikes is presented in Yule et al. (1990) and Stewart (1992). Although some are definitively altered by the advanced argillic alteration and a few are locally silicified and pyritized, most of these dikes postdate the silicic alteration, but predate Late Silurian ductile deformation (McKenzie, 1986; Yule et al., 1990; Stewart, 1992; Dubé et al., 1998).

1-Advanced argillic alteration (AA)
The advanced argillic alteration zone is mainly located in the structural hangingwall of the ore zone and its sharp contact with the silicic alteration zone is marked, in the deposit area, by the 51A fault. This alteration zone is up to 300 m wide and is present over the entire length of the hydrothermal system. It is mainly hosted by GFP's and by the Riot Intrusive Suite and is characterized by the presence in various proportions of pyrophyllite, kaolinite, andalusite, sericite, paragonite, diaspore, alunite and natroalunite with quartz, rutile and pyrite (McKenzie, 1986; Yule et al., 1990; Stewart, 1992; Dubé et al., 1994; 1995; 1998). The advanced argillic alteration zone can be subdivided into three sub-zones (AA_1, AA_2, AA_3), based on the presence or absence of m-scale silicic lenses and of alunite (see legend for details).

2-Massive silicic alteration (S)
At least three stages of massive silicic alteration are present in the alteration zone and define distincts sub-zones: an initial "barren" buff silicic zone of regional extent (first stage) and a more localized grey to light grey silicic zone (second stage). The latter is subdivided into three sub-zones: a pyrite-rich sub-zone, known as the "pyrite cap", a more localized auriferous grey silicic sub-zone hosting the gold mineralization, and a low grade grey-silicic sub-zone enveloping the ore. All zones are characterized by an almost complete leaching of Al_2O_3, MgO, CaO, Na_2O and K_2O. A third stage characterized by breccia containing clasts of the auriferous grey silicic alteration in a whaler silicic matrix was only locally recognized underground.

Buff silicic alteration stage (first stage Sl_1, barren to weakly auriferous): Although locally preserved within the deposit, this buff silicic alteration is a major constituent of the siliceous rocks to the southwest of the ore zone. This type of silicic alteration is essentially composed of fine grained quartz, with disseminated rutile and traces of pyrite (locally up to 2-3%), although it becomes more pyritic approaching the deposit.

The buff silicic alteration is hosted at least in part by volcaniclastic rocks respectively interpreted as lapilli tuff and as ash flow to crystal tuffs. These lapilli tuffs are located at a stratigraphic level similar to that of the unaltered Third Pond Tuff located farther to the SW. Some blue-quartz-bearing GFP are also locally present within this barren silicic alteration zone.

Grey silicic alteration (second stage of massive silicic alteration):
i)Ore zone: Sl_{2a}
Gold mineralization at Hope Brook is disseminated and defines an orebody up to 70 m wide and with known lateral and vertical extensions of 750 and 500 m, respectively. At depth, the intensity of the grey silicic alteration hosting the ore zone decreases gradually as it becomes thinner and grades into a low grade to barren grey silicic sub-zone (Sl_{2b}) with local buff silicic alteration.

The ore zone is characterized by light-to dark-grey colors, massive very fine grained quartz with locally up to 10-15% of very small vugs (≤1-3 mm), and by the presence of several percent of sulfides (≤ 5-10%), either as disseminations, impregnations or, more commonly, veinlets. The vugs are locally filled by very fine grained chalcopyrite and/or pyrite and locally form larger cm-wide aggregates of vugs.

Numerous barren mafic dikes cut across the grey silicic altered rocks. They are NW to NE-trending and locally represent up to 25% of the ore zone. Most are post-silicic alteration and strongly deformed. They commonly contain the S_1 fabric and some are folded. Two undeformed and unmineralized Chetwynd dikes cut across the ore and the mafic dikes.

ii)Low grade grey silicic sub-zone: Sl_{2b}
The immediate hanging wall and footwall to the ore zone are characterized by light-grey to dark grey massive silicic rocks with traces to a few percent pyrite as disseminations or impregnations This sub-zone is anomalous in gold to weakly auriferous (≤1-1.5 g/t Au).

iii)Pyrite-rich grey silicic sub-zone ("pyrite cap"): Sl_{2c}
The pyrite-rich grey silicic sub-zone, also known as the "pyrite cap" (McKenzie, 1986), is characterized by up to 15-20% pyrite as disseminations in the matrix or, more commonly, as anastomosing veinlets and semi-massive to massive cm- to m- wide pyritic bands commonly oriented sub-parallel to S_1. Locally, the pyrite-rich sub-zone is clearly hosted by m-wide GFP of the Riot Intrusive Suite with up to 20% blue quartz and disseminated rutile. Because of its close proximity with the Cinq Cerf Fault Zone, this sub-zone has been highly deformed, especially its northern limit which is mylonitized.

STRUCTURAL GEOLOGY

Multiple episodes of deformation are recognized regionally in the Hope Brook area, including pre-Silurian (D_1) and Silurian-Devonian deformation increments (D_2-D_3). The D_1 phase of deformation has been documented regionally (O'Brien et al., 1991), but corresponding structures have not been recognized in the vicinity of the deposit. This is probably due to the presence of intense hydrothermal alteration and high D_2 strain as documented below. A further complication stems from the fact that the main structural elements in both the Silurian and Late Proterozoic sequences are co-planar.

D_2-D_3 Main Phase of ductile deformation (post-422 Ma/pre-390 Ma)
D_2: The D_2 event records the development of the Late Silurian Cinq Cerf Fault Zone, which is a high strain zone, overlapping the contact between the Silurian and Late Proterozoic rocks. Most of the hydrothermally altered rocks around the deposit are located within the D_2 high strain zone. Outside this fault zone, the strain is highly heterogeneous but, in general, of moderate intensity with local metre-wide high strain zones, especially in the Late Proterozoic rocks.

Away from the Cinq Cerf Fault Zone, the deformation is dominated by a NE-trending and southeasterly steeply dipping foliation, generally parallel to bedding. Given the coplanarity of D_1 and D_2 structures, as indicated above, there is a possibility that in the Late Proterozoic rocks the fabric outside the southern limit of the Cinq Cerf Fault Zone could be a S_1-S_2 fabric. Although, this fabric progressively intensifies towards the Cinq Cerf Fault Zone and suggests that it is most probably an S_2 fabric. A number of D_2 high strain zones defined by intense NE-striking, steeply dipping and essentially bedding parallel S_2, overprint all lithologies except the Chetwynd Granite.

Within the Cinq Cerf Fault Zone, rocks are highly strained and commonly mylonitized although the strain is heterogeneous due to competency contrast between the massive silicic rocks and the advanced argillic alteration zone and Whittle Hill Sandstone rocks; some massive silicic rocks have preserved their primary texture. Stretching lineations are rather poorly developed but, moderately to steeply plunging stretching lineations (L_2) are locally present in the La Poile Gr conglomerate. Aspect ratios of granitoid cobbles indicate that the D_2 bulk strain was mainly dominated by flattening. However, local shear bands in quartz-pyrophyllite schists exposed at the Chetwynd Shaft combine with the oblique- to down-dip lineations clearly indicate reverse-sinistral sense of shearing along the Cinq Cerf Fault Zone. Local evidence of dextral strike-slip motion given by book shelves and C-S type fabric present within the Whittle Hill Sandstone are compatible with local, shallow plunging stretching lineations present on S_2 and with E-W trending sub-vertical extensional quartz veins.

D_2 S_3 subvertical crenulation cleavages strikes N-S and less commonly NW-SE. S_3 cleavages are axial planar to S-SW to NE-plunging centimetre to metre-scale asymmetric to chevron F_3 folds.

D_3-Brittle Structures
Brittle faults are widespread in the Hope Brook deposit. Two important D_3 faults: the 11A and 51A faults are NE- to ENE-trending and sub-vertical. They both contain sub-horizontal striations.

Note: For a detailed geological description of the deposit and U-Pb zircon dating see Stewart (1992) and Dubé et al. (1998).

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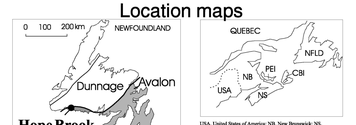

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