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MINERALIZATION IN WESTERN WHITE BAY

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ABSTRACT

The western White Bay area has a complex metallogeny, characterized by three broad styles of mineralization: i) structurally controlled mesothermal gold mineralization, ii) stratabound carbonate-hosted galena mineralization and iii) granite-hosted fluorite and molybdenite mineralization. The gold mineralization occurs in a variety of units of different ages and rock types. The mineralization and related alteration appear to be concentrated along fault and shear zones and may crosscut lithological contacts, e.g., at Rattling Brook. The alteration assemblages and variety of host rocks, along with the presence of CO_2-rich fluid inclusions in associated quartz gangue, suggest that the mineralization formed at considerable depths and is mesothermal rather than epithermal as has been previously suggested. It is possible that most of the gold occurrences in the western White Bay area formed as a result of large-scale, deep-seated hydrothermal circulation during late Silurian or younger times. The carbonate-hosted galena mineralization is found in brecciated dolostone within the Lower Volcanic formation. This mineralization is not enriched in gold and may have formed from fluids emanating from the Carboniferous Deer Lake Basin to the south. The granite-hosted fluorite and molybdenite mineralization is minor and is found within the Gull Lake intrusive suite and related aplitic dykes. It is likely related to late-stage magmatic processes and is probably not related to the gold mineralization in the area.

INTRODUCTION

This report is a partial compilation of metallic mineral occurrences in the western White Bay area. These data have been compiled as part of a larger forthcoming report (Tuach and Saunders, *in preparation*) produced as the result of a five-year metallogenic study of the area.

The western White Bay area has had a long but sporadic history of mineral exploration beginning with the discovery of the West Corner Brook gold showing in 1898, and the working of the Browning gold mine in 1903. In the mid 1930's the Simms Ridge and Freemans prospects were discovered and trenched and the Browning Mine was re-examined. Other than a reconnaissance survey by Newmont in the 1960's, little work was done in the area until the late 1970's, when Noranda Exploration Company Limited discovered the Turners Ridge Prospect. However, during the 1980's, exploration activity has increased substantially, sparked by the discovery of the Rattling Brook gold deposit and the release of much ground that had been tied up under the old concession system.

The Department of Mines and Energy began a metallogenic study of the area in 1985. This work has been documented in several papers and field-trip guides including those by Tuach (1986, 1987a, b), Tuach and French (1986), Tuach *et al.* (1988), Saunders and Tuach (1988), and Tuach and Saunders (1990). The present paper presents a metallogenic synthesis of the western White Bay area, drawing heavily on these reports and on the data presented in numerous mineral exploration assessment reports on open file with the Newfoundland Department of Mines and Energy. Emphasis has been placed on gold-bearing occurrences and many small base-metal-only indications have not been described. The work has shown that the western White Bay area is host to at least three broad styles of mineralization, namely structurally controlled gold mineralization, stratabound carbonate-hosted lead mineralization, and minor granite-hosted fluorite and molybdenite mineralization. This paper describes significant examples of the occurrences and presents some interim conclusions concerning their various types of genesis.

GENERAL GEOLOGY

The regional geology of the White Bay area has been described by Smyth and Schillereff (1982) and Tuach (1987a, b). The area is bisected by the Doucers Valley fault complex, a major structural lineament that juxtaposes middle to late Proterozoic granitic and gneissic basement and Eocambrian to Cambrian platformal sediments to the west, with Paleozoic oceanic and continental volcanic and sedimentary rocks to the east (Figures 1 and 2). The fault complex has a long history of brittle and ductile movement dating from as early as Ordovician to Late Carboniferous or younger (Lock, 1969, 1972; Hyde, 1979; Tuach, 1987a).

The oldest rocks in the area are Precambrian quartzofeldspathic gneisses of the basement Long Range Inlier, which outcrops west of the Doucers Valley fault complex. These are intruded by late Proterozoic megacrystic to equigranular, granodioritic to granitic bodies, including the Apsy and Main River plutons. The gneisses and intrusive rocks are unconformably overlain by platformal clastic rocks

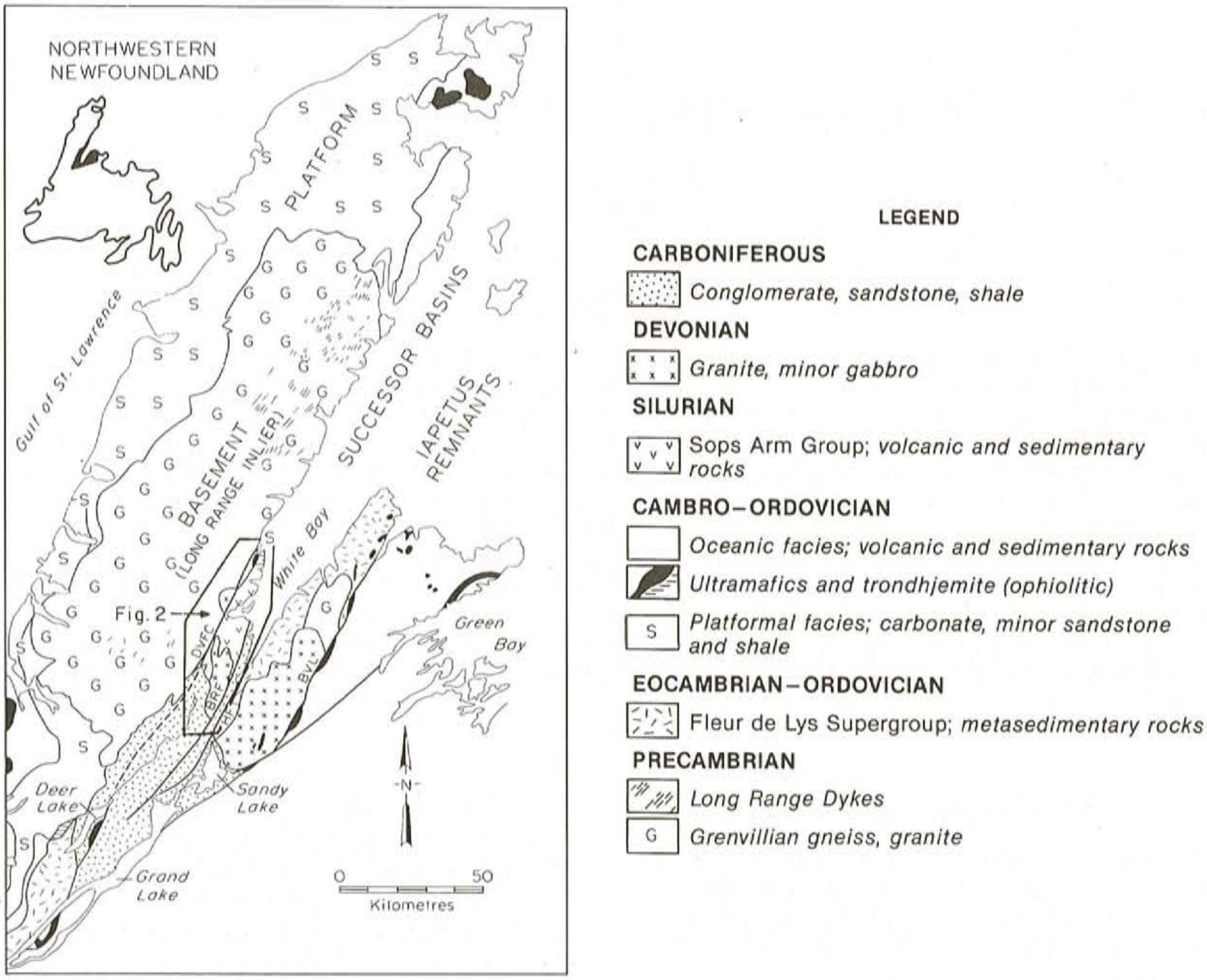


Figure 1. *General geology and tectonic elements of northwestern Newfoundland (from Tuach, 1987a). DVFC—Doucers Valley fault complex; BVL—Baie Verte Lineament; BRF—Birchy Ridge fault; HF—Hampden fault.*

and carbonates of the Eocambrian to Cambrian Coney Arm Group.

The Paleozoic rocks to the east of the Doucers Valley fault complex include Cambro-Ordovician ophiolitic, volcanic and volcaniclastic sequences of the Southern White Bay Allochthon (Smyth and Schillereff, 1982). These represent vestiges of the Iapetus Ocean (Williams, 1979) that were obducted westward during the Ordovician Taconian Orogeny (Williams and Stevens, 1974). The allochthonous rocks include slate, mélange and polydeformed mafic schist and form a laterally continuous, thin belt along the Doucers Valley fault complex. The ophiolitic Coney Head Complex (Williams, 1977), composed of tonalite—trondhjemite, minor gabbro and granite, is also included in the Southern White Bay Allochthon (Smyth and Schillereff, 1982).

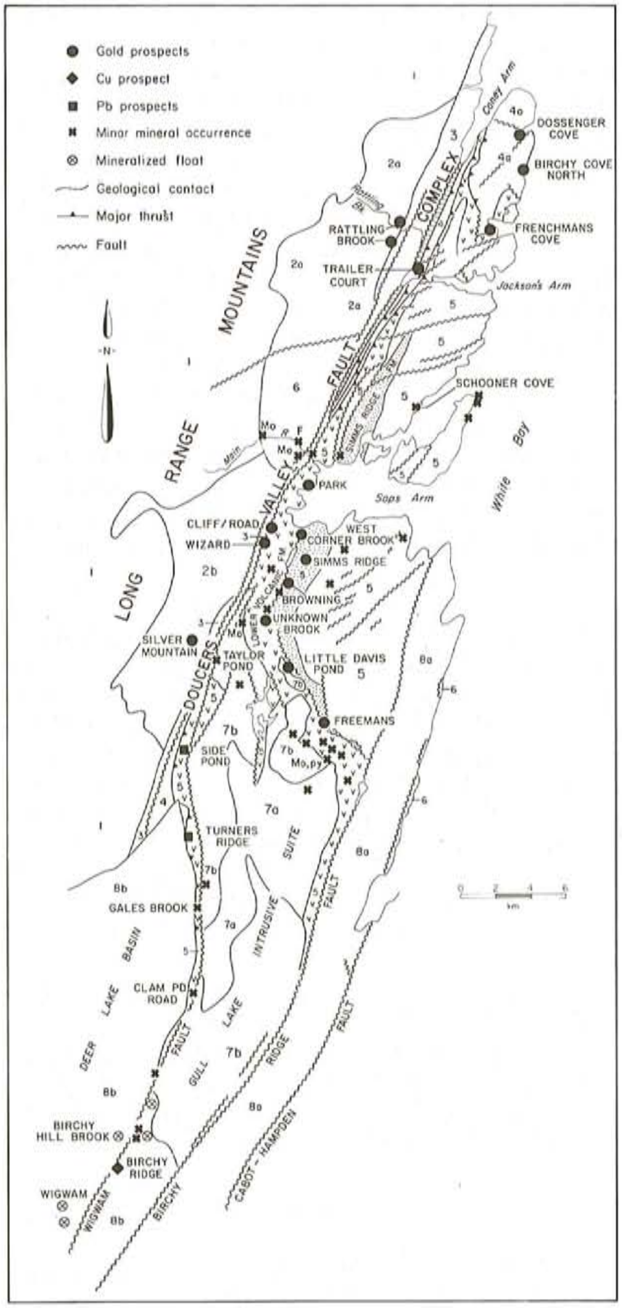
Silurian volcanic and sedimentary rocks of the Sops Arm Group unconformably or structurally overlie rocks of the Coney Arm Group and the Southern White Bay Allochthon. Within the Sops Arm Group, the Lower Volcanic formation and the Simms Ridge Formation host several gold occurrences (Figure 2). The Sops Arm Group dips moderately to the east and has been affected by west-directed thrusting that produced recumbent fold structures and a well-developed cleavage in the sedimentary units. It has been interpreted as one of several terrestrial caldera complexes formed during and after the final closure of Iapetus (Coyle and Strong, 1987).

The Sops Arm Group is intruded by the Devonian Gull Lake intrusive suite (Figure 2), which is made up of a variety of gabbroic to granitic rocks. The Devils Room granite, which intrudes the Long Range Inlier to the west of the Doucers Valley fault complex is included in the Gull Lake intrusive suite.

The youngest rocks in the area are the Carboniferous sediments of the Deer Lake Basin, which unconformably overlie or are faulted against the older rocks.

MINERALIZATION AND ALTERATION

The western White Bay area hosts three broad styles of mineralization:



LEGEND

UPPER PALEOZOIC (Basin-fill sequences and intrusions)

CARBONIFEROUS

8 **8a,** Anguille Group (Tournaisian): *greywacke, shale, minor sandstone and conglomerate;* **8b,** Deer Lake Group (Visean): *conglomerate, sandstone, siltstone*

DEVONIAN (ca. 398 Ma)

7 Gull Lake intrusive suite: **7a,** *intermediate and mafic intrusive rocks;* **7b,** *granite and trondhjemite*

6 Devils Room granite

SILURIAN

5 Sops Arm Group

LOWER PALEOZOIC ALLOCHTHON

CAMBRIAN – MIDDLE ORDOVICIAN

4 Southern White Bay Allochthon: *partially ophiolitic (mélange containing ultramafic blocks is cross-hatched);* **4a,** Coney Head Complex

LOWER PALEOZOIC AUTOCHTHON (Platform)

3 Coney Arm Group: *carbonate, shale, quartzite*

PRECAMBRIAN (Grenvillian basement)

MIDDLE PROTEROZOIC AND EARLIER

2 *Massive to foliated, feldspar-megacrystic, granitoid plutons;* **2a,** *Apsy pluton;* **2b,** *Main River pluton*

1 *Leucocratic gneiss, amphibolite, and gabbro*

Figure 2. *General geology and mineral occurrences in western White Bay. The Lower Volcanic formation and the Simms Ridge Formation of the Sops Arm Group are patterned. Compiled by Tuach (1987a) from mapping by Smyth and Schillereff (1981, 1982), Hyde (1982) and Erdmer (1986a,b).*

i) Structurally controlled mesothermal gold–base-metal mineralization occurs in the volcanic and sedimentary rocks of the Silurian Sops Arm Group (e.g., Browning Mine, Unknown Brook) as well as in Late Proterozoic granitoid rocks and unconformably overlying Eocambrian to Cambrian sediments (Rattling Brook and Silver Mountain) (Figure 2). Anomalous gold values have been found also, within the Murrays Cove schist and Coney Head Complex of the Southern White Bay Allochthon.

ii) Stratabound galena mineralization occurs in brecciated, altered dolostone of the Lower Volcanic formation at Turners Ridge and Side Pond (Figure 2).

iii) Minor fluorite and molybdenite are found in the granites and related aplitic dykes of the Gull Lake intrusive suite, which includes the Devils Room Granite (Figure 2).

GOLD MINERALIZATION

Gold mineralization is found in a variety of units of different rock types, ranging in age from Precambrian to at least as young as Silurian.

The most important deposit found to date is the Rattling Brook deposit and related peripheral showings (see Bruneau, 1984; French, 1985), hosted by Late Proterozoic altered granodiorite of the Apsy pluton and by unconformably overlying platformal sediments of the Coney Arm Group. Pyrite and arsenopyrite with associated gold are hosted by fractures, veinlets and shear zones and are disseminated within altered wallrock. Alteration minerals include K-feldspar, albite, ankerite, siderite and sericite. This mineralization has been previously extensively described in numerous assessment files and by Tuach and French (1986), McKenzie (1987b), Saunders and Tuach (1988). At the Silver Mountain showing, similar mineralization and alteration occur along faults within the Main River pluton (Figure 2). Here, gold values ranging between 100 and 5150 ppb have been found in pyrite-rich silica–carbonate–feldspar–sericite altered phases of the host granodiorite. Sporadic enrichments of chalcopyrite, galena and molybdenite, accompanied by pyrite and weakly anomalous gold, have also been found (French, 1987b).

Gold mineralization in the Rattling Brook area also occurs within Eocambrian to Cambrian platformal sediments of the Coney Arm Group that unconformably overly the mineralized granitoid. Minor gold mineralization occurs sporadically within the Coney Head Complex and the Murray's Cove schist of the Southern White Bay Allochthon.

The southern half of the Silurian Sops Arm Group is host to numerous gold occurrences that occur along shear zones. These are described more fully below.

Southern White Bay Allochthon

Carbonate alteration occurs intermittently over a distance of at least seven kilometres along the Doucers Valley fault complex. The alteration, which consists of Fe- and Mg-carbonate, sericite and green fuchsitic mica, is developed within sheared, chloritized slivers of mafic to ultramafic? rock within the Murray's Cove schist (O'Sullivan, 1986; Holmes *et al.*, 1988). Minor amounts of pyrite and arsenopyrite occur locally. The alteration zone has been extensively sampled but has returned only sporadic weakly anomalous (up to 450 ppb) gold values. At the Trailer Court occurrence (Figure 2), near the northeastern end of the alteration zone, a quartz, sericite, ankerite schist that contains minor pyrite, is exposed over a 120 m interval within chloritized mafic volcanics. The alteration here has been extensively chip- and channel-sampled (O'Sullivan, 1986; Tuach, 1986) but did not returned significant gold values. Near the other end of the alteration zone, about 6 km to the southwest, however, till concentrates have yielded several grains of visible gold and have returned gold values of up to 15.1 ppm (O'Sullivan, 1986).

Sporadic low-grade Au mineralization has been found in quartz–carbonate veins and localized pyritic shear zones that cut a variety of rock types in the Coney Head Complex. Quartz–carbonate veins, locally containing molybdenite, chalcopyrite and pyrite, cut gabbroic to tonalitic rocks along the western shore of White Bay (French, 1987a). Samples from these veins generally returned Au assays of <200 ppb, but a value of 4600 ppb Au over a 0.75 m width was returned from one quartz–carbonate vein on the coast (Birchy Cove North occurrence–MODS ref. 12H/15-Mo004). This vein also contains chalcopyrite, pyrite and about 0.5 percent molybdenite. Nearby swarms of sheeted leucocratic muscovite granite dykes contain disseminated pyrite and are cut by numerous quartz veins (Smyth and Schillereff, 1982). A 1.5-m-wide quartz–feldspar pegmatite, which cuts quartz gabbro about 150 m to the north, contains minor pyrite, chalcopyrite and molybdenite (Smyth and Schillereff, 1982). The mineralized pegmatite and the granite dykes may be genetically related to the gold–molybdenite-bearing quartz veins.

To the northwest of the above showing, numerous quartz–carbonate veins that contain galena ± pyrite cut a quartz–sericite schist unit that may be altered volcanic rock (French, 1987a). This schist has a maximum exposed width of 30 m and a strike length of 0.75 km along a northeast-trending fault zone. It contains finely disseminated pyrite and is host to silica–carbonate–potassium alteration similar to that seen at the Rattling Brook deposit (French, 1987a). A grab sample from a quartz–carbonate vein that cuts this schist at Dossenger Cove (MODS ref. 12H/15-Pb002) returned 5.4 percent Pb, 34 ppm Ag and about 170 ppb Au.

At the southern margin of the Coney Head Complex at Frenchmans Cove (MODS ref. 12H/15-Au002), a grab sample from a quartz–carbonate vein in a localized zone of pyrite-rich sheared granitoid has returned a value of 1800 ppb Au (O'Sullivan, 1986). This occurrence is also known as Jacksons Arm North (Tuach, 1990).

Sops Arm Group

Gold mineralization in the Sops Arm Group occurs in lode quartz veins in unaltered to strongly sericitized and carbonatized, altered volcanic and sedimentary rocks. The gold occurrences are concentrated in the Lower Volcanic and Simms Ridge formations and are generally found along or near shear zones (Figure 2). The quartz veins generally contain carbonate and minor to significant amounts of base metals (principally pyrite, chalcopyrite, galena and sphalerite); locally tourmaline or barite occur in the veins. The two main showings, which are located along a north–south-trending fault that runs along a small brook (Corner Brook), are the Unknown Brook prospect and the Browning Mine (a past producer of about 5.1 kg of Au). The other occurrences are generally small, or are characterized by sporadic Au concentrations, and are hosted by quartz veins or altered shear zones. These include the Simms Ridge, West Corner Brook, Road, Wizard and Freemans occurrences (Figure 2). Other small base-metal (i.e., pyrite, chalcopyrite, galena, sphalerite, bornite, malachite) occurrences and barite-bearing quartz veins are found in various units within the Sops Arm Group. Many of these are on file with the Newfoundland Department of Mines and Energy's Mineral Occurrence Data System, and may or may not have been assayed for Au or other metals.

A description of the more significant occurrences within the Sops Arm Group follows.

Unknown Brook Gold Prospect

At the Unknown Brook showing (MODS ref. 12H/10-Au005) gold is found in syn-deformational pyritic quartz–carbonate–potassium feldspar veins. These occur within a conglomerate bed at the top of the Lower Volcanic formation near the contact with the overlying Simms Ridge Formation and are above and parallel to a thrust plane (Figure 3) that is defined by a 15-m-thick zone of pervasive and intense sericite alteration (Tuach *et al.*, 1988). This was described as 'sheared, carbonatized and pyrophyllitized' by Snelgrove (1935). However, recent XRD analysis (Tuach and Saunders, *in preparation*) of three samples from this zone indicates only muscovite and quartz. Minor pyrite and narrow quartz–carbonate veins are also present in the alteration zone and siliceous, cigar-shaped rods surrounded by thin bands of sericite are ubiquitous (Plate 1). Previous workers have considered these rods to be deformed primary structures such as rhyolitic lithophysae or pyroclastic fragments. However, they may be tectonic lithons (formed by the intersection of anastomosing foliation seams) that were produced during movement along the thrust plane (B. O'Brien and J. Hayes, personal communications, 1990). Hayes and O'Driscoll (1990) described similar structures in pyrophyllitized and sericitized shear zones within the Harbour Main Group.

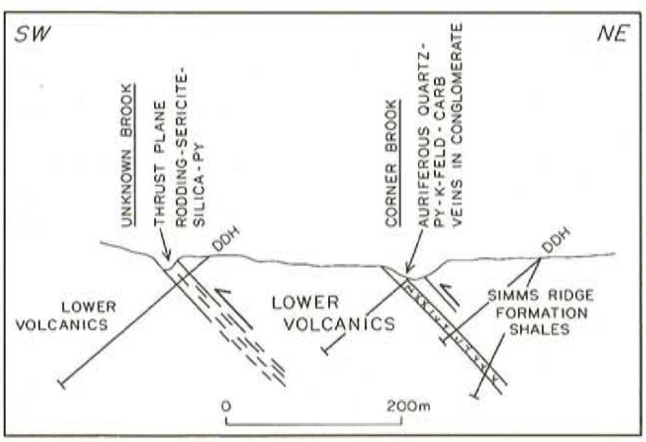


Figure 3. *Schematic section of the geology in the vicinity of the Unknown Brook deposit, as defined by drilling by U.S. Borax Exploration. Gold-bearing quartz–potassium feldspar–pyrite veins occur in a conglomerate at the top of the Lower Volcanic formation. An underlying silica-sericite alteration zone is interpreted to represent a thrust plane. From Tuach* et al. *(1988) based on information provided by B. Mercer.*

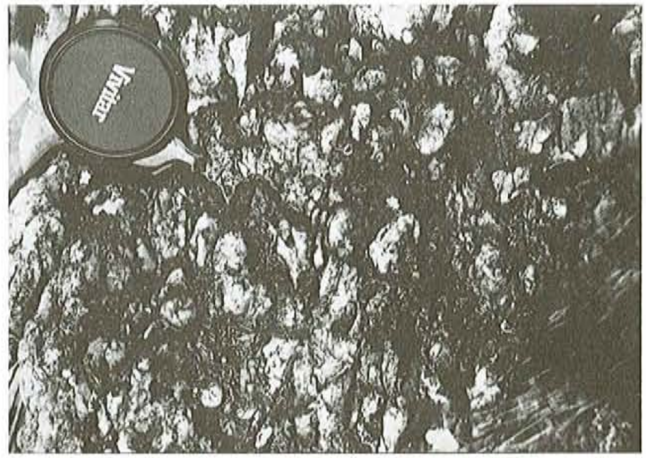


Plate 1. *Cigar-shaped siliceous rods in silica–sericite alteration zone at Unknown Brook. These structures may be tectonic lithons formed by the intersection of anastomosing foliation seams.*

The main gold zone is exposed at the junction of Unknown Brook and Corner Brook and for about 250 m upstream (Figure 2), where several lenticular, weakly deformed, auriferous, K-feldspar–quartz–carbonate–pyrite veins up to 25 cm wide cut the conglomerate (Tuach, 1987b). The veins also contain minor galena and fluorite and rare stibnite; the gold occurs as tiny inclusions of electrum (Au:Ag is 80:20) within galena (Burton, 1987).

Drilling in this area by U. S. Borax yielded the following intersections from four out of nineteen holes: 9.3 ppm Au over 1.74 m, 8.6 ppm Au over 2.59 m, 35.7 ppm Au over 0.33 m, and 78.9 ppm Au over 0.12 m; grab samples of vein material from outcrop have returned values of up to 85 ppm Au, 180 ppm Ag and 7450 ppm Pb (Burton, 1987).

Browning Mine

At the Browning Mine (MODS ref. 12H/10-Au001) deformed syn-deformational, or possibly pre-deformational, quartz veins occur in altered volcanic and sedimentary rocks of the Lower Volcanic and Simms Ridge formations (Tuach, 1987b).

This mine was the site of the first gold mining in Newfoundland in 1903. Approximately 149 troy ounces (5.1 kg) of Au were produced from 1000 tons of ore (Murray and Howley, 1918; Snelgrove, 1935). The rock was crushed in a stamp mill, and the gold recovered by use of a Wilfley table (Murray and Howley, 1918; Lundberg, 1936). The mine was developed in 1902 but by 1904 production had ceased as the high-grade ore was apparently exhausted. In 1936, the mine was partly dewatered and the workings mapped; several samples were taken with negative results (Lundberg, 1936).

The workings, described by Lundberg (1936) and Heyl (1937), consisted of three vertical shafts located on the east bank of Corner Brook. The southern shafts are approximately

70 m apart and were connected by an irregular sloping drift at a depth of about 20 m; another shaft is located about 200 m to the northeast. An adit runs from the east bank of the brook to the middle shaft. Material from the waste tips can be examined nearby.

Mineralization and alteration is located at the contact between mafic volcanics of the Lower Volcanic formation and foliated shales of the Simms Ridge Formation. The shales strike parallel to Corner Brook, about 025° and dip about 30° southeast (Snelgrove, 1935; Heyl, 1937); the underlying volcanics are essentially conformable. A low-angle east-dipping fault cuts through the shales near the contact with the underlying felsic volcanics and can be traced along or parallel to the brook for about 1 km (Heyl, 1937; McKenzie, 1985a). This fault generally parallels, but locally crosscuts, bedding; there appears to have been some rotational movement but the amount of displacement has probably not been great (Heyl, 1937). Where the fault outcrops beneath the adit, it is represented by a schistose, chloritic band, up to 1 m wide (Tuach, 1987b). Elsewhere, it is manifested only by an indistinct crushed zone (Heyl, 1937).

Shales above the fault are typically sericitic, carbonate spotted and locally pyritic and are cut by quartz–carbonate–sulphide veins up to 0.5 m thick (McKenzie, 1985a). The sericite alteration ('pyrophyllite' of Snelgrove, 1935) of the shales is locally very intensive; X-ray diffraction analysis of a sample of this alteration from upstream from the adit revealed muscovite, quartz and dolomite (Tuach and Saunders, *in preparation*). Smaller areas of alteration affect the shales and minor silicic tuff beds farther upstream.

The carbonate-spotting (see Tuach, 1987a, Plate 5) of the Simms Ridge shales is a regional feature and is ubiquitous south of Sops Arm. To the north of Sops Arm, these spots are absent and the Simms Ridge shales are apparently unaltered (O'Sullivan, 1986). These spots, which have been previously described as siderite by numerous workers, are in fact the result of partial to complete replacement of light-coloured carbonate crystal porphyroblasts by limonite during surface weathering. The XRD analysis of samples from the intense sericite alteration zone suggests the unweathered crystals are dolomite. They are locally flattened along the foliation of the host rock.

A unit of grey, massive, orange- to brown-weathering carbonate locally outcrops beneath the fault. This unit is 5 to 10 m thick, contains cherty lenses, and is characterized by fuchsite spots and disseminated galena and pyrite mineralization (McKenzie, 1985a; Tuach, 1987b). It is cut by narrow quartz–carbonate–galena veinlets and galena fills porosity within the rock (Plate 2). It grades into an underlying fuchsitic, pyritic, intensely carbonate-spotted unit that forms the base of the Simms Ridge Formation (Figure 4). The galena-rich carbonate zone may be the result of massive replacement of the host rock (McKenzie, 1985a) or it may be the altered equivalent to fossiliferous limestone beds at the base of the Simms Ridge Formation (these contain minor disseminated galena) that outcrop approximately 500 m upstream (Tuach, 1987b).

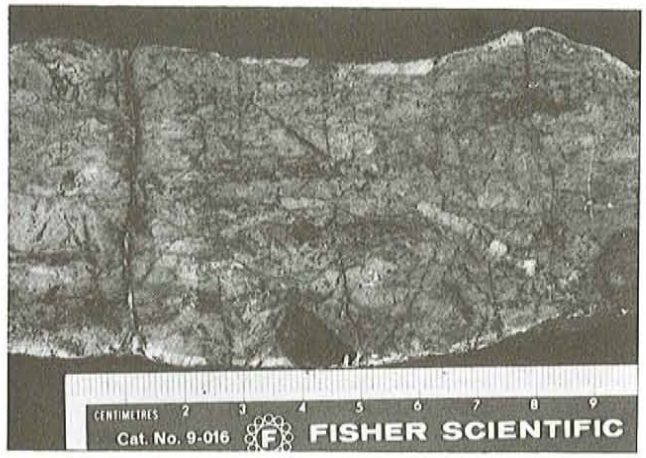


Plate 2. *Disseminated galena mineralization filling open spaces in massive carbonate unit at the Browning Mine.*

Quartz–carbonate veins are common in all the outcrops and locally contain sulphides and anomalous gold. They vary from boudinaged and tightly folded in the plane of the schistosity to crosscutting, post-deformational veins (Tuach, 1987b). Heyl (1937) reported that quartz lenses are most abundant within four feet of the low-angle fault, and that narrow quartz veins are also found along the fault plane. The quartz lenses are generally between 18 and 30 inches long and 3 and 9 inches thick, and strike parallel to bedding but dip more steeply (Heyl, 1937).

The mineralization as described by J. P. Howley in 1902 consisted of quartz vein-hosted pyrite, chalcopyrite, sphalerite, galena and minor specularite and pyrrhotite; gold appeared to be concentrated with the sphalerite and galena, but rare free gold as wire and nuggets in the quartz was also found. High silver values were also associated with the galena (Murray and Howley, 1918). Howley also reported that gold was panned from crushed wallrock and overlying soils as well as from vein material. Currently, minor pyrite, galena, chalcopyrite and sphalerite in deformed quartz veins are exposed in the blasted cut at the north end of the alteration zone (Tuach, 1987b). These mineralized veins may represent the ore horizon; a grab sample from a one-inch-wide chalcopyrite vein returned two analyses of more than 7000 ppb Au (Tuach and Saunders, *in preparation*).

In 1985 and 1986, BP-Selco Resources Limited carried out exploratory trenching and diamond drilling in the vicinity of the Browning Mine. Figure 4 shows a simplified cross-section based on data from two drillholes (McKenzie, 1985a, 1987a). A chip sample over a 3 m interval of shale cut by 5- to 10-cm quartz veins produced a gold assay of 740 ppb; a 0.4-m-wide quartz–carbonate–sulphide vein in a drillhole assayed 7.2 ppm Au and a 2-m-long section of brecciated, pyritic, felsic tuff cut by quartz–carbonate veins assayed 1.4 ppm Au. The fuchsitic carbonate unit was found to contain tens to hundreds of ppb Au (McKenzie, 1985a).

Trenching and drilling (2 holes) were also carried out at the newly discovered Browning West showing about 1 km

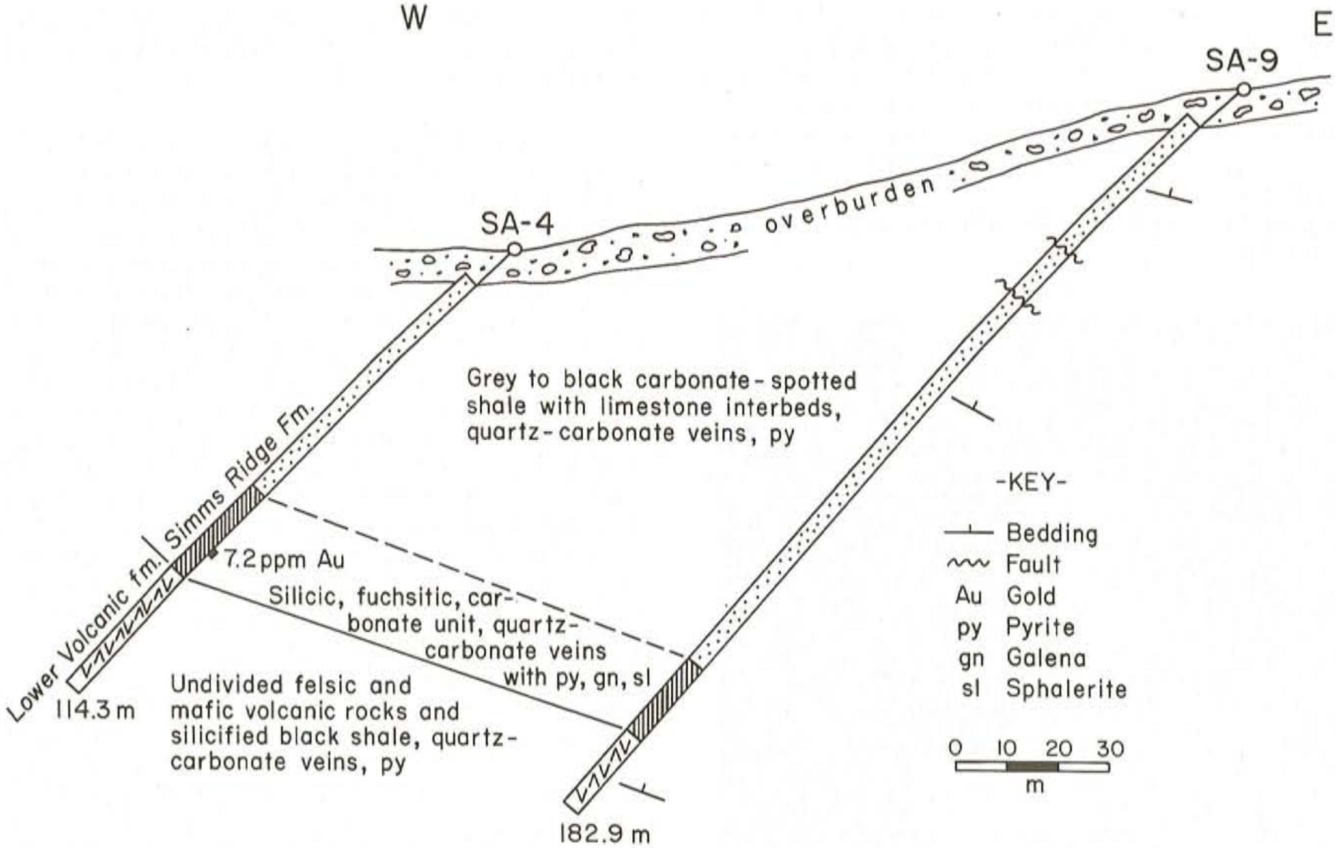


Figure 4. *Simplified cross section through two drillholes from the Browning Mine area. From McKenzie (1985a, 1987a). The contact between the silicic, fuchsitic, carbonate unit (dashed line) is in places a low-angle, semi-conformable fault, below which a 5- to 10-m-thick, massive, galena-bearing, carbonate unit occurs locally in surface exposures.*

due west of the Browning Mine. The drillholes intersected brecciated, carbonatized and sericitized felsic volcanics. A 2-m-long section of core containing a 10-cm-wide quartz–carbonate–pyrite vein assayed 2670 ppb Au. A random chip sample of vein quartz from throughout a similarly altered and mineralized trench assayed 4850 ppb Au (McKenzie, 1986).

Other Gold Occurrences in the Sops Arm Group

Auriferous deformed quartz veins cut volcanic rocks of the Lower Volcanic formation along the Doucers valley fault complex. At the Wizard showing (MODS ref. 12H/10-Au006) (Figure 2) strongly foliated, sericitic schist is developed within felsic tuff near the contact with overlying chloritic mafic volcanics (O'Sullivan, 1986). The sericitic zone contains disrupted and tightly folded 3- to 30-cm-wide quartz veins that locally make up 60 percent of the section. The quartz veins contain minor pyrite and tourmaline, and traces of galena and have returned gold values of 5300 and 6150 ppb from grab samples and 2300 ppb over a 2.4 m channel sample (O'Sullivan, 1986; Tuach and Saunders, *in preparation*). Drilling by Esso Minerals Limited has traced the zone of quartz veining for a strike length of 285 m and to a depth of 50 m. The best drill results were 1700 ppb over 0.7 m and 1000 ppb over 0.8 m from two closely spaced (15 m) holes–one down-dip from the other (O'Sullivan, 1986). To the north, at the Road showing or Sops Arm Road showing (MODS ref. 12H/10-Au008) (Figure 2) and the nearby Cliff Zone occurrence (MODS ref. 12H/10-Au007), auriferous quartz veins and shear zones cut brecciated tuff of the Lower Volcanic formation over a strike length of at least 1 km. Minor pyrite, galena, chalcopyrite and barite occur locally in the veins. The host rock is variably chloritized, sericitized and carbonatized. Gold values of up to 3650 ppb from grab samples (O'Sullivan, 1986) and 990 ppb from chip samples (McKenzie, 1985b; Tuach, 1990) have been identified. These outcrops are on or near faults of the Doucers Valley fault complex, and are severely deformed and schistose. The deformation of the quartz veins and the development of local areas of intense brecciation and 'gouge' in these exposures is probably due to movement along the Doucers Valley fault complex during the Carboniferous, and these features have been superimposed on earlier more ductile deformation features (Tuach, 1987b).

The Park Prospect (MODS refs. 12H/15-Pyr009 and -Pyr010) (Figure 2), includes several small occurrences (Tuach, 1986). A 020°-trending, 30-cm-wide vertical pyrite-bearing quartz vein and several smaller veins cut sericitized tuff of the Lower Volcanic formation over a 20 m distance in a roadcut. A similarly trending, 3-m-long, galena-bearing quartz vein occurs about 25 m west of the road. Chips from the galena-bearing vein returned Au values of 2730 ppb and chips from a quartz–pyrite vein on the road returned Au values of 203 and 541 ppb. Plate 3 shows galena with associated gold in a sample from this occurrence. A similar style of mineralization outcrops over a 30 m² area in a nearby quarry. Mineralization consists of stringer pyrite, minor chalcocite and chalcopyrite in narrow quartz veins cutting rhyolitic tuff. Chips from this outcrop returned Au values of 120 ppb.

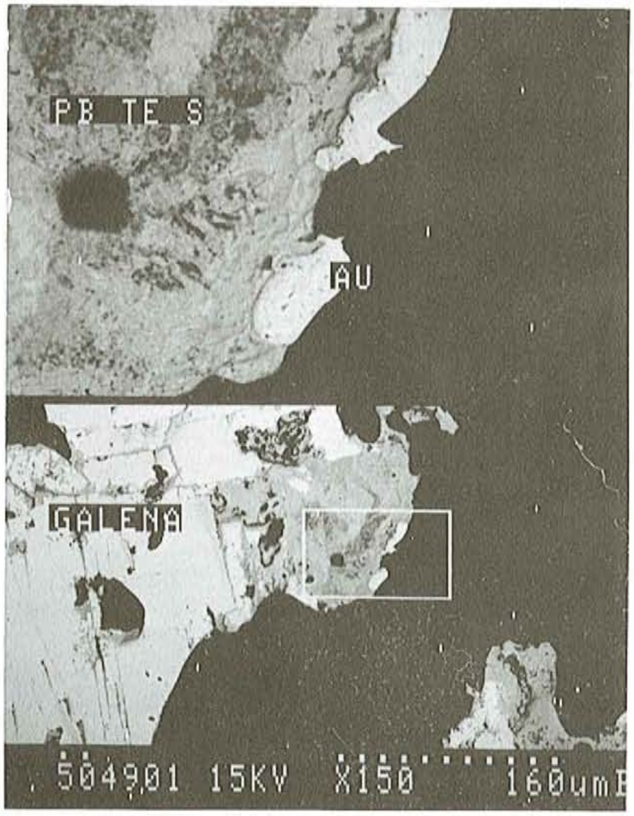


Plate 3. *Gold on rim of galena grain in quartz–pyrite vein, which is one of several mineralized veins that cut tuffs of the Lower Volcanic formation at the Park Prospects. Scanning electron photomicrograph (top is 5x bottom). The larger gold grain is 30 microns long.*

The West Corner Brook prospect (MODS ref. 12H/10-Au002) was the first discovered gold occurrence in the Sops Arm area. It was staked in 1898 by J.M. Jackman and a 19-m-long adit, a shallow shaft and several test pits and trenches were excavated at three localities. The following description of this showing was provided by D. Wilton (personal communication, 1990). An intense network of ramifying quartz ± carbonate veins cuts rhyolite porphyry and tuff of the Sops Arm Group. Some of the larger veins are sigmoidal. The veins and, to a lesser extent, the wallrock, contain clots of pyrite, and minor galena, chalcopyrite and sphalerite; specularite is common in the larger veins. The fresh rhyolite is purplish, but intensive hematization has locally imparted a pinkish colour. The rhyolite is also variably sericitized and is locally fractured and brecciated. Snelgrove (1935) assayed three grab samples from mineralized veins; the highest results were about 4400 ppb Au and 63 ppm Ag from a pyritic quartz vein. Grab samples of vein material assayed up to 1 ppm Au.

The Simms Ridge Prospect (MODS ref. 12H/10-Au003) was discovered in 1933 and by 1936 nineteen trenches and a shallow shaft had been excavated. Snelgrove (1935) visited the area during trenching and Heyl (1937) provided a detailed trench map. The trenches were excavated to explore a 150-m-long northeast-trending zone of irregular and lenticular quartz veins that cut shales of the Simms Ridge Formation and also cut a pretectonic felsite dyke (Unit 22 of Smyth and Schillereff, 1982) that intrudes the shales. The shales exhibit the typical carbonate-spotting and fuchsitic alteration (see above) and both the shales and the felsite are variably sericitized and locally contain disseminated pyrite. Individual quartz veins are up to 5 m thick, and contain sporadic disseminated to fist-sized bunches of sulphides (mainly pyrite, chalcopyrite and galena). Snelgrove (1935) reported visible native gold associated with the galena and confirmed this with microscopic study. He also reported an assay of 5 ozs., 4 dwts., 12.8 grs. Au (about 180 ppm) and 47 ozs., 19.2 grs. Ag (about 1600 ppm) from a selected sample of weathered galena; ten channel samples, however, returned values of nil to 1.7 ppm Au. Lundberg (1936) reported an average grade of 0.04 oz/t (1.37 ppm) Au from 43 samples taken by a variety of methods (grab, chip, channel and bulk sampling). More recently, four grab samples from two trenches returned values between 0.23 and 0.87 oz/t (7.8 and 29.6 ppm) Au (O'Sullivan, 1981) and five samples from a large quartz vein at the showing returned Au values between 340 and 1150 ppb (McKenzie, 1985b). The gold values, however, are erratic and spotty and a significant deposit has not been outlined. The association of gold with galena is seen in other occurrences in the area (e.g., the Park Prospect, Plate 3).

The Freemans prospects (MODS ref. 12H/10-Au004) were discovered and trenched in 1935. Narrow quartz–carbonate veins cut clastic and carbonate sediments of the Simms Ridge Formation. Minor amounts of pyrite and chalcopyrite occur in the veins and disseminated pyrite, chalcopyrite, galena and sphalerite are locally present in the carbonate beds (Heyl, 1937; McKenzie, 1986). Locally, fine black needles of tourmaline are found in the quartz veins (Heyl, 1937). A sample of mineralized limestone returned a Au value of about 4.3 ppm (Heyl, 1937). BP-Selco Resources Limited resampled the old trenches in 1986, but reported only sporadic Au values of less than 100 ppb and a Cu value of about 0.5 percent (McKenzie, 1986).

Similar mineralization occurs about 3.5 km to the northwest near Little Davis Pond, in proximity to, and within the Big Davis Pond granite, a small high level stock that is part of the Gull Lake intrusive suite. This mineralization was discovered and sampled by BP-Selco Resources Limited (McKenzie, 1986, 1988). Samples from a 25-cm-wide quartz–pyrite vein that cuts the granite returned assays of 0.65 and 0.42 oz/t (22.3 and 14.4 ppm) Au, and were found to contain anomalous Ag, Bi, Pb and W. Two nearby quartz–pyrite–arsenopyrite–fluorite veins returned values of less than 40 ppb Au. The wallrock to the veins was not found to be mineralized. The surrounding carbonate member of the Simms Ridge Formation is cut by an extensive quartz–carbonate veinlet stockwork that locally contains pyrite, galena, chalcopyrite, sphalerite, fluorite, and malachite (MODS ref. 12H/10-Pyr020). A sample of this mineralization returned a value of 1900 ppb Au, >200 ppm Ag, 774 ppm Bi and more than 1 percent each of Cu and Pb; another sample returned a value of more than 1 percent Zn and a third assayed 570 ppb Au (McKenzie, 1986, 1988).

Mineralized (pyrite, galena, chalcopyrite) quartz veins cut a quartz monzonite sill within the Natlins Cove Formation at Schooner Cove (MODS ref. 12H/15-Ag001). Two selected sulphide-rich samples gave anomalous Ag (69 and 45 ppm) but no gold (Snelgrove, 1935).

STRATABOUND CARBONATE-HOSTED LEAD MINERALIZATION

Significant galena mineralization occurs in altered brecciated dolostone of the Lower Volcanic formation (Plate 4). In this unit, mineralization occurs sporadically over a distance of 15 km. Two main concentrations of mineralization, the Turners Ridge (MODS ref. 12H/11-Pb001) and Side Pond (MODS ref. 12H/11-Pb002) deposits, and several smaller occurrences, e.g., Gales Brook (MODS ref. 12H/10-Pb001) and Taylor Pond (MODS ref. 12H/10-Pb003) have been outlined by mapping and drilling (Dimmell, 1979; Mercer, 1986). Minor galena mineralization is also found in the surrounding felsic volcanics of the Lower Volcanic formation.

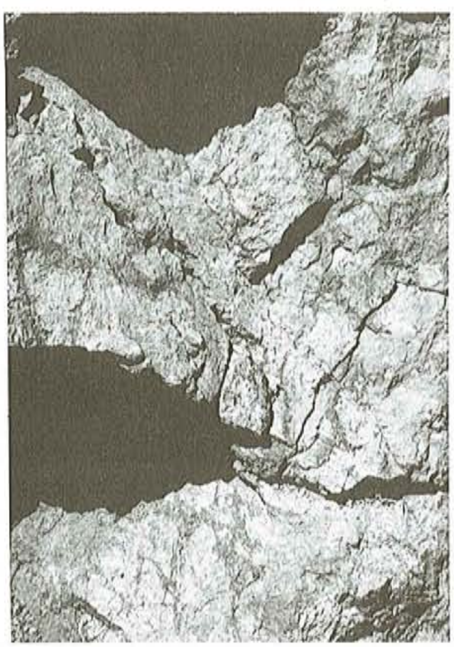


Plate 4. *Galena forms matrix to brecciated dolostone of the Lower Volcanic formation at Turners Ridge. Vertical distance about two metres.*

The Turners Ridge deposit contains approximately 200,000 tonnes of 3 to 4 percent lead; a schematic section through the deposit (Dimmell, 1979) is shown in Figure 5. The grey-green rock is predominantly severely brecciated dolostone characterized by local pervasive calcite alteration. Breccia fragments are generally angular and are commonly non-rotated, but where brecciation is very intense, fragments are fine-grained, rounded and corroded by calcite. Coarse- to fine-grained galena accompanied by calcite and minor barite, silica, pyrite and sphalerite occurs in fractures and fracture stockworks (Plate 4; Tuach, 1987a, Plate 6). The calcite has corroded and replaced rims of dolostone fragments. Brecciation, mineralization and calcite alteration are most intense at the Turners Ridge deposit, and not as well-developed at the Side Pond showing to the north, where mineralization is generally restricted to irregular veins.

Drilling has shown that the Silurian dolostone and rhyolite have been thrust westward over coarse, relatively undeformed conglomerate of the Carboniferous North Brook Formation (Figure 5), and additional (contemporaneous?) low-angle thrusts may occur in the Silurian volcanic rocks. For example, at the Turners Ridge deposit rusty-weathering, buff to pink, severely brecciated rhyolite of the Lower Volcanic formation has been locally thrust over the dolostone (Plate 5). These low-angle thrusts may represent localized, late movements on the adjacent Wigwam Fault (Tuach, 1987b). Minor galena mineralization occurs in the brecciated rhyolite near its contact with the dolostone, indicating that mineralization postdates the thrust faulting and is at least as young as Carboniferous.

FLUORITE AND MOLYBDENITE

Smyth and Schillereff (1982) reported minor fluorite and pyrite occurrences in the Moose Lake granite and Dunford (1984) reported fluorite occurrences in the Devils Room granite. In the latter, it occurs as fracture coatings and in the matrix of a 1-m-wide tuffisite zone (Tuach, 1986).

Minor coarse-grained molybdenite is found in granite pegmatite, quartz veins and pods within the Gull Pond granite and traces of molybdenite occur in small quartz veins in the Devils Room granite (Tuach, 1987a). Molybdenite mineralization also occurs in aplite dykes that cut the Gull Pond granite, the Black Duck Ponds trondhjemite and the Sops Arm Group in the Gull Pond Brook area (Dimmell, 1979). Many of these occurrences are listed with the Mineral Occurrence Data System of the Newfoundland Department of Mines and Energy (MODS ref. 12H/10-Mo001-008 and 12H/15-Mo002/003). Assays of mineralized aplite float returned values as high as 1.8 percent Mo and a quartz–aplite vein containing pyrite, chalcopyrite and a grey metallic mineral returned an analysis of 0.37 oz/t (12.7 ppm) Ag (Dimmell, 1979). Dimmell (1979) also reported silt sample analyses in excess of 1000 ppm Mo, 600 ppm Pb, 500 ppm U and 60 ppm WO3 from areas underlain by the Gull Lake intrusive suite.

DISCUSSION AND CONCLUSIONS

On a regional scale, there is an apparent spatial relationship between the Doucers Valley fault complex and

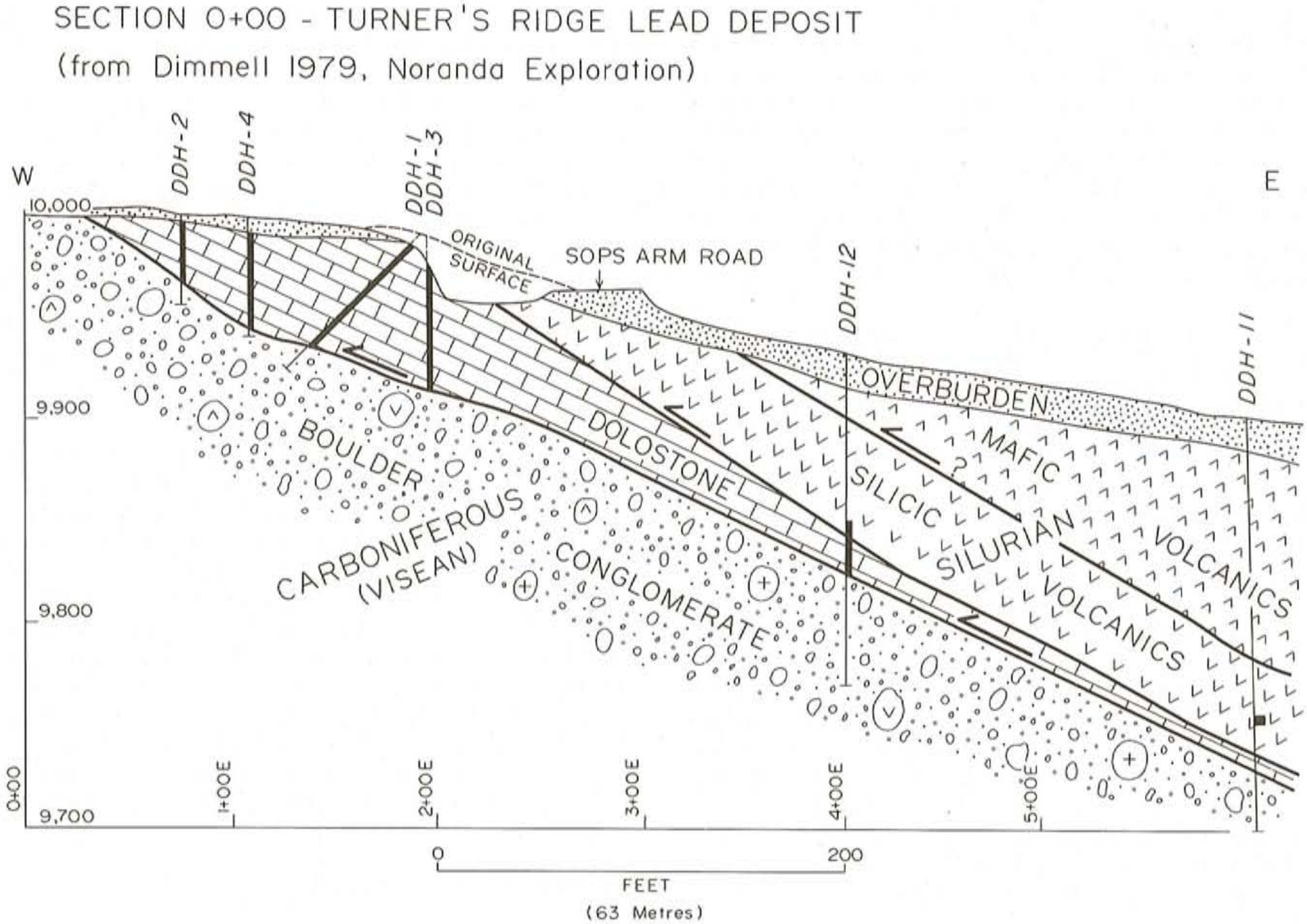


Figure 5. *West-east drill section across the Turners Ridge lead prospect. Mineralized portions of drill core are indicated by thicker lines. From Tuach (1987a) after Dimmell (1979).*

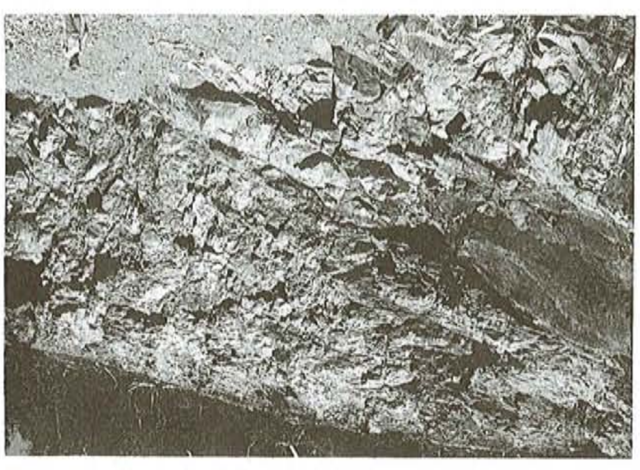


Plate 5. *Rhyolite thrust over galena-bearing brecciated dolostone at the Turners Ridge deposit. Both units are members of the Silurian Lower Volcanic formation.*

gold occurrences in the western White Bay area. Mineralization is hosted by a variety of rock types and is generally confined to veins and fracture stockworks, and as such, is clearly epigenetic. Davenport and McConnell (1988) have shown that elements such as As and Sb are enriched in lake-sediment samples on a regional scale in the Baie Verte–White Bay area. Areas of enrichment are associated with gold occurrences and major lineaments (e.g., the Doucers Valley fault complex and the Baie Verte Lineament) and indicate that hydrothermal systems were operative on a regional scale. Therefore, it is possible that all the gold occurrences in the western White Bay area formed from a single widespread mineralizing event. The Doucers Valley fault complex and subsidiary structures may have provided a conduit along which hydrothermal fluids circulated. Tuach *et al.* (1988) suggested that the ubiquitous carbonate porphyroblasts that occur in much of the Silurian Simms Ridge Formation are the product of hydrothermal alteration and their distribution outlines the areal extent of hydrothermal systems in Silurian rocks of the White Bay area.

There is some evidence that gold mineralization in the Sops Arm Group ranges from syn- (or possibly pre-) deformational to post-deformational with respect to Late Silurian thrusting (Tuach, 1987a,b). For example, at the Browning Mine there is a variation from boudinaged and tightly folded to crosscutting post-deformational quartz–carbonate veins. Veins at the Simms Ridge and Unknown

Brook occurrences are boudinaged, but those at the West Corner Brook prospect are mostly post-deformational. Mineralization is apparently structurally controlled to the extent that fault gouge planes and permeable shear zones, as well as areas of tensional fracturing, appear to have provided pathways for fluid flow and open spaces for mineral deposition.

The Rattling Brook deposit has many of the characteristics of mesothermal gold deposits, including high As, high Au/Ag ratios, high CO_2 contents in fluid inclusions, and intermediate pH alteration assemblages.

The gold showings in the Sops Arm Group may have resulted from the same mineralizing event that formed the Rattling Brook gold deposit. Tuach *et al.* (1988) pointed out that the presence of ductile thrust zones in less competent rocks, and tensional mineralized veins in more competent rocks, suggests a depth of vein formation in excess of 3 km, contradicting earlier suggestions that the alteration and mineralization in the Sops Arm Group resulted from epithermal processes. In addition, CO_2-rich fluid inclusions have been observed in quartz veins from the Browning, Sops Arm Road and Park showings (Tuach and Saunders, *in preparation*), and are typical of mesothermal rather than epithermal deposits (Nesbitt *et al.*, 1986).

The alteration assemblages found around many of the occurrences include carbonate, fuchsitic mica, and sericite. Although pyrophyllite has been reported from some occurrences (cf. Snelgrove, 1935; O'Sullivan, 1986; McKenzie, 1986) it has not been conclusively identified. X-ray diffraction of 'pyrophyllite' from the Unknown Brook occurrence and the Browning Mine showed only sericite.

At Rattling Brook, gold occurs in pyrite and apparently is also associated with arsenopyrite (there is a positive Au:As association). There is little enrichment of base metals. Pyrite and arsenopyrite and locally gold are also found in alteration zones within the Murray's Cove schist. However, in the Sops Arm Group gold is apparently associated with galena; Cu and Zn are locally enriched and As is not significantly enriched. Such contrasts in metal content may result from regional elemental zonation and could reflect local variations in host-rock composition or fluid composition, pressure or temperature.

Differences in alteration styles may relate to the wall-rock composition, which has a direct effect on the mineralogy of the resulting alteration assemblage (cf. Phillips and Brown, 1987; Colvine *et al.*, 1984). For instance Böhlke (1989) found that disseminated sulphide mineralization formed in granite wall rock, and carbonate alteration formed in ultramafic rock affected by the same mineralizing fluid. This could explain the differences in alteration associated with gold–pyrite–arsenopyrite mineralization in the Murray's Cove schist and Apsy pluton (Rattling Brook deposit).

It has been suggested (Tuach and Saunders, *in preparation*) that the Gull Lake intrusive suite may have provided the heat necessary for circulation of gold-bearing hydrothermal fluids within the rock column, and as well may have been a partial fluid source. A more direct genetic link, i.e., formation of gold mineralization within the Sops Arm Group by magmatic–hydrothermal processes, does not seem likely in the apparent absence of large-scale hydrothermal alteration within the Gull Lake intrusive suite and the general lack of granophile element (Mo, F, W) enrichment in the gold-bearing quartz veins. The mineralized veins within and adjacent to the Big Davis Pond granite are somewhat of an exception in that they contain fluorite and are locally enriched in W and Bi. To the north, gold-bearing veins within the Coney Head Complex contain significant molybdenite (e.g., Birchy Cove occurrence) and may be genetically related to nearby leucocratic muscovite granite dykes and molybdenite-bearing quartz–feldspar pegmatites. Such localized enrichments in granophile elements could result from either a direct magmatic–hydrothermal input, or by remobilization of these elements from older granite source rocks by leaching and reprecipitation by hydrothermal fluids.

The minor molybdenite and fluorite mineralization within the Gull Lake intrusive suite and related aplitic dykes is the result of late-stage magmatic processes and is probably not directly related to the gold mineralization in the White Bay area.

The galena mineralization at Turners Ridge and related showings is not enriched in gold and appears to be completely unrelated to the mesothermal gold mineralization in the White Bay area. The mineralization postdates the thrusting of the hanging-wall rhyolite over the host dolostone, indicating a relatively young age. The Carboniferous Deer Lake Basin to the south is a possible source of the Turners Ridge mineralization. The brecciated dolostone of the Lower Volcanic formation may have acted as a structural and chemical trap for upwelling lead-rich basinal fluids. Carboniferous carbonate rocks on the Port au Port Peninsula also host galena mineralization that is accompanied by calcite and barite gangue.

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