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MESOTHERMAL GOLD MINERALIZATION IN THE SILURIAN SOPS ARM GROUP, WESTERN NEWFOUNDLAND: A DESCRIPTIVE AND HISTORICAL OVERVIEW

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ABSTRACT

The Silurian Sops Arm group, in the White Bay area of western Newfoundland, consists of bimodal volcanic rocks and terrestrial to shallow-marine sedimentary rocks. It has always been viewed as a single stratigraphic sequence, but may instead comprise discrete western and eastern sequences, separated by an important fault zone. Gold was first discovered over a century ago, and was produced in small quantities from a vein-hosted deposit. The early exploration of this area is a fascinating part of Newfoundland's mining history.

Gold mineralization in the Sops Arm group is epigenetic and is associated with mesothermal-style quartz and quartz-carbonate veins that typically also contain base-metal sulphides such as pyrite, chalcopyrite, galena and sphalerite. Auriferous veins are mostly hosted by volcanic and volcaniclastic rocks of the Pollards Point formation, or by sedimentary rocks of the Simms Ridge Formation, which respectively sit west and east of the proposed structure separating the two sequences within the Sops Arm group. Alteration signatures associated with the mineralization are difficult to evaluate, but much of the sericitization and chloritization may actually be an unrelated regional feature. However, iron carbonate alteration is spatially associated with gold-bearing veins at the former Browning Mine. Most mineralization is low-grade, but grab samples near the former Browning Mine contain up to 315 ppm Au, confirming some very early reports of high-grade concentrations. The Unknown Brook prospect also locally exhibits high grades, up to 79 ppm Au, and veining here is traced along strike for some 800 m. Gold–Ag correlations are well developed in all areas, but contrary to previous suggestions, there is no correlation between Au and either Pb or Zn at the Browning Mine, where Au appears instead to be correlated with Cu. At the Simms Ridge Prospect, there is no Au–Cu correlation, but there may be correlation between Au and Pb.

The distribution of gold mineralization could in part be controlled by the fault zone between the western and eastern sequences of the Sops Arm group, but other factors may be of equal importance. Most gold prospects lie within 2 km of a large posttectonic granitoid pluton, and quartz veining in general is more prevalent in the south of the area, where these granites occur. This does not necessarily indicate any genetic link between the gold and the granites, but high heat flow associated with the latter may be associated with greater fluid flux from deeper sources, as suggested for many mesothermal gold provinces.

INTRODUCTION

PROJECT OVERVIEW

Southwestern White Bay is one of several areas in Newfoundland that are viewed as prospective for gold mineralization. The largest exploration project in the area is focused on disseminated gold mineralization in Precambrian basement rocks and Cambro-Ordovician sedimentary rocks along the Cat Arm Road, for which Carlin-type deposit models have been advanced and evaluated (Wilton, 2003; Kerr, 2004a, 2005). This mineralization was discovered about 25 years ago, during road construction for a hydroelectric project (Tuach and French, 1986), but the first gold discoveries in the district were made over a century ago, and one of the first gold mines on the Island operated briefly here ca. 1903-1904. This deposit, and most other gold prospects in the area, are hosted by Silurian rocks of the Sops Arm group (Figure 1). A brief survey of these gold occurrences was completed last year (Kerr, 2004b), and part of the 2005 field season was devoted to more detailed evaluation of the gold mineralization, coupled with geological mapping aimed at reassessment of local stratigraphy and structure. A companion report (Kerr, *this volume*) discusses

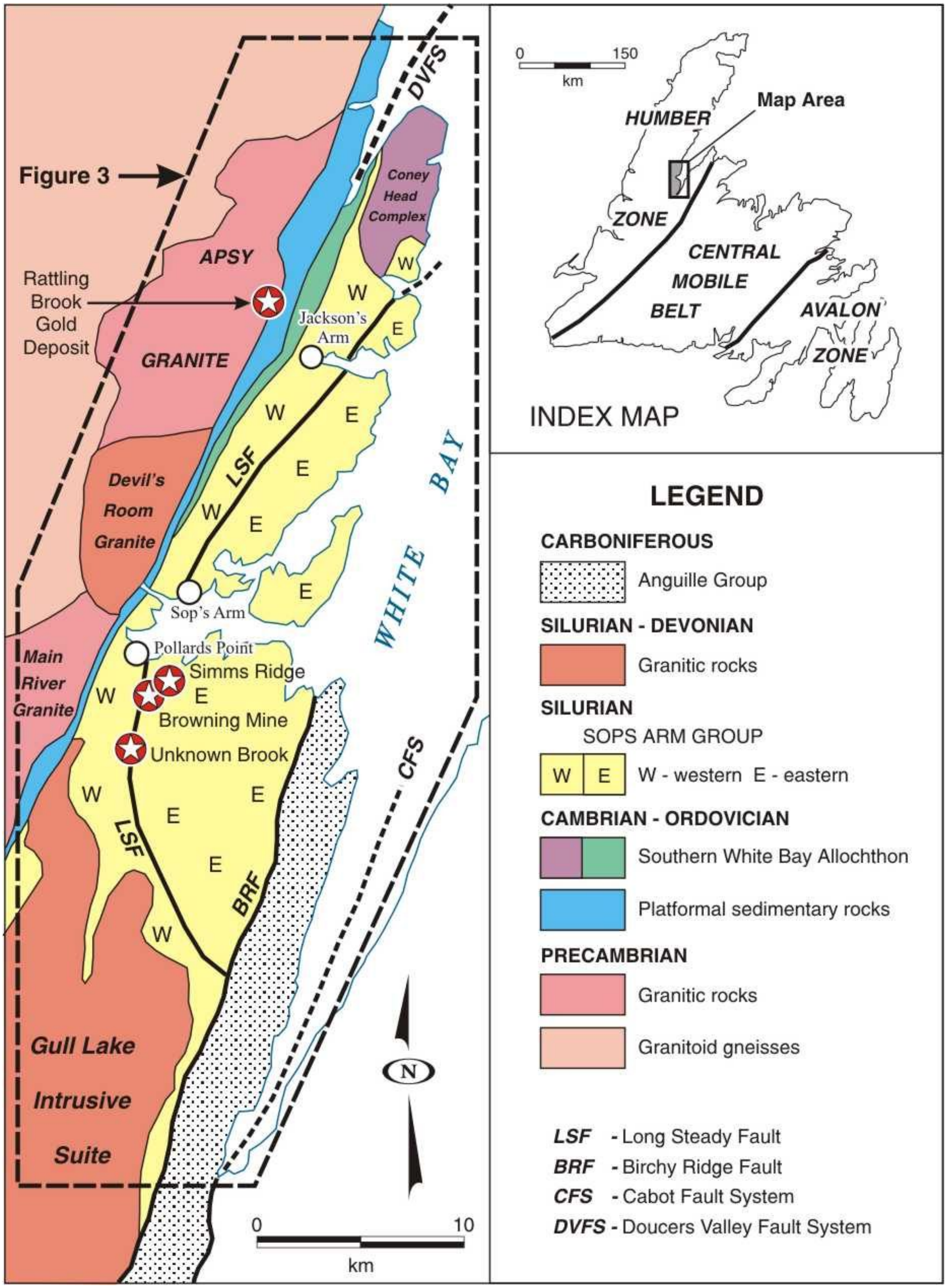

Figure 1. *Regional geology of the western side of White Bay, showing the distribution of the western and eastern sequences of the Sops Arm group, and the locations of the most significant gold prospects within the area. Geology after Smyth and Schillereff (1982) and Kerr (*this volume*).*

the Sops Arm group and suggests some alternative interpretations of its geology. This report provides an interim review of the most significant gold prospects hosted by Silurian rocks, and is based on previous work and assessment reports, coupled with field observations. Petrographic and geochemical work on samples collected during 2005 remains incomplete, and these results will be presented subsequently. As is always the case, future work may lead to revision of some preliminary opinions expressed herein.

PREVIOUS WORK AND RELATED STUDIES

This is by no means the first investigation of the Sops Arm group. The earliest observations by Alexander Murray and James P. Howley predated the discovery of gold, and the summary by Howley (1902) provides the first mention of gold-bearing quartz veins. Little is known about the early days of exploration, and reports by Snelgrove (1935), Lundberg (1936) and Heyl (1937) provide the first detailed information about individual prospects. Geological mapping was completed by the original Geological Survey of Newfoundland prior to Confederation (Heyl, 1937; Betz, 1948) and later by the Geological Survey of Canada (Neale and Nash, 1963). The Sops Arm group was part of a doctoral study focused largely on felsic volcanism (Lock, 1969a, b), but this makes little mention of mineralization. In the early 1980s, Smyth and Schillereff (1982) summarized the regional geology based upon regional mapping and compilation, and published maps at 1:25 000 scale. The results of metallogenic studies were discussed by Tuach and French (1986), Tuach (1986, 1987a) and Tuach and Saunders (1988, 1991), but much of this work was aimed at the Cat Arm road area. A later summary of mineral occurrences (Saunders, 1991) provides the most recent account of gold mineralization in the Sops Arm group, and was a valuable source for this report. Currie (2004) completed a thesis study on samples from several prospects, including limited isotopic, fluid inclusion and mineral geochemistry data; these data were also summarized by Currie and Wilton (2005).

There have been many exploration programs in this area, but relatively few of these progressed to advanced exploration or diamond-drilling programs. Regional programs were conducted by Brinex, Noranda Exploration, BP-Selco and Esso Minerals, and more focused efforts were made by U.S. Borax, Carrick Resources and Commodore Mining. These programs included both base-metal and gold exploration, and also some target units outside the Sops Arm group. Most of this activity took place in the 1970s and 1980s, and subsequent activity has been limited. Local prospectors now hold much of the ground, including the former Browning Mine. Assessment reports from exploration projects were important sources for this report, and these are referenced individually in conjunction with subsequent descriptions of the mineralization. Recent work by Mr. Tom McLennon in two key areas is also discussed in the report.

REGIONAL GEOLOGY AND METALLOGENY

The western side of White Bay contains rocks of Proterozoic to Carboniferous age (Figure 1). An abbreviated summary of the regional geology, modified after Smyth and Schillereff (1982) and Kerr and Knight (2004) is presented below.

The oldest rocks are ca. 1500 Ma granitoid gneisses of the Long Range Inlier, which are intruded by granitoid rocks of 1030 to 980 Ma age (Heaman *et al*., 2002), and late Precambrian (~615 Ma) Long Range dykes. These Precambrian rocks are bounded to the east by a narrow belt of Cambro-Ordovician sedimentary rocks, which rest unconformably upon the basement. The Cambro-Ordovician sequence includes most of the formations recognized along the Gulf of St. Lawrence (Kerr and Knight, 2004), but its continuity is disrupted by major faults. The Precambrian basement and these autochthonous to parautochthonous cover rocks are bounded to the east by the Doucers Valley fault zone, an important lineament that essentially divides western White Bay into two parts (Figure 1). This structure probably has a complex history of reactivation throughout the Paleozoic (e.g., Tuach, 1987a). Cambro-Ordovician rocks east of the Doucers Valley fault system belong to a disrupted Taconic allochthon termed the Southern White Bay Allochthon (Smyth and Schillereff, 1982; Figure 1), which includes assorted clastic sedimentary rocks, metavolcanic rocks, minor ultramafic rocks and trondhjemites (Coney Head Complex; Williams, 1977). These rocks represent deep-water sequences and sections of oceanic crust transported westward across the ancient continental margin of North America. The eastern part of the area is dominated by the Silurian Sops Arm group (Figure 1), which consists of felsic and lesser mafic volcanic rocks, conglomerates and largely clastic sedimentary rocks (Lock, 1969a, b). The Sops Arm group is considered to have been deposited unconformably on the Southern White Bay Allochthon, but definitive relationships are preserved only at one locality, and most contacts between the two are faults. Silurian and pre-Silurian rocks were subjected to significant Silurian or post-Silurian deformation, which becomes more intense toward the west. Syn- to posttectonic granitoid rocks of probable Silurian age are abundant in the south of the area, where they intrude the Sops Arm group and older rocks (Figure 1). Superficially similar granite that intrudes Precambrian basement west of Sop’s Arm (Devil’s Room Granite) has been dated at 425 +/- 10 Ma (Heaman *et al.*, 2002). Diabase dykes cut Cambro-Ordovician carbonate rocks, but have not been reported to cut the Sops Arm group. The youngest rocks in the area are Carboniferous sedimentary rocks of the

Anguille and Deer Lake groups (Figure 1), which unconformably overlie all Ordovician and Silurian rocks, including those of plutonic origin. The Deer Lake group lies west of the area in Figure 1.

Excluding several Precambrian events that affected gneisses of the Long Range Inlier, the area records at least three major orogenic events. The Ordovician Taconic Orogeny resulted in emplacement of the Southern White Bay Allochthon over authochthonous Cambro-Ordovician rocks. The Silurian Salinic Orogeny and/or the Devonian Acadian Orogeny strongly affected Silurian and older rocks and created much of the present geological architecture, including regional folding. These events were accompanied and followed by granitoid plutonism. Carboniferous or post-Carboniferous events (Variscan Orogeny) were also important, as rocks of the Anguille Group are tightly folded and older Silurian rocks have locally been thrust over the Deer Lake Group. Major lineaments such as the Doucers Valley fault system are inferred to have been sites of significant strike-slip motion during Carboniferous and post-Carboniferous times, but these structures were likely established during earlier Paleozoic events (Tuach, 1987a; Kerr and Knight, 2004). Although the correlation of granites across the Doucers Valley fault system has been used to constrain displacement (Tuach, 1987b), this argument is by no means definitive. The Cabot Fault zone, which emerges through White Bay and controls the Carboniferous basin, may similarly represent a zone along which there were major Carboniferous strike-slip motions.

The Silurian rocks of the Sops Arm group contain most of the gold mineralization discovered prior to the 1980s. Mineralization is dominantly vein-hosted (Tuach, 1986; Saunders, 1991; Kerr *et al*., 2004). Disseminated to stockwork-style gold mineralization was discovered in the early 1980s in Precambrian granitoid rocks and adjacent Cambro-Ordovician sedimentary rocks along the Cat Arm road, where it was explored by BP-Selco, and is now under exploration by Kermode Resources. The most recent descriptions of this mineralization are by Wilton (2003) and Kerr (2004a, 2005). Lead and Zn mineralization occurs in thin carbonate units within volcanic rocks of the Sops Arm group, and is generally considered to be of Carboniferous age (Saunders, 1991). Minor Cu–Ag mineralization is present in Carboniferous sandstones (Saunders, 1991) and minor occurrences of fluorite, molybdenite and galena are reported from plutonic rocks (Saunders, 1991). There are also several industrial minerals prospects, notably limestone and marble (Howse, 1995).

AN OVERVIEW OF THE GEOLOGY OF THE SOPS ARM GROUP

The rocks of the Sops Arm group were initially described by Heyl (1937), although the modern definition of this stratigraphic unit was introduced by Lock (1969a, b). Smyth and Schillereff (1982) modified Lock's subdivisions, and mapped the component formations over a wider area. A companion report (Kerr, *this volume*) describes and illustrates these Silurian rocks, and suggests an alternative interpretation of stratigraphy and structure, which has possible relevance to mineralization. Readers are referred to the companion report for complete discussion, but a simplified overview is presented below. The stratigraphy of the Sops Arm group is summarized in Figure 2, and a simplified geological map (also showing the locations of the principal mineral occurrences discussed here), is presented in Figure 3. Previous studies of the Sops Arm group assumed that it forms a single continuous stratigraphic sequence, with the oldest formations in the west and the youngest formations in the east. Kerr (*this volume*) suggests instead that there is a structural break within the sequence, which allows for definition of two discrete stratigraphic sequences whose exact age relationships remain unclear.

The Western Sequence of the Sops Arm Group

The western sequence consists of a lower package of felsic volcanic and pyroclastic rocks, lesser mafic volcanic rocks and conglomerates, overlain by a fining-upward sequence of terrestrial to fluviatile sedimentary rocks dominated by conglomerates and sandstones. In the southwest, there are also some carbonate rocks, but it is not clear exactly how these fit into the stratigraphy. The western sequence corresponds to the Pollards Point, Jackson's Arm and Frenchman's Cove formations (Figure 2). Note that Pollards Point formation is a new (informal) name suggested as a replacement for the Lower Volcanic formation of Smyth & Schillereff (1982). The western sequence is largely juxtaposed by faults with the Southern White Bay Allochthon or an attenuated sliver of Cambro-Ordovician sedimentary rocks (Figure 3). This contact is mostly coincident with the Doucers Valley fault zone, where intense brittle deformation obscures any original relationships. However, there is one location in the north of the area where an apparently unconformable relationship is preserved (Williams, 1977; Kerr, *this volume*). This ties the western sequence to the local pre-Silurian rocks. The exact age of the western sequence is not established, because it is unfossiliferous and the volcanic rocks have never been dated accurately. Early workers (e.g., Heyl, 1937) actually considered it to be Ordovician, but since the work of Neale and Nash (1963), it has been viewed as Silurian.

The Eastern Sequence of the Sops Arm Group

The eastern sequence includes two formations, which appear to be in stratigraphic continuity. The lowermost com-

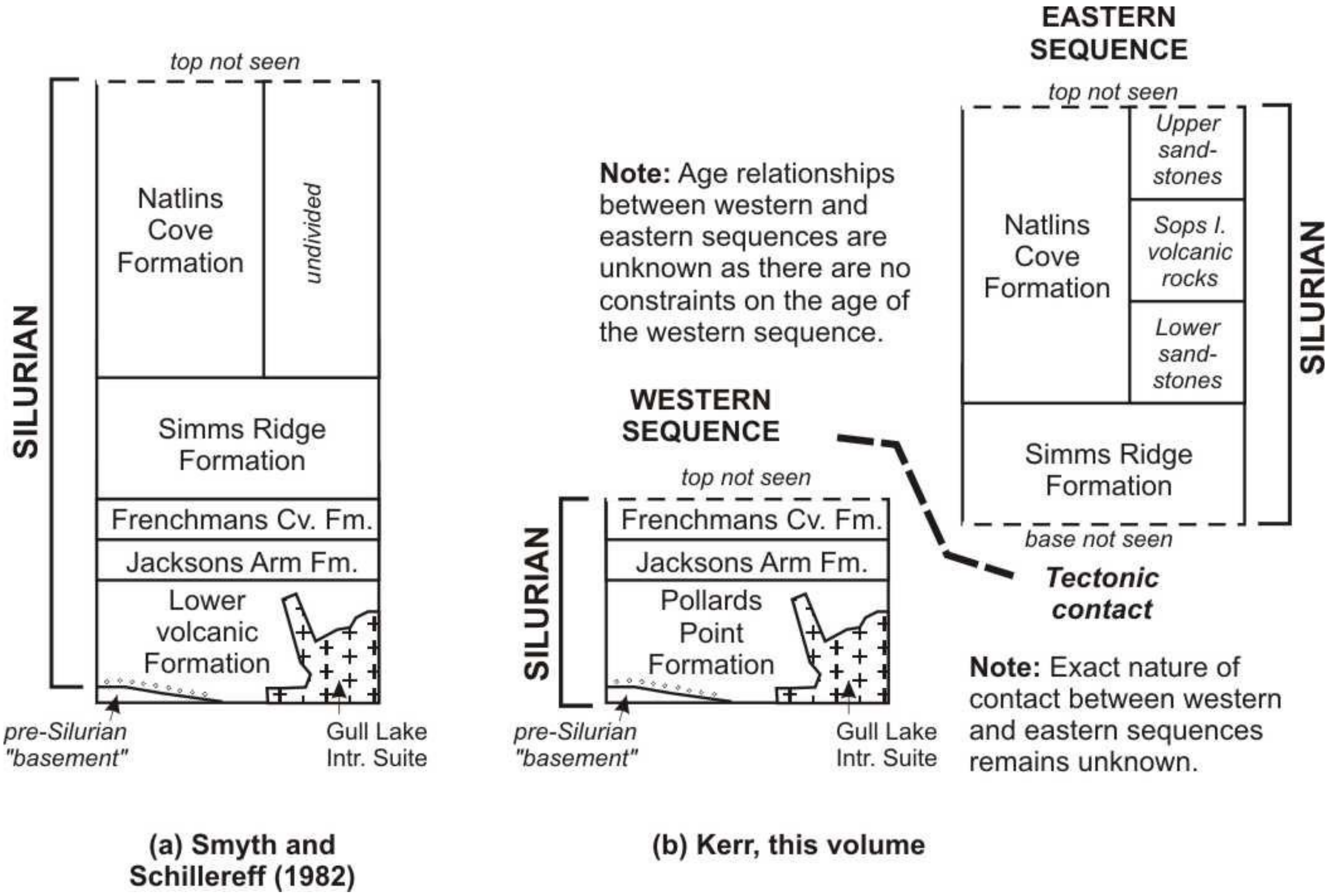

Figure 2. *A summary of stratigraphic nomenclature suggested by Smyth and Schillereff (1982) and Kerr (*this volume*). Note that no implications of relative age are intended by the positioning of the columns for western and eastern sequences in part (b). See Kerr (*this volume*) for discussion.*

prises a sequence of variably calcareous siltstones, locally with thin fossiliferous limestone units, and is termed the Simms Ridge Formation (Figure 2). This is overlain by a sandstone-dominated sequence, including some relatively pure quartzites, which eventually passes up into coarse gritty sandstones and conglomerates containing felsic volcanic debris. Thin limestone units within the sequence contain marine corals, crinoids, gastropods and brachiopods. These sedimentary rocks correspond to the lower part of the Natlins Cove Formation (Figure 2). They are overlain by felsic volcanic and pyroclastic rocks, associated with lesser amount of mafic volcanics, and some associated clastic sedimentary rocks. The volcanic rocks correspond to the middle part of Natlins Cove Formation (Figure 2), and are in turn overlain by a second sequence of thinly bedded sandstones. This simple threefold division of the Natlins Cove Formation was originally suggested by Heyl (1937), who defined three members. The volcanic rocks include spectacular flow-banded rhyolites and ignimbrites that are of subaerial origin, but most of the sedimentary rocks of the eastern sequence appear to represent a marine environment. They contrast with the terrestrial and fluvial sedimentary rocks of the western sequence. The age of the eastern sequence is controlled rather poorly by fossils indicating an middle to uppermost Silurian age (Heyl, 1937; Kerr, *this volume*). The stratigraphic top of the eastern sequence is not seen, as it is bounded to the east by the Birchy Ridge fault, which juxtaposes it against Carboniferous rocks (Figure 3).

Relationships between Western and Eastern Sequences

The boundary between the western and eastern sequences is interpreted to be an important fault zone, for which the term Long Steady fault zone is proposed by Kerr (*this volume*). This structure is associated with strong deformation, notably in the rocks that bound it to the east. The presence of a fault in this location is also implied by the disappearance of some formations along a prominent lineament, although previous workers attributed this to facies changes. Kerr (*this volume*, see also later discussion) suggests instead that the Jackson's Arm and Frenchman's Cove formations of the western sequence are excised along the

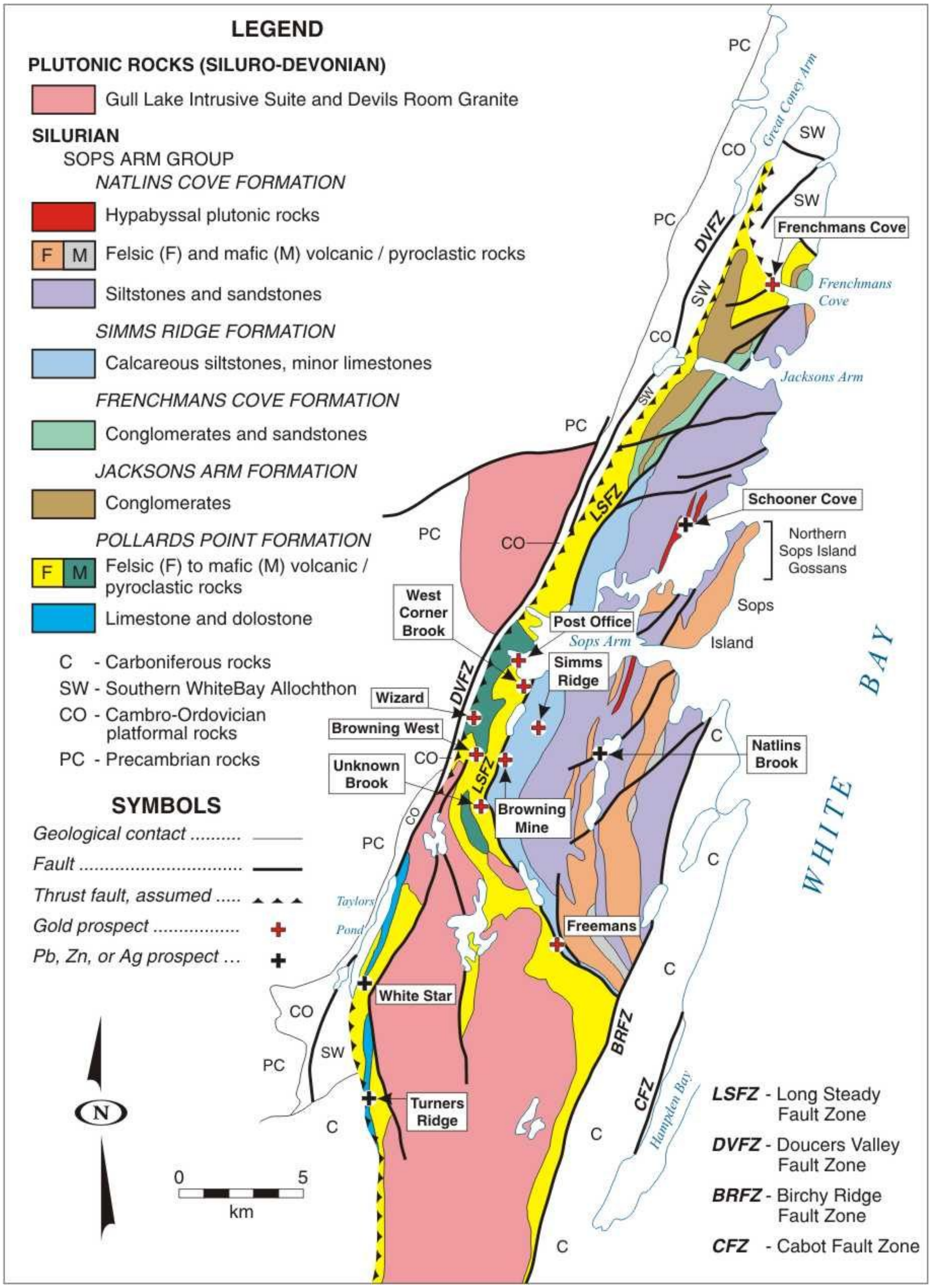

Figure 3. *Simplified geology of the Sops Arm group and spatially associated plutonic rocks, showing the locations of precious-metal and base-metal showings discussed in this report. For details of geological relationships and rock types, see the companion report (Kerr,* this volume*). Geology modified after Smyth and Schillereff (1982).*

fault, and that the Simms Ridge Formation of the eastern sequence is excised or stongly attenuated along it (Figure 3). The exact nature of the Long Steady fault is not known, but transposed early folds in the Browning Mine area (Kerr, *this volume*) suggest that it has a complex early history. The Long Steady fault zone is tentatively interpreted as a thrust fault developed during regional deformation of the Sops Arm group, during Salinic and/or Acadian orogenic events. If this interpretation is correct, it raises the possibility that the eastern sequence is actually in part older than the western sequence, or partially equivalent in age but deposited in a different location and environment.

Structural Patterns in the Sops Arm Group

Structural patterns in the Sops Arm group are superficially fairly simple, but may have hidden complexity. Most of the rocks dip to the east, and also young in that direction, suggesting that they are right-way-up. A single cleavage is widely developed, and this generally dips eastward with an attitude steeper than bedding, supporting this general conclusion. There are local exceptions to this pattern, and some parts of the eastern sequence, notably the Simms Ridge Formation, contain tight folds that are locally overturned toward the west (Lock, 1969a; Smyth and Schillereff, 1982; Kerr, *this volume*). However, there is no widespread structural inversion of the sedimentary rocks. Larger, more open folds with north–south-trending axes are implied by map patterns in the north of the area. Many small fault zones are defined by offsets of individual units, including a prominent set that trends east-northeast to east-west in the centre of the area (Figure 3). It is suggested that the tight westward-verging folds in the eastern sequence of the Sops Arm group were developed in conjunction with motions along the Long Steady fault zone.

The overall structural pattern of the Sops Arm group is "sigmoidal", in that strike changes from north-south to northwest-southeast south of Sop's Arm, and then returns to its original orientation west of Hampden Bay (Figure 3). A large, roughly rhomboidal area in the south is underlain by the granitoid rocks of the Gull Lake Intrusive Suite. There are no regionally extensive plutonic rocks north of Sop's Arm. This flexure in regional strike appears to be a later feature, and is attributed to dextral motions on the fault systems that now bound the Sops Arm group (Kerr, *this volume*).

GOLD MINERALIZATION

This section of the report provides some historical and descriptive information on gold mineralization within the Sops Arm group, with emphasis upon important mineralized localities in the area south of Sop's Arm. Brief descriptions are provided for several other minor gold occurrences, and also for silver and copper occurrences. Gold mineralization outside the Sops Arm group, in the Southern White Bay Allochthon, and in younger plutonic rocks is not discussed here; details of these occurrences are contained in Saunders (1991).

SPATIAL DISTRIBUTION

Figure 3 indicates the locations of gold showings and possibly related mineralization in the Sops Arm group. The most obvious cluster is in the area south of Sop's Arm, including the West Corner Brook, Browning Mine, Simms Ridge, Unknown Brook and Freemans prospects. These and nearby minor gold occurrences are confined to two of the formations within the Sops Arm group, i.e., the Pollards Point formation (lower volcanic formation of Smyth and Schillereff, 1982) and the adjacent Simms Ridge Formation (Figure 3). The boundary between these two formations in this area has long been considered as a fault, and this is now considered to be part of the important regional structure termed the Long Steady fault zone (see above summary, and Kerr, *this volume*). The association between significant gold mineralization and this fault zone may be more than coincidental or simply spatial, and this issue is discussed subsequently.

WEST CORNER BROOK PROSPECT

The West Corner Brook prospect was one of the earliest gold discoveries on the Island of Newfoundland. According to Martin (1983), James M. Jackman first came to the Sop's Arm area to harvest lumber for use in the Tilt Cove copper mines. In 1896, he noticed free gold in some quartz veins on the west bank of Corner Brook, and staked two claims on the property. An adit was driven for 19 m above the brook, and it remains clearly visible today (Plate 1a). According to Martin (1983) additional claims were then acquired to the south of Jackman's ground by Robert G. Rendell, who had initially registered Jackman's claims on his behalf. These, and the original claims, later became part of a mineral license held jointly with a Mr. John Browning, upon which the Browning gold mine was eventually developed (*see below*). The West Corner Brook prospect is described by Snelgrove (1935) and Betz (1948) and summarized by Tuach (1987b) and Saunders (1991).

Mineralization is hosted largely, but not entirely, by several quartz-carbonate veins that cut pink to purplish rhyolite of the Pollards Point formation, originally described as quartz porphyry by Snelgrove (1935). The veins outcrop at the mouth of the adit, and also in the walls and roof of the adit, and are gently dipping to flat-lying. Most are a few tens of centimetres in width and obviously discontinuous. They are difficult to examine and sample in the adit area, but a

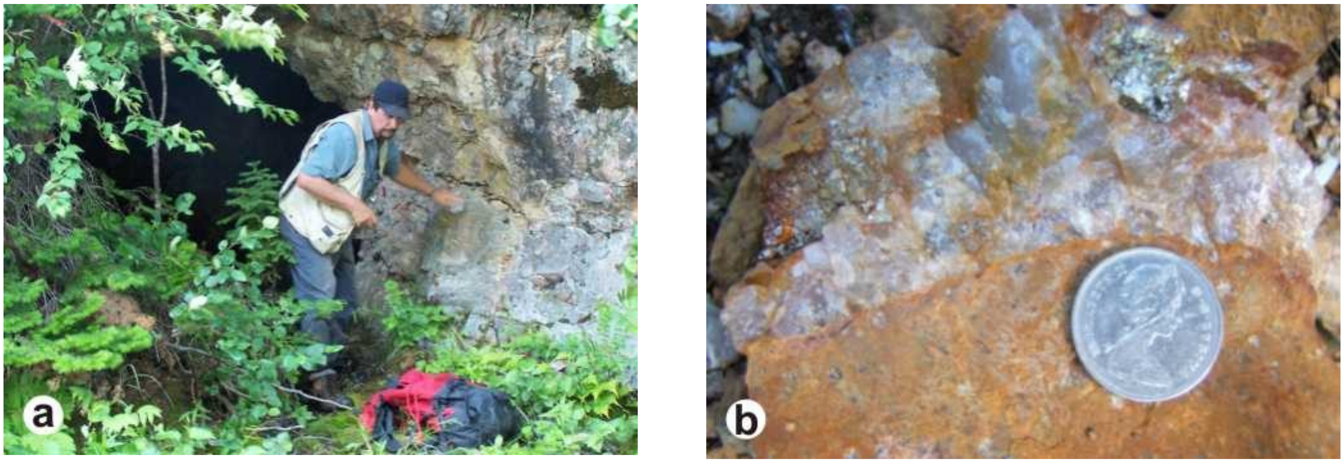

Plate 1. *The West Corner Brook prospect, near Pollards Point. (a) Adit adjacent to Corner Brook, partially obscured by trees; host rocks are of felsic volcanic origin. (b) Quartz vein in porphyritic rhyolite, containing clots of pyrite and chalcopyrite.*

small waste dump across the brook from the adit provides good samples of the extracted material. The vein material contains irregular clots of sulphides, dominated by pyrite, chalcopyrite and minor galena (Plate 1b). Sphalerite was reported by Snelgrove (1935), but was not observed by the author. The rhyolitic wall rocks in broken material also contain minor disseminated sulphides, but not to the same extent as the veins themselves. Information on the grades of this material is scanty, but Snelgrove (1935) reported assays, converted by Saunders (1991) to about 4.4 ppm Au and 60 ppm Ag, and grab samples later collected by U.S. Borax (Burton, 1987) contained up to 1 ppm Au. Material from the small waste dump was sampled during the summer of 2005, but these results are not yet available. There is no evidence of any significant alteration of the wall rocks around the sulphide-bearing quartz-carbonate veins, and the host rhyolites are typical of the unit elsewhere.

The West Corner Brook prospect has received little or no subsequent attention, and is considered largely of historical interest, however, the rights are currently held by Mr. Noel Murphy. The style of mineralization, in which gold is associated with polymetallic sulphides in quartz and quartz-carbonate veins, is typical of other gold prospects in the area that are more completely explored and better known, e.g., Unknown Brook.

THE BROWNING MINE

The Browning Mine is the best-known gold deposit in the area and has the distinction of being one of the first-producing gold-only deposits on the Island of Newfoundland. Having said this, its production can hardly be described as prolific. Martin (1983) states that only one shipment ever left the Sop's Arm area, in 1903, when 150 ounces of gold (worth about $US 75 000 at today's prices) were shipped in canvas bags by boat and cart to Howley, and thence by train to St. John's. According to the mineral statistics report for 1903 (Howley, 1904), this production came from some 1000 tons of ore, indicating an average grade of some 0.15 oz/ton, or about 5 ppm Au. Betz (1948) noted that this figure may be in error as the grade seems so low, and the actual tonnage of ore extracted may have been significantly lower. According to Martin (1983), the site was abandoned in 1904, but machinery and explosives were left behind; the accidental discovery of the latter two years later by a local man, Mr. Cornelius Ricketts, resulted in a loud explosion and his premature demise. The shafts at the mine site were filled in by the Mineral Development Division in 2003, but the original adit remains in a cliff on the east bank of Corner Brook (Plate 2a). There is abundant quartz vein and wall-rock material in a waste dump at the top of the bank, but no traces of machinery or equipment remain.

There was an attempt at reactivation in the 1930s, and some exploration work and diamond drilling were completed in the 1980s; these efforts are summarized below. Like the West Corner Brook prospect, the Browning Mine came to be seen as of purely historical interest, and the original mining grants eventually lapsed. The mineral rights are currently held by prospector Tom McLennon of Grand Falls, who has conducted systematic sampling of quartz veins in the old mine area, and throughout the surrounding country, including the Simms Ridge prospect (*see below*).

History of Investigation and Exploration

Martin (1983) provides some details on the initial discovery. Following John Jackman's initial discovery and the contentious staking south of the West Corner Brook prospect, Robert G. Rendell and John Browning hired a New Zealander, Mr. Andrew Stewart, to evaluate the prospect and

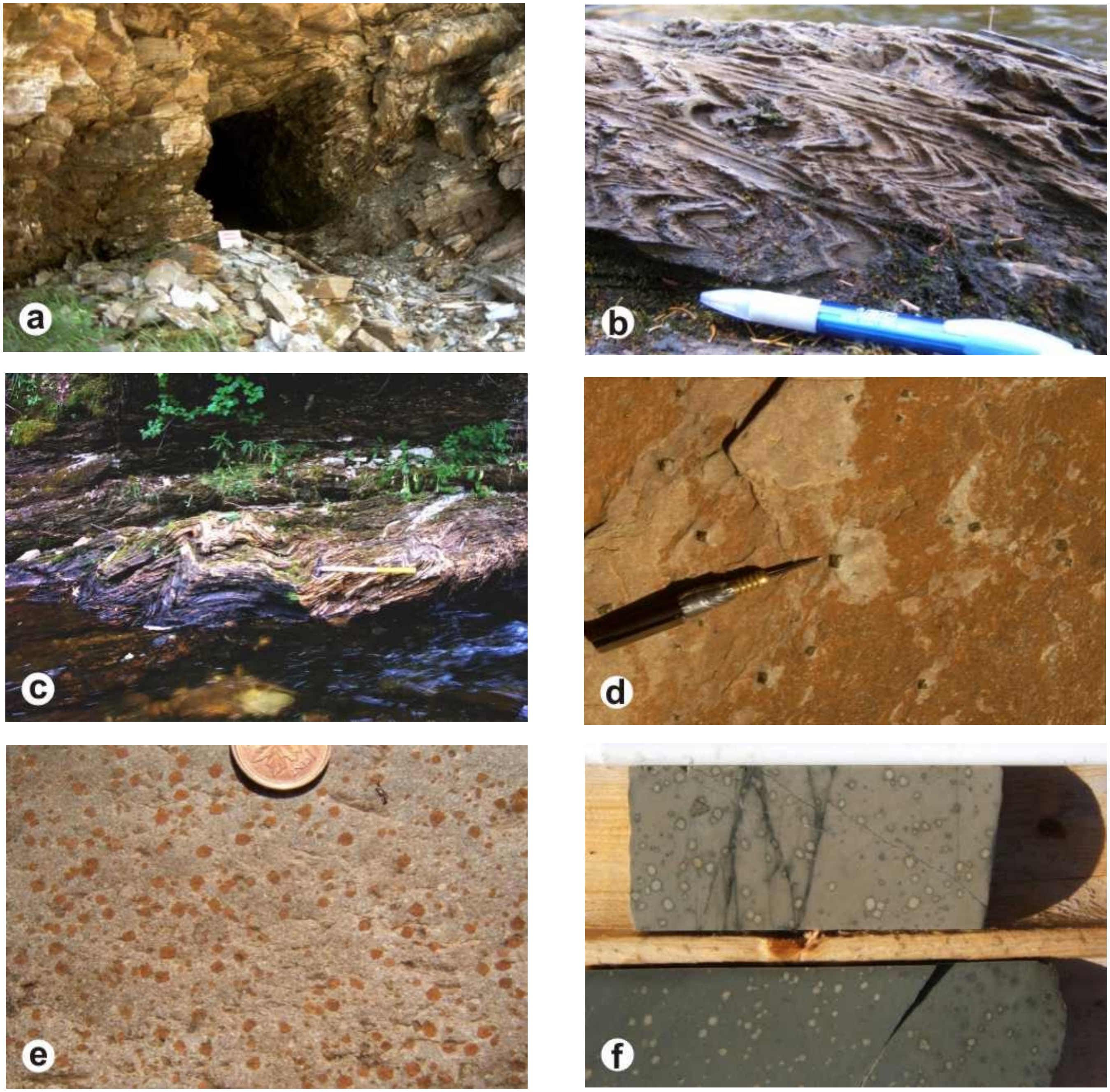

Plate 2. *The Browning Mine area. (a) Adit adjacent to Corner Brook, showing sericitic siltstone host rocks and the strong deformation in the fault zone exposed at the level of the adit. (b) Rootless early (intrafolial) folds in the fault zone, indicating its complex history. (c) Late folds affecting the fabric in the fault zone, and indicating southward motion of the upper block, to the right of the photo. (d) Cubes of pyrite in sericitic siltstone and sandstone host rocks. (e) "Siderite spots" in sericitic siltstone. (f) Drill core showing white carbonate spots representing the same feature as (e) but without the effect of weathering.*

the adjoining lands. Stewart discovered more gold-bearing quartz veins in Corner Brook south of their property boundary, and in June 1902 more claims were acquired in Browning's name. Howley (1902) visited the site during this period, and recounts his discussion with Mr. Stewart, as follows:

> *"During my visit, Mr. Stewart made several washings in my presence from crushed quartz in which no gold was previously observable even with the aid of lens. Nearly all these washings exhibited*

> *signs or colour of gold, and some were quite rich. One, in particular, made from about three ounces of crushed vein rock, yielded, according to his estimate, an average of about ten ounces to the ton"*

Howley makes reference to the presence of a shaft on the property, and observed "nuggets and strings of the precious metal" in hand samples that he was able to observe. He also noted that the visible gold was most often associated with sphalerite and galena, rather than with pyrite alone, and noted also the presence of chalcopyrite and hematite in the ores. From this brief visit, he concluded that:

> *"The indications altogether are of so favourable a character as to give ample promise that here at least a good gold proposition exists"*

Unfortunately, this rosy prediction was unfulfilled, for the Browning Mine was abandoned within 2 years of Howley's visit. According to a later account by Snelgrove (1935), problems first arose due to the long-simmering boundary dispute with the former partner James Jackman, who also claimed the area, and eventually won a court case on the matter. Unfortunately for Jackman, most of the gold was gone by the time of his legal victory, and the grades had by then fallen drastically. Howley (1904) reported that the yield at the mine had dropped to "3 dwts per ton", or about 5 ppm gold. These statements imply that the grade had once been much better, suggesting that much less than 1000 tons of "ore" had actually been extracted; perhaps this figure includes the waste, as material was hand-picked.

In the early 1930s, claims were staked in the area by the "Sop's Arm Mining Company" following the discovery of gold and silver at Simms Ridge (*see below*). This activity led to the first published summary of gold deposits in Newfoundland (Snelgrove, 1935), and the first detailed description of the geology in the mine area. Snelgrove referred to two shafts and an adit at the site, and noted the white quartz veins containing the sulphides. He also made reference to the variations in attitudes of these veins relative to bedding and cleavage in the host rocks, then described as "Ordovician slate and sandstone", and to the presence of a fault zone near the mine site. He confirmed the presence of the minerals noted previously by Howley (1902), but saw no signs of visible gold. Assay results from three samples collected in the mine waste dumps revealed "no more than a trace of gold". Heyl (1937) and Betz (1948) provided more detailed discussions of local geology, but no additional information on the character of mineralization.

The Sop's Arm Mining Company commissioned their own assessment of the Browning Mine, which was completed under the supervision of pioneer geophysicist Hans Lundberg, famous for his use of electromagnetic prospecting in discovering the Buchans orebodies. The mine workings were dewatered partially and were then explored using a makeshift raft! The results were summarized by Lundberg (1936), who again described the presence of a fault zone in the workings, and the irregularity of the quartz veins. Numerous chip and channel samples were collected, but the results were very disappointing. Lundberg's summary of the results seems to carry a veiled hint of suspicion about the very presence of gold at the site:

> *"In general, the sampling results were negative and this prospect fails to show anything of interest at present as far as gold values are concerned. It is a remarkable fact that no work of recent years, save for one exception, has confirmed the presence of the gold reputed to occur in this area. The one exception is the high assay obtained by the Sop's Arm Mining Company from a sample of a short vein, two inches wide, exposed in Corner Brook between the old mine and the east shaft. This vein is heavily impregnated with chalcopyrite, but in spite of careful inspection and the panning of roasted, crushed specimens, sights of free gold could not be obtained."*

It is perhaps not surprising that Lundberg's final judgment on the Browning Mine was nothing short of dismissive:

> *"The Browning Mine and Grant appear to possess no economic potentialities whatsoever"*

The next evaluation of the deposit was in the 1970s, when British Newfoundland Exploration Ltd (Brinex) held the rights to much of the western White Bay area. The exploration history and geology were reviewed by Sampson (1973), who again refers to the presence of a significant fault in the mine area. His experience with sampling apparently replicated those of Snelgrove and Lundberg almost forty years previously.

The only modern exploration program in the area of the Browning Mine was conducted in the mid 1980s by BP-Selco, who were at that time exploring the Rattling Brook gold deposit in the Cat Arm road area. The program included prospecting, soil sampling and limited diamond drilling, and is summarized by McKenzie (1985, 1987). In total, 9 drillholes were completed over a strike length of about 1 km, testing the area immediately beneath the old workings and its strike extension (Figure 4). Two holes completed beneath the old workings gave poor results, with the best assay at 0.45 ppm Au over a very narrow width. A hole located some 200 m south of the mine gave the best result, containing 7.2 ppm Au over 0.4 m in a quartz-carbonate vein, and a hole located a farther 600 m to the south returned 1.4 ppm Au over 2 m (Figure 4). Three more holes completed in 1986 in the area south of the mine tested the continuity and depth extension of this mineralization, but produced no results of interest (McKenzie, 1987). Exploration work then ceased on the property, until its recent acquisition by prospector Tom McLennon. Mr. McLennon has to date completed systematic sampling of quartz veins exposed in Corner Brook and in the surrounding area.

Geology, Mineralization and Alteration

Descriptions of local geology are provided by all previous workers, notably Snelgrove (1935), Heyl (1937), Tuach (1986, 1987b) and Saunders (1991). Following 2004 field work, an updated summary was prepared for a GAC Newfoundland Section field trip (Kerr *et al*., 2004), which is revised and expanded below. Most of the outcrop in the area is exposed in the bed of Corner Brook, and some of the features discussed below may not be visible (or safely accessible) during high water conditions. Figure 4 is a generalized sketch map of the area around the Browning Mine, showing the locations discussed below, the locations of drillholes completed by BP-Selco, and the most significant assay results.

All of the outcrops in the brook within a few hundred metres of the mine site are assigned to the Simms Ridge Formation, which consists of calcareous siltstones and shales, with interbedded limestones, sandstones and possible felsic tuffs (Lock, 1969a, b; Smyth and Schillereff, 1982; Kerr, *this volume*). In the mine area, variably sericitic calcareous siltstones and related schists are predominant. The brook runs subparallel to regional strike, which trends almost north-south (010 to 020°) and dips to the east at 25 to 35°. Bedding is difficult to see in most of the outcrops, and the prominent partings may actually represent cleavage planes rather than primary bedding. Although all outcrops belong to the same formation, their appearance varies in the mine area from north to south. Downstream from the adit (north), and upstream for about 100 m from the adit (south), the rocks are pinkish to beige or yellow and strongly sericitic, locally to the point where they feel soapy to the touch (Plate 2a). Beyond about 150 m upstream from the adit (south), their sericitic character is diminished, and the siltstones are dark grey to brownish, with only local pale sericitic zones. In the region to the north of the adit, brown spots (the "siderite spots" described by previous workers) are abundant to the point where the rocks appear diseased (Plate 2e). These also become less obvious upstream from the adit, although they remain present locally; this transition may be deceptive, because the brown spots are much easier to see in the paler-coloured sericitic rocks. The same transition, from sericitic schists to dark siltstones, is visible at the adit itself, where the upper parts of the cliff face differ in appearance from those at the base.

The sericitic siltstones are in part demarcated by a zone of strongly deformed schistose rocks, representing the fault discussed by all previous workers (Plate 2a, b). This fault zone runs along the east bank of Corner Brook around the adit and north of it, and eventually crosses it about 125 m south of the adit (Figure 4). At this point, it actually coincides with a carbonate unit within the siltstones, which is very strongly foliated. The attitude of fabric in the fault zone is essentially the same as that of the cleavage developed in both hanging-wall and footwall rocks. The fabric within the fault zone is of composite origin, because it contains transposed early folds in one location (Plate 2b). As discussed by Kerr (*this volume*) this fault zone is considered to be part of the Long Steady fault zone, an important regional structure that separates the western and eastern sequences of the Sops Arm group. At this particular locality, the fault is entirely within the Simms Ridge Formation, but mixed mafic and felsic volcanic rocks of the Pollards Point formation occur just west of Corner Brook (Figure 4), and were intersected in the lower parts of some drillholes completed by BP-Selco (McKenzie, 1985, 1987). The contact between sericitic schists and the volcanic rocks in drillholes is described as a "black shale", which likely represents a fissile unit at another discrete fault plane within a composite structure. The strong fabric in the mine fault zone is affected by later folds on the east bank of Corner Brook north of the adit; these folds have gently east-dipping hinges (in the plane of the fault zone) and have a "Z" geometry suggesting that the upper block moved southward (Plate 2c). This interpretation differs from the eastward motion suggested by Heyl (1937) based on observations within the mine workings.

There are scattered pyrite cubes in the sedimentary host rocks throughout the mine area, particularly south of the adit (Plate 2d), but sulphide mineralization is essentially confined to quartz-carbonate veins. Surface exposures and diamond drilling indicate that quartz-carbonate veins are largely confined to the Simms Ridge Formation, although the structurally underlying volcanic rocks were not tested for more than a few tens of metres. The adit itself sits immediately above the fault zone, and crosscutting veins are clearly visible in the walls and roof of the tunnel. These were apparently not the main gold-bearing structures, as they were not excavated, and contain little if any sulphides. Quartz-carbonate veins are also present in the fault zone

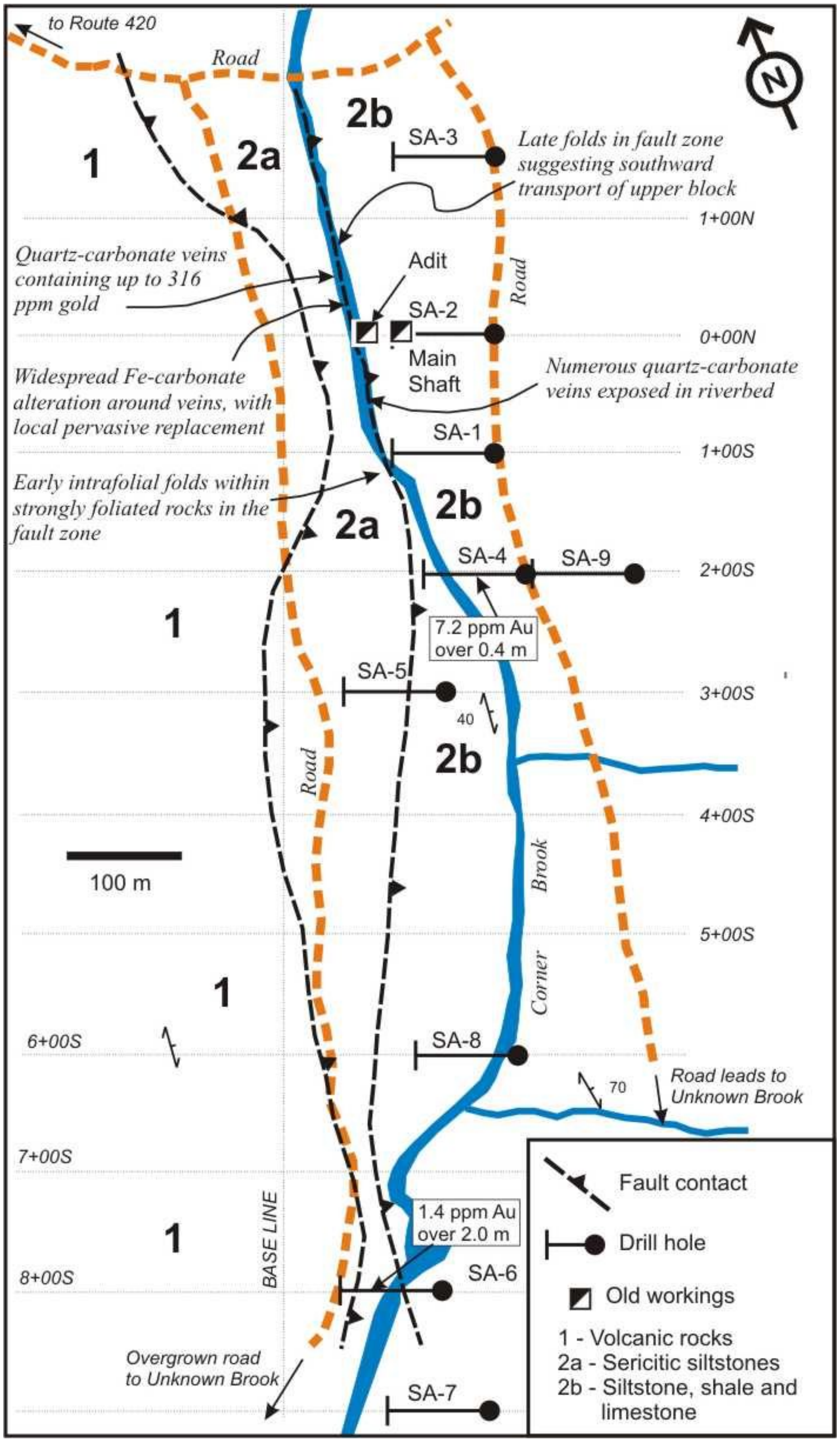

Figure 4. *Sketch map showing the Browning Mine area, local geology, and the locations of diamond-drillholes completed by BP-Selco in 1985 and 1986. Modified after a map prepared by McKenzie (1985). Note that outcrop is very limited outside the bed of Corner Brook, and the positions of contacts are thus approximate.*

itself, where they are generally concordant with the fabric and locally appear to be folded (Plate 3a). Quartz-carbonate veins are also common in the surrounding outcrops, where they vary widely in attitude and width. Most veins have widths of a few tens of centimetres, and most are discordant to the cleavage within the host rocks. In the area north of the adit, it seems that steeply dipping quartz veins oriented at 150 to 160° predominate, whereas quartz veins oriented at 025 to 030° predominate south of the adit. The latter trend is similar to that of the fault zone, although the veins dip more steeply, and some of these veins are boudinaged, suggesting post-emplacement motions along the fault. However, these patterns remain to be confirmed through systematic measurement of vein attitudes. Sulphides are not common in the quartz-carbonate veins and, where they do occur, their distribution is sporadic. Examination of material from the waste dumps confirms earlier identification of pyrite and chalcopyrite, with subordinate galena and sphalerite, but only pyrite and chalcopyrite were observed in the *in-situ* veins. Examples of typical quartz veins in outcrop and drill core are shown in Plate 3a-f.

Systematic sampling of quartz veins exposed in and around the old mine (T. McLennon, personal communication, 2005) provides new information on grades and inter-element correlations (Figure 5). The results vary widely, but auriferous samples typically contain from 0.5 ppm Au to 30 ppm Au, and 9 samples contain >4 ppm Au (Figure 5). Two samples from discrete thin quartz-carbonate veins in the riverbed north of the adit contained 122 ppm and 316 ppm Au respectively, confirming the locally high grades noted in the earliest reports (Howley, 1902). Silver values for auriferous samples are also high, ranging up to 188 ppm Ag (in the sample containing 316 ppm Au). The highest-grade vein (Plate 3b) is narrow (4 to 8 cm wide) chalcopyrite-rich (> 5% Cu), and was noted to contain some visible gold during the 2004 GAC Fall Field Trip; it could be the "one exception" noted by Lundberg in his otherwise negative 1936 comments (*see above*). Contrary to previous suggestions based on visual results, there is little correlation between Au and either Zn or Pb, which would indicate an association with either sphalerite or galena. If anything, there is marked correlation between Au and Cu, which suggests an association with chalcopyrite (Figure 5). There is also good correlation between Au and Ag, as seen also at Simms Ridge and Unknown Brook (*see below*). Currie (2004) found little Au in his samples, and was unable to demonstrate any geochemical associations. Currie and Wilton (2005) did not detect any free gold, but suggested that it was present as invisible gold or microinclusions in pyrite. They also identified the presence of As-rich pyrite in the rims of larger pyrite crystals. It is hard to envisage invisible gold or microinclusions generating whole-rock grades of >300 ppm, and mining refractory gold would have been impossible 100 years ago; thus, free gold must certainly have been present in the deposit.

Previous descriptions of the mine area have emphasized the sericitic nature of some host rocks and suggest or imply a link between this alteration and gold mineralization. However, the sericitic siltstones discussed above occur elsewhere in the same structural setting on both the south and north shores of Sop's Arm, and are thus more likely a regional feature, of either primary or secondary origin (Kerr, *this volume*, see later discussion). Drilling by BP-Selco suggested that these sericitic rocks are weakly anomalous in gold (10 to 100 ppb) but this slight enrichment is not necessarily linked to their sericitic nature. In streambed outcrops north of the adit, orange-brown alteration haloes, typical of iron carbonate alteration, are visible around some quartz veins (Plate 3c). Locally, the siltstones appear to have been completely transformed to massive orange-brown carbonate via intense quartz veining (Plate 3d). This massive carbonate material is also described by Tuach (1987b) and Saunders (1991), who also report that it contains disseminated galena and pyrite. The "siderite spots" in the sericitic host rocks likewise appear to be a regional feature (Saunders, 1991; Kerr, *this volume*), and there is no evidence in the outcrops that they are preferentially developed adjacent to quartz veins. Rather, the brown carbonate alteration zones around some of the smaller veins appear to eradicate the "siderite spots" (Plate 3c). According to Saunders (1991) the spots are actually light-coloured dolomitic crystals that are partly replaced by limonite as a consequence of surface weathering. In the fresh BP-Selco drill core, they actually have a white colour (Plate 2f).

Future Potential

Mineralization at the Browning Mine is clearly confined to narrow quartz-carbonate veins, and the distrubution of sulphides within veins tends to be erratic; as such, they represent a difficult target for further exploration. The inability of subsequent studies to confirm the high gold grades implied by the earliest reports (Howley, 1902) impeded sustained exploration programs over the years. The more recent work by Tom McLennon (personal communication, 2005; Figure 5) has confirmed the auriferous nature of quartz-carbonate veins exposed in the old mine area, and indicated that very high grades (122 to 300 ppm Au; 3.5 to 8.8 ounces per ton) may be present. The drilling completed by BP-Selco in the 1980s was mostly at the old mine site and along strike to the south, rather than to the north of the mine, where these high values occur (Figure 4). However, the local geology implies that volcanic rocks of the Pollards Point formation must lie at relatively shallow depths in this area, which limits the available room for future exploration, assuming that auriferous veins are indeed confined to the

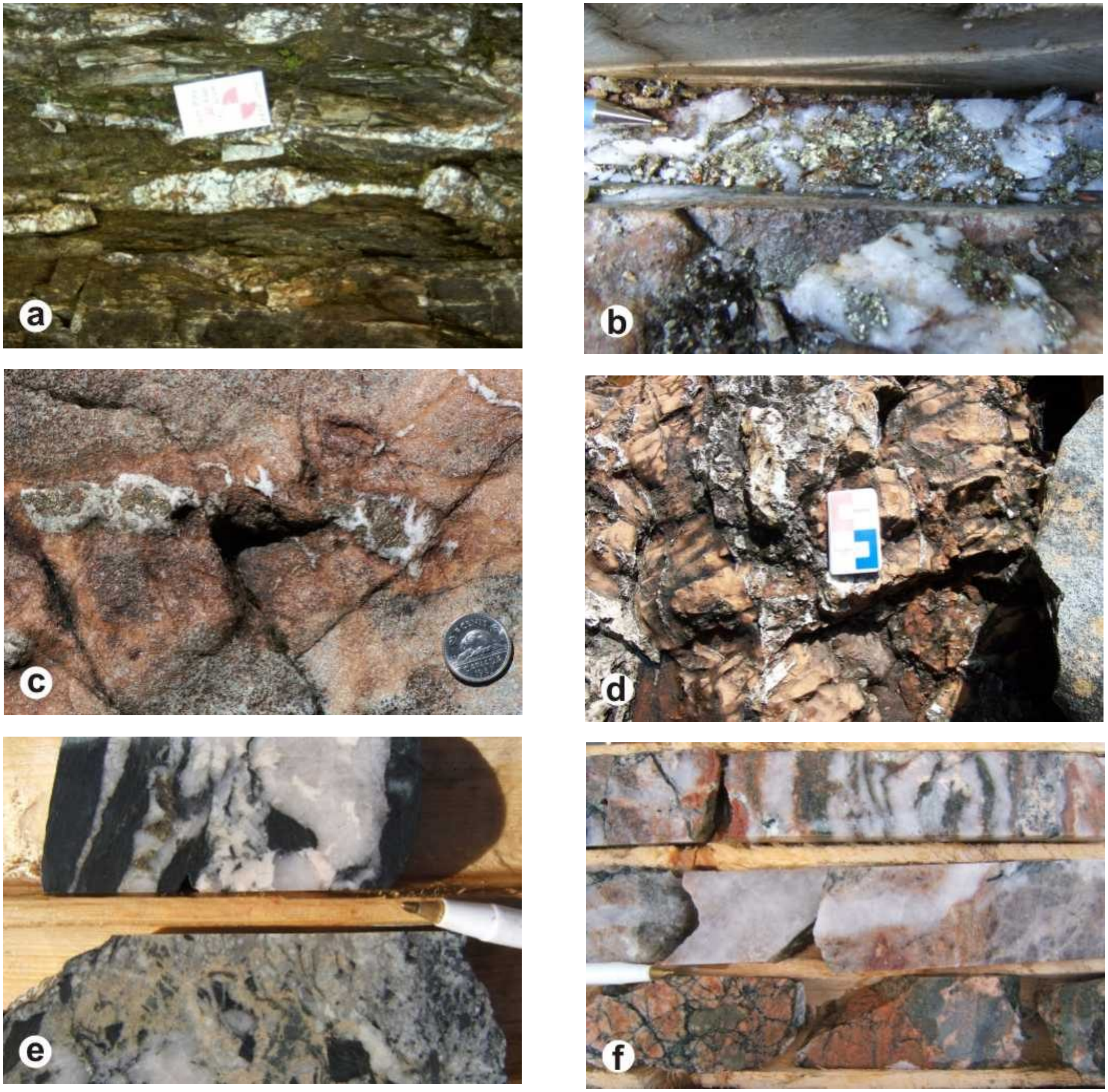

Plate 3. *The Browning Mine area. (a) "Concordant" quartz-carbonate veins in the fault zone adjacent to the adit; note possible fold closure at top right. (b) Thin quartz vein containing abundant chalcopyrite; a channel sample from this spot contained 316 ppm Au. (c) Iron carbonate alteration halo around a sulphide-rich quartz vein, overprinting "siderite spots" in the wall rocks. (d) Pervasive, near-total replacement of siltstone by iron carbonate in an area of intense quartz veining. (e) Quartz-carbonate vein in drill core, showing wall-rock fragments and selvages, and pyrite clots in upper sample; hole SA-4. (f) Quartz veining in felsic volcanic rocks in hole SA-6.*

Simms Ridge Formation. The old adage stating that "the best place to find a new mine is next to an old one" has been proven true in many case histories, and there is no doubt that much of the area around this particular old mine has yet to be tested by drilling.

THE SIMMS RIDGE PROSPECT

The Simms Ridge prospect eluded the pioneering efforts of Messrs. Jackman, Rendell and Stewart, and was discovered in 1932, on a wooded hilltop some 1.5 km north-

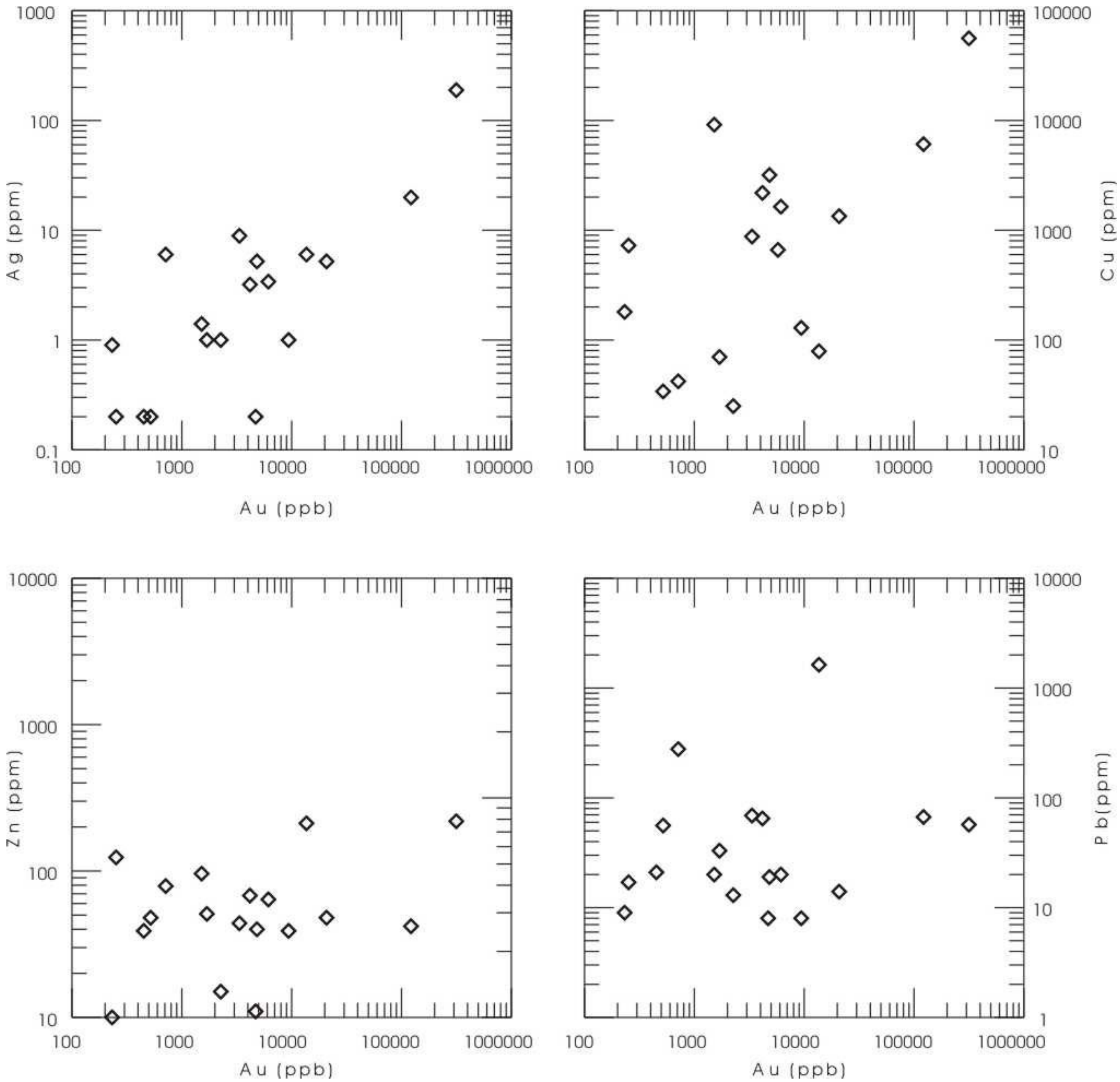

Figure 5. *Relationships between precious metals (Au, Ag) and base metals (Cu, Pb, Zn) in samples of mineralized quartz veins around the Browning Mine. Samples collected by T. McLennon and analyzed at Atlantic Analytical Ltd., Springdale; data presently unpublished.*

west of the Browning Mine. At this time there was a "mild staking rush" in the Sop's Arm area (Lundberg, 1936). It was evaluated intermittently for several years, and has since languished in obscurity, aside from occasional visits by exploration companies and survey geologists. In the 70 years since discovery, thick bush aggressively reclaimed the prospect, and it became more and more difficult to reach the site and find the trenches. Access was greatly improved in 2005, when the Mineral Development Division paid a visit to the site with an excavator to attempt remediation work on a reputed shaft, and opened up the old access trails. The rights are presently held by Mr. Tom McLennon of Grand Falls, and the improved access will greatly assist his future prospecting efforts.

History of Investigation and Exploration

Mr. William Simms worked for the Buchans Mining Company in 1930 and 1931, and was engaged by the Sop's Arm Mining Company to apply his talents in White Bay.

Simms' name was attached to the showing that he found and the hill itself is designated as "Simms Ridge" on official topographic maps. Indeed, Simms was eventually honoured with an entire geological formation, which is rare in the prospecting world! The area around the prospect was cleared and trenched in 1933, as word spread of a "significant gold discovery" in the Sop's Arm area. The first geologist to visit the site was G.V. Douglas, who travelled to Sop's Arm in the fall of 1934 (Douglas, 1934). He was impressed by the width of the quartz vein on the ridge, but noted that sulphides were sporadic and extensively leached, suggesting that the only way to truly assess grade would be through bulk sampling. Seven samples were collected, from which the best result was 0.08 oz/ton Au (~2.8 ppm) and 2.1 oz/ton Ag (~80 ppm); five of seven samples showed negligable gold. Snelgrove (1935) reports that seven shallow trenches revealed quartz veins (with minor carbonate) and wall rocks composed of "sericite schist" and slate. He reported pyrite, chalcopyrite, galena and dyscrasite (a silver antinomide mineral, Ag_3Sb), and free gold and silver. Secondary minerals included anglesite (lead sulphate), covellite, malachite and hematite. He also noted an unknown sulphide "Mineral X", which he suggested to be luzonite ($3Cu_2S \cdot 4CuS \cdot As_2S_5$). Assay results reported by Snelgrove (1934) were essentially those of Douglas (1934), with the exception of a sample of "weathered galena" reported to contain over 5 oz/ton Au (~180 ppm) and 47 oz/ton Ag (~1640 ppm). Needless to say, this result was widely quoted by subsequent workers, although it was not always appreciated that it came from a mineral specimen, rather than a rock sample.

Hans Lundberg (1936) was next on the scene with an option on the property, but first had to resolve legal issues related to the actual ownership of the property, and the funding of the assessment effort. By this time "numerous" shallow trenches had been excavated at Simms Ridge, and a 5-m-deep shaft had reportedly been sunk adjacent to a large quartz vein. The sulphide mineralization was described as "disseminated grains, veinlets and scattered bunches of galena, pyrite and chalcopyrite". Under Lundberg's supervision, G.W. Moore of the Buchans Mining Company collected channel samples from all of the trenches. Lundberg (1936) presents no table of assay data, but notes that the average gold content of 43 channel samples was approximately 0.04 oz/ton (~ 1.4 ppm) and the best result was a mere 0.13 oz/ton (~4.5 ppm). Moore's opinion of the results was not encouraging:

> "..*although the gold values are remarkably uniform and persistent, they are too low grade to be of economic importance.*"

The findings of Heyl (1937) resembled those of Snelgrove (1935) although he does note that the prospect appeared to consist of numerous individual "*en-echelon*" quartz veins rather than a single massive vein. He also described the local geology in more detail. Heyl (1937) considered Simms Ridge to be the most promising of the gold prospects in the Sop's Arm area, and recommended diamond drilling for further assessment. This apparently did occur in 1939, and a report on the findings was filed (Howse, 1939), but the document could not be located. According to Scott (1990), who apparently read a copy, the best result was a mere 0.05 oz/ton (1.6 ppm) gold over about 5 feet.

From this point on, the trees and bushes were left in peace to reclaim the ridge. Simms Ridge merited only a brief mention by Brinex (Sampson, 1973). In 1980, Esso Minerals examined the site as part of a brief exploration program, and collected samples. These returned generally low values, but four samples contained from 0.23 to 0.87 oz/ton gold (8 to 30 ppm Au; see also Figure 6). No further work was recommended (O'Sullivan and Dunsworth, 1981). There is no record of significant exploration activity by BP-Selco at Simms Ridge, although they established a grid at the site, and a soil survey over parts of this gave uninteresting results (McKenzie, 1986). The rights were subsequently acquired by prospector Tom McLennon of Grand Falls, but no work was conducted until 2005, when access was finally improved following remediation attempts. Work to date has consisted of sampling mineralized quartz veins at the site.

Geology, Mineralization and Alteration

There is relatively little to see at the site today and, until recently, it was very difficult to even find the prospect site. The UTM coordinates originally provided as part of MODS file 12H/10/Au003 (507050E/5508380N) are incorrect, and should be replaced by 506740E /5508415N, which is the location of the largest trench and corresponds with the spot indicated on the maps of Smyth and Schillereff (1982). In 2004, R.J. Wardle and the author spent several hours looking for the prospect on a hot summer day, and found it only by chance, when we fell into a shallow trench a few minutes after resolving to abandon the quest. The site is completely overgrown with tangled spruce and alder (Plate 4a), and the shallow trenches now provide little exposure. During remediation efforts in 2005, the central part of the prospect (Trenches 3 and 17; Figure 6, after Heyl, 1937) were approached from the north with an excavator, which generated some new outcrop in this region. The following discussion is summarized from previous accounts, and modified in the light of observations during 2004 and 2005.

The prospect area lies within the Simms Ridge Formation, about 1 km east of its structural base, here considered to be marked by the Long Steady fault zone (Figure 3). The dominant rock types in the area are thin-bedded, well-

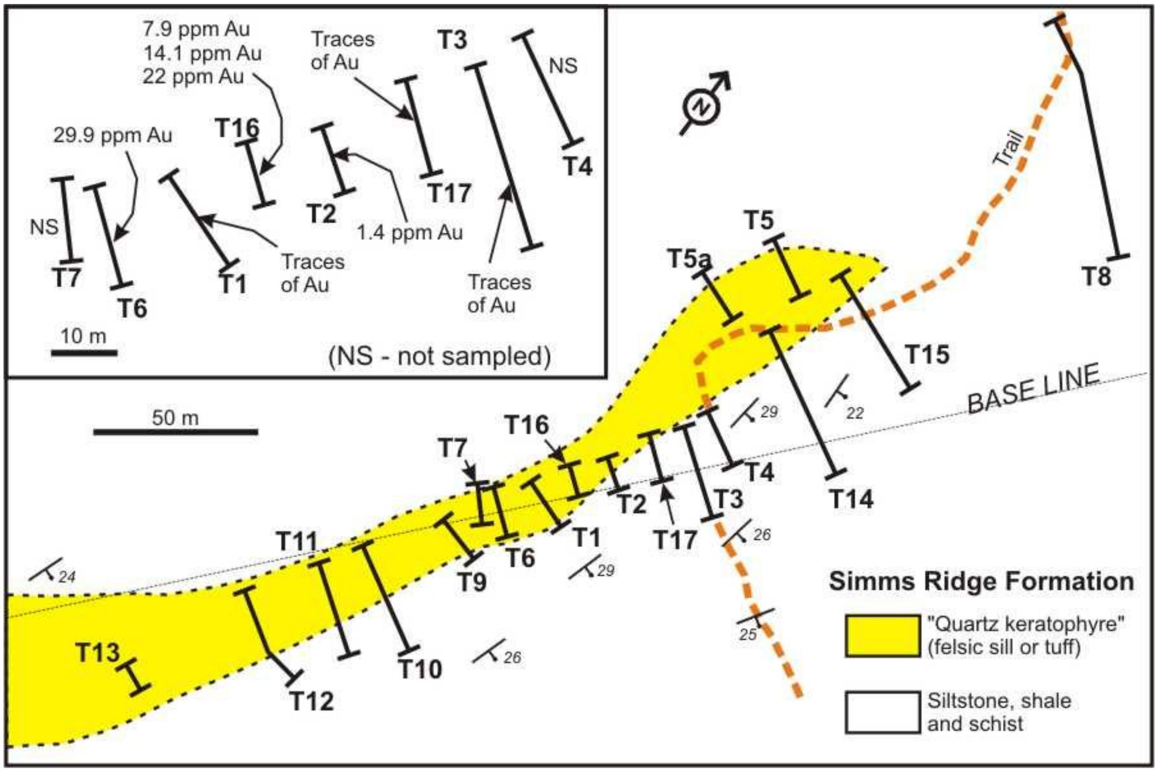

Figure 6. *Sketch map showing the area of the Simms Ridge prospect. Modified after a map prepared by Heyl (1937) with information on gold grades from O'Sullivan and Dunsworth (1981). Inset map is an enlargement of the central part of the prospect.*

cleaved shales and siltstones, with variably developed "siderite spots". The siltstones strike at 010 to 020°, and dip eastward at 20-35° (Plate 4). The siltstones are pale coloured and sericitic, but not as strongly sericitic as those at the Browning Mine. According to Heyl (1937), particularly intense sericitization occurs along the eastern side of the zone. The main quartz vein system is associated with a more massive rock type, which was termed "quartz keratophyre" by early workers (Snelgrove, 1935; Heyl, 1937). This is a pale green, fine- to medium-grained, sericitic rock dominated by quartz and altered feldspar (Plate 4b). This altered igneous rock is more competent than the surrounding metasediments. According to Heyl (1937), the rock is sodic rather than potassic, with abundant albite. This rock type was interpreted to be of intrusive origin by Heyl (1937) and shown as such by Smyth and Schillereff (1982). Contacts between siltstone and "keratophyre" are exposed in the re-excavated trench, where they are conformable with the strong cleavage in the former. It is thus possible that the "keratophyre" instead represents a tuffaceous horizon within the siltstones, but it could equally be a sill-like intrusion. There are other felsic units located southeast of the prospect itself, but at least some of these are pinkish to pale purple felsites of rather different appearance. The greater intensity of quartz veining in these igneous units presumably reflects their greater competence and ability to develop fracturing; felsitic units elsewhere in the Sops Arm group typically host numerous quartz veins (Kerr, *this volume*).

The work from the 1930s suggests that a large quartz vein occurs in the central part of the prospect, notably in Trenches 3 and 17 (Figure 6). Recent field observations suggest that quartz veining is abundant here, but a continuous single vein cannot be confirmed. Rather, there appear to be several discrete quartz veins with widths in the 10s of centimetres, which occur both in siltstones and "keratophyre", but are more abundant in the latter (Plate 4b). The "keratophyre" commonly contains many small quartz veins, and hosts some disseminated sulphide around these. The more abundant sulphides occur in the veins in dispersed patches and clots, and include pyrite, chalcopyrite and prominent galena (Plate 4c, d). Dyscrasite or luzonite were not identified, but Snelgrove's (1935) description suggests that they are only visible under the microscope. Float blocks and new outcrop on the excavator trail to the prospect indicate that there is more than one unit of "keratophyre", and that smaller quartz veins containing similar sulphide minerals occur widely just to the north of the main vein system. The shaft reputed to exist in Trench 3 (Figure 6) could not be confirmed, although this was the deepest of any previous excavation. Sampling by Esso Minerals (O'Sullivan and Dunsworth, 1981) produced interesting results from Trench

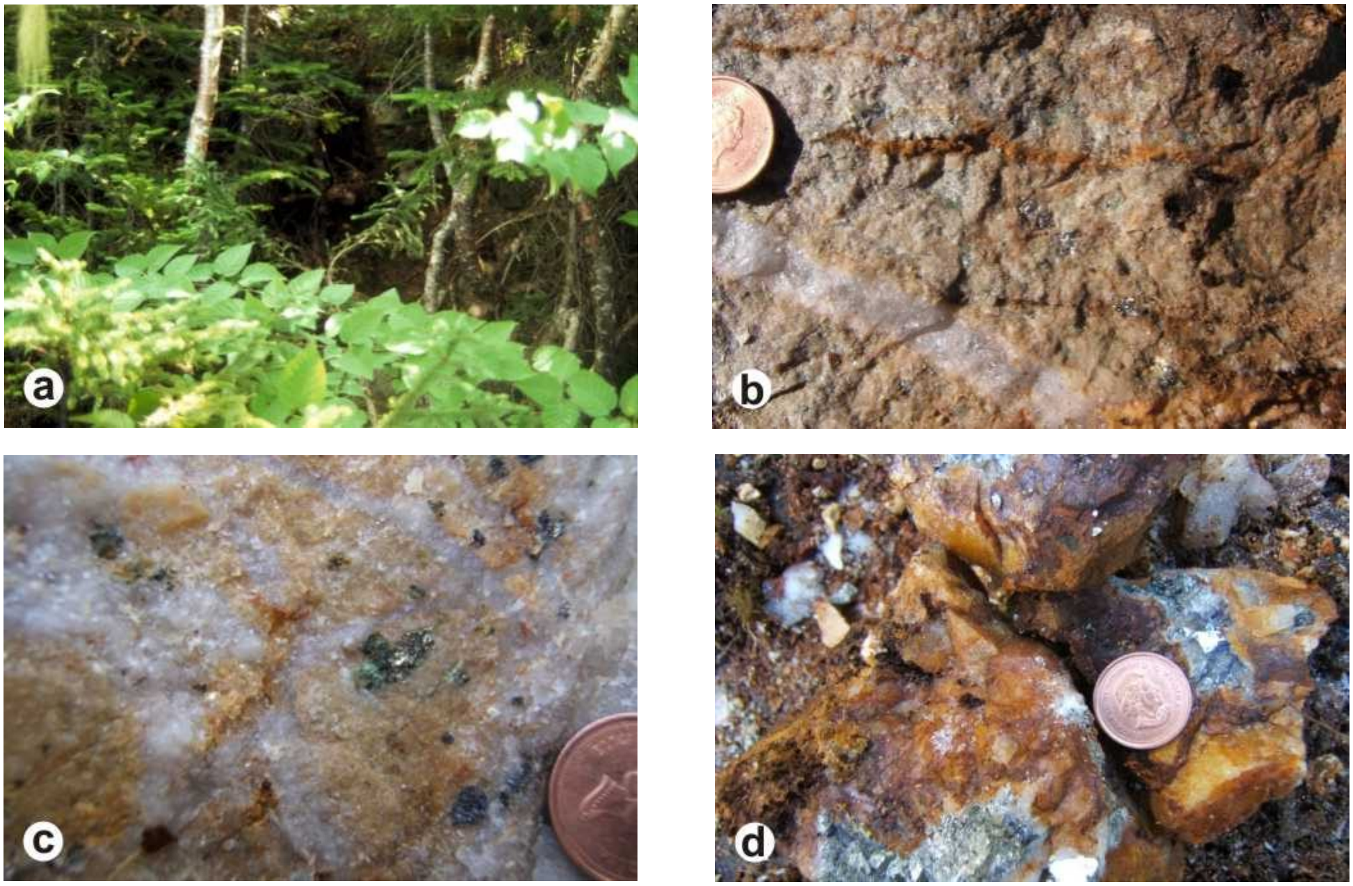

Plate 4. *The Simms Ridge prospect. (a) Site of an exploration trench in 2004, illustrating the thick bush and difficulty in seeing any geological relationships at the site. (b) The "quartz keratophyre" of Heyl (1937), representing either a concordant felsic sill or tuff unit; note quartz veins and disseminated sulphide in wall rocks. (c) Part of a mineralized quartz vein, showing clots of pyrite and chalcopyrite. (d) Sulphide-rich quartz vein, containing pyrite (yellowish) and abundant galena (blue-grey).*

16 (7.9 - 22 ppm Au and Trench 6 (29.9 ppm Au) but found only traces of gold elsewhere (Figure 6, inset).

New information on metal grades at Simms Ridge is available from recent work by Mr. Tom McLennon (Figure 7). Six samples of mineralized veins contain 0.5 ppm to 6.2 ppm Au, and 8 ppm to 60 ppm Ag. Some samples also contain significant Pb, up to 1.9 wt%. Higher Au values are accompanied by the highest Ag and Pb values, but no obvious correlation is evident between Au and Cu or Au and Zn. In this respect, these preliminary data from Simms Ridge are subtly different from those obtained in the Browning Mine area (Figure 5). Currie (2004) suggested that there was a correlation between Au and Pb in his four samples, which contained up to 1.6 ppm Au.

Future Potential

The fundamental issues at Simms Ridge are the average grades over potential mining widths and the precise extent of mineralized quartz veins at the site, neither of which appear to be reliably established from previous work. In terms of grade, the data reported by Lundberg (1936) from channel samples are probably a more accurate indication than more recent grab samples, because the former likely include dilution from barren wall rocks. These suggested bulk grades of <2 ppm Au are not encouraging, but they need to be confirmed through modern analyses. The improved access to the site should now allow for better assessment of the extent of mineralized quartz veins beyond the central area in Figure 6, and it is hoped that more information will be provided in a future account.

THE UNKNOWN BROOK PROSPECT

Amongst the gold prospects of the Sops Arm group, Unknown Brook is the only site at which extensive diamond drilling has been completed. Mineralization was discovered in the 1930s, during the same period as the Simms Ridge and Freemans prospects. In 1985 and 1986, U.S. Borax con-

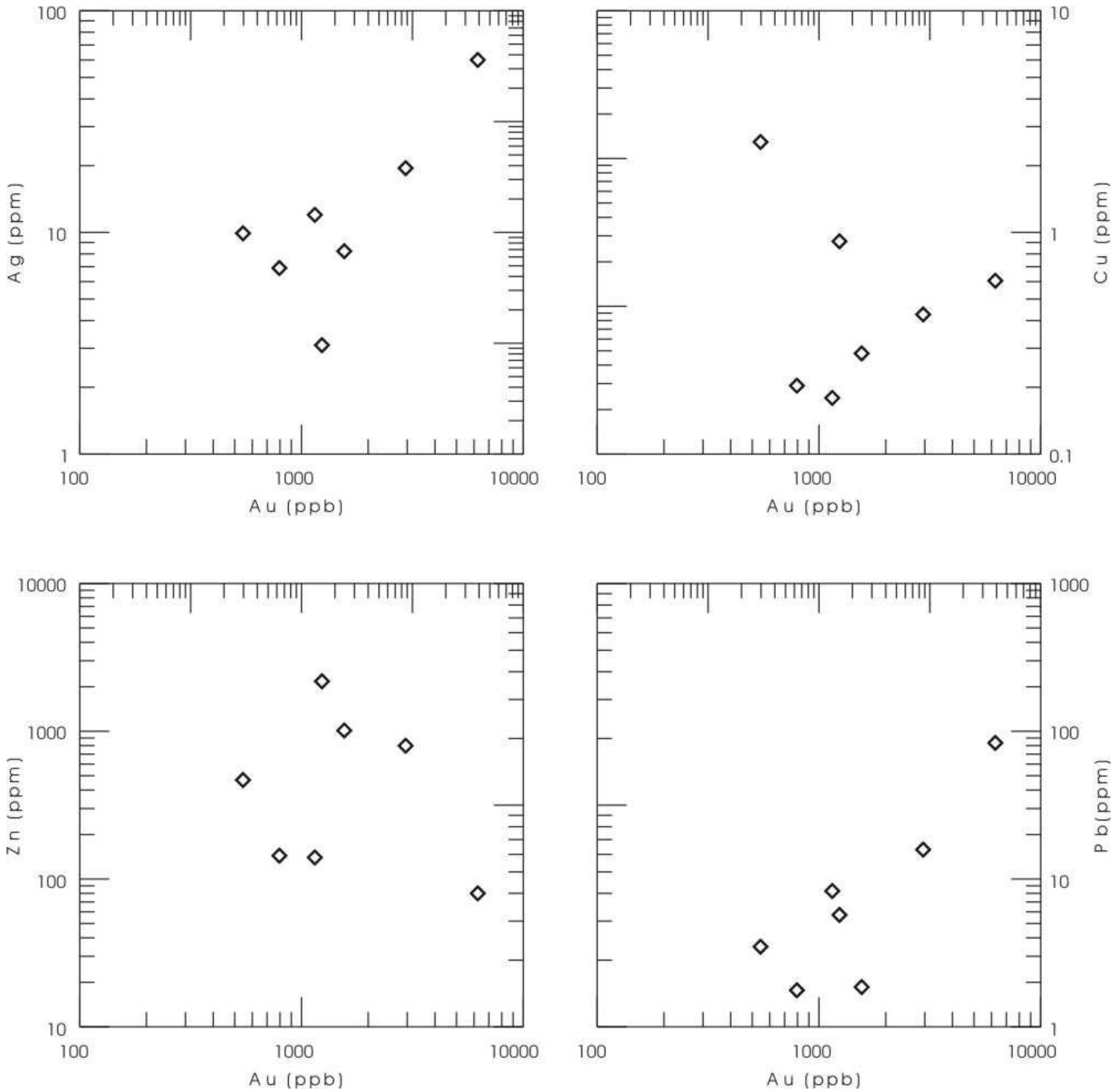

Figure 7. *Relationships between precious metals (Au, Ag) and base metals (Cu, Zn, Pb) in samples of mineralized quartz veins at the Simms Ridge prospect. Samples collected by T. McLennon and analyzed by Atlantic Analytical Ltd., Springdale. Data presently unpublished.*

ducted a detailed exploration program including geophysics, surficial geochemistry and diamond drilling. Interesting gold grades were obtained over narrow widths, but continuity and consistency were difficult to establish. The property was held at the time and subsequently by the well-known local explorationist Lewis Murphy, through Commodore Mining Company Ltd; it is now held by Lewis' son Noel Murphy.

History of Investigation and Exploration

Mineralization was apparently discovered here around the same time as at Simms Ridge, but little information could be found concerning the initial work, other than that claims were staked. Snelgrove (1935) provides the first description, noting quartz veins containing reddish "dolomite", with minor amounts of pyrite, galena and specular hematite, at the junction of an "unknown" tributary and Corner Brook, some 2 km south of the Browning Mine (Figure 3). He noted that veins were located near the contact of slates and felsite, and that the latter showed intense "pyrophyllitization", which he compared to the "agalmatolite" known near Manuels, which would later become the well-known pyrophyllite mine.

Commodore Mining eventually acquired the original claims, and U.S. Borax optioned the property. Exploration in 1985 and 1986 resulted in the completion of 19 diamond-drillholes, which tested a broadly "conformable" zone of quartz veining developed in assorted volcanic and volcaniclastic rocks of the Pollards Point formation adjacent to their faulted contact with the Simms Ridge Formation (Figure 8). The results are presented by Burton (1987) and were later discussed in an excellent report by Scott (1990). Prospecting efforts located anomalous samples from vein outcrops and quartz vein float, with Au contents locally as high as 85 ppm Au, and sporadic high Ag contents. Drilling intersected mineralization over a strike length of about 800 m, but the intervals were narrow and difficult to correlate from place to place. The best results gave impressive grades (up to 2.3 oz/ton Au, or 79 ppm Au) but the best overall results were in the first few holes, one of which contained 8.6 ppm Au over 2.6 m. These are certainly the best drilling results from any prospects in the Sops Arm group to date, but no further exploration work was conducted on the property.

Geology, Mineralization and Alteration

The Unknown Brook prospect is accessible via two disused logging roads that follow the valley of Corner Brook on its east and west sides; both roads reach to within a few hundred metres of the site. From this point bush traversing is required, because the old drill trails are now completely filled with dense alders. There is very little outcrop outside the stream bed of the tributary brook (Figure 8). The quartz veins are best exposed in the bed of Unknown Brook, where they cut a strongly foliated, schistose, calcareous siltstone that resembles some of the rocks exposed in the fault zone near the Browning Mine (*see above*). Quartz veins are also present in some of the volcanic outcrops upstream in the brook. The fabric in the calcareous schist, presumed to represent the Simms Ridge Formation, strikes at 130° and dips 70°E, indicating that regional trends have altered as part of the regional flexure of the Sops Arm group in this area (Figure 3). The calcareous schist, however, is not the main host to veins intersected in drill core (*see below*). It is not visibly sericitic, and lacks the "siderite spots" reported elsewhere. The veins crosscut the fabric, have irregular geometry, and contain a prominent red mineral identified as potassium feldspar (presumably Snelgrove's "dolomite"), in addition to quartz and white carbonate (Plate 5a, c). The most obvious sulphides are pyrite and chalcopyrite; minor galena was also observed. These findings corroborate previous descriptions (Burton, 1987; Tuach, 1987b; Saunders, 1991). To the west of the surface showings, Unknown Brook exposes mafic and felsic volcanic rocks, including the "pyrophyllitized" unit noted initially by Snelgrove (1935). This has a striking "rodded" appearance in outcrop (Plate 5b) interpreted either as stretched primary features or tectonic lithons (Saunders, 1991). XRD analysis of this unit (reported by Saunders, 1991) suggests that it does not contain pyrophyllite, but rather fine-grained muscovite (sericite ?) and quartz. This strongly altered felsic volcanic rock was also tested by diamond drilling, but was not auriferous (Burton, 1987; Scott, 1990). Saunders (1991) suggested that it might represent a thrust fault developed within the volcanic rocks, structurally below a similar thrust at the volcanic - Simms Ridge Formation contact. This interpretation is consistent with the presence of a major structure at this boundary (Kerr, *this volume*).

Diamond drilling (Figure 8) tested approximately 800 m of strike length along the valley of Corner Brook, with holes drilled to the southwest. Several key holes were examined in 2005, but parts of the following discussion are drawn from earlier reports. Collectively, the 19 drillholes define a crude stratigraphy consisting of felsic volcanic and pyroclastic rocks at the base (west), overlain by chloritic mafic rocks and the strongly sericitized zone exposed in Unknown Brook. Above the sericitic rocks are varied volcaniclastic sedimentary rocks, including coarse arkosic sandstones and some conglomeratic units of pale grey-green to pink or red colour; the clasts in the conglomerates are of felsic volcanic origin (Plate 5c). This is the predominant host rock to the auriferous quartz veins described below, rather than the calcareous schistose host rock at the surface showing. The upper parts of some drillholes collared in the east contain well-bedded siltstone with thin calcareous layers and schistose rocks that resemble those at the surface showing. In hole UB-85-03, these are strongly foliated at the contact with the volcaniclastic rocks, and show indications of complex folding (Plate 5d). The sedimentary rocks are considered to represent the Simms Ridge Formation, and to be in tectonic contact with the volcaniclastic rocks, considered to be part of the Pollards Point formation. Repetition of the siltstones and the volcaniclastic sequence was also observed in this hole, implying that the fault zone at the formational boundary is a composite structure. Abundant faulting is also reported in holes UB-86-10 and 11, which are mostly within the Simms Ridge Formation (Figure 9), and in several other drillholes (Burton, 1987; Scott, 1990). Construction of drill sections is impeded by the lack of elevation data, but the general geometry can be established in areas where two or more holes are aligned (Figure 9; modified after Scott, 1990). The volcaniclastic unit that acts as the principal host

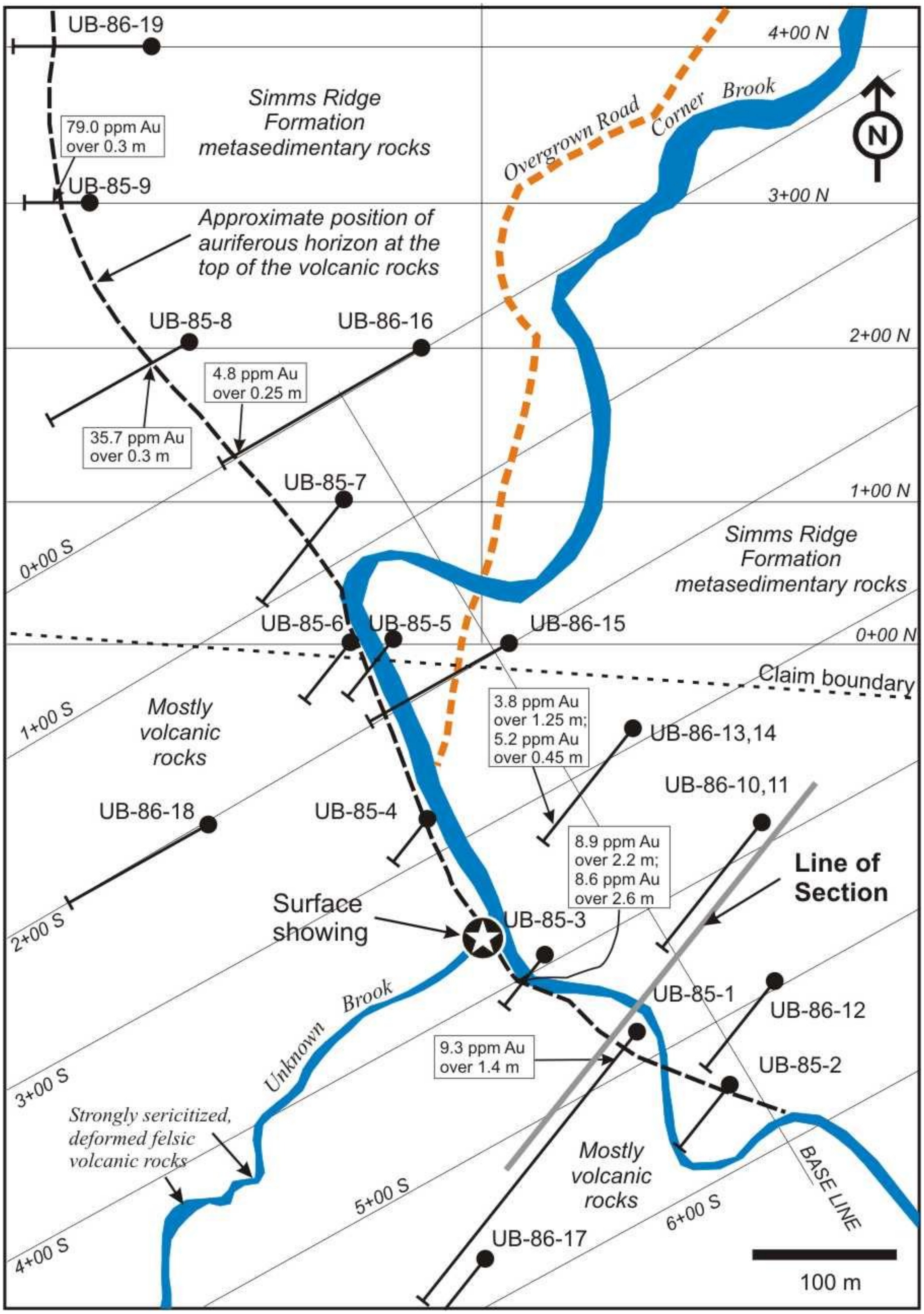

Figure 8. *Sketch map showing the area of the Unknown Brook prospect, local geology and the locations of diamond-drill-holes completed by U.S. Borax in 1986 and 1987. Modified after a map prepared by Burton (1987).*

Plate 5. *The Unknown Brook prospect. (a) Quartz-carbonate-feldspar vein cutting schistose calcareous siltstone at the surface showing. (b) Strongly deformed, sericitic felsic volcanic rocks from the structural footwall to the prospect, showing prominent downdip lineation. (c) Part of a mineralized quartz vein cutting a poorly sorted red volcaniclastic conglomerate (lower left) and arkosic sandstone (top right) host rocks. The yellow-brown mineral in the vein is iron carbonate, and the bright red mineral is K-feldspar. (d) Strongly deformed Simms Ridge Formation in the fault zone structurally above the auriferous horizon; note folding in pale carbonate unit.*

to mineralization dips eastward, and its top appears to be a structural discontinuity, interpreted here as the Long Steady fault zone.

The gold mineralization is associated with locally spectacular quartz-feldspar-carbonate veins (Plate 5a, c), that cut the volcaniclastic rocks and (locally) cut the overlying Simms Ridge Formation siltstones. The principal sulphide mineral visible in the core is pyrite, with minor galena. Burton (1987) mentions very minor stibnite and fluorite. The highest gold values invariably correspond to narrow sulphide-rich sections, which have now decomposed to pyrite sands. A consultant report completed on 3 samples (D.F. Strong, *in* Burton, 1987) identified pyrite, galena Ag–telluride and a Pb–Ag sulphide mineral. The galena was observed in fractures within the pyrite, suggesting that it developed following brecciation and fracturing of that mineral. The study also identified free gold which, upon microprobe analysis, proved to be electrum (about 80% Au alloyed with 20% Ag). The red mineral in the veins was identified by microprobe analysis as virtually pure K-feldspar, with essentially no albite or anorthite component; XRD analysis suggested that it is microcline, rather than orthoclase or adularia (as suggested in the U.S. Borax drill logs). The pattern of the veins is chaotic, and in some places they run almost along the axis of the drill core, making it almost impossible to calculate the true widths of some of the mineralized intervals. The only geochemical data available are the assays reported by U.S. Borax in their drill logs, which report only Au and Ag. Data from 4 selected drill-holes are illustrated in Figure 10, and demonstrate a good correlation between Au and Ag, consistent with the occurrence of electrum documented by D.F. Strong (*in* Burton, 1987). Inspection of data from surface samples and float (compiled by Scott, 1990) does not reveal any obvious correlation between Au and the base metals Cu, Pb and Zn. Regrettably, base-metal data are not available for drill-core samples.

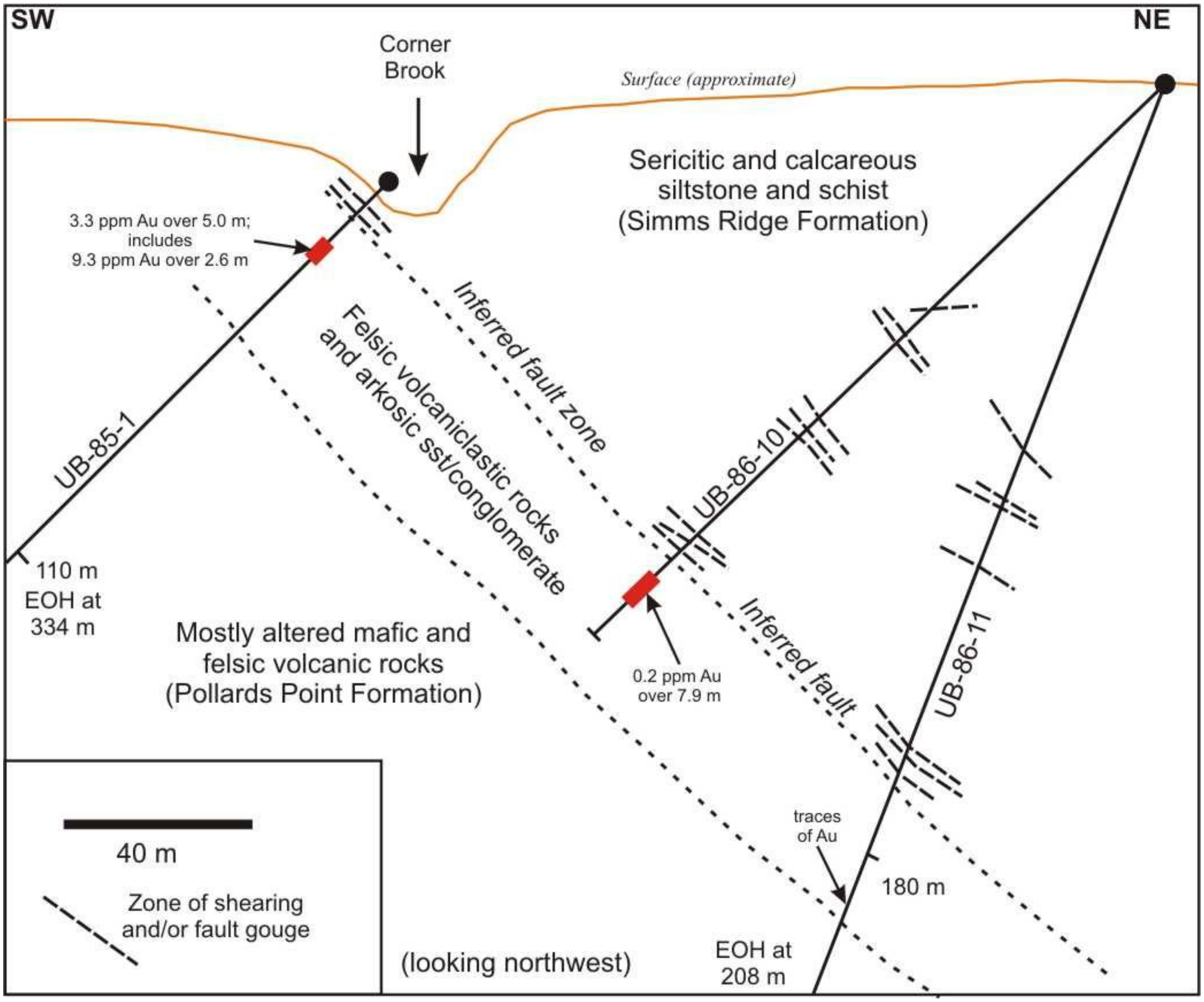

Figure 9. *Generalized cross-section through the Unknown Brook prospect. Modified after Scott (1990); for location of the section lines,* see *Figure 8.*

The principal alteration described in assessment reports is sericitization, which affects all units intersected by the drilling. However, in the holes examined in 2005, there is no apparent relationship between the intensity of sericitic alteration and the locations of auriferous veins. This does not rule out a relationship between the two, but it raises the possibility that sericitic alteration is a regional "early" feature that predates vein emplacement, as suggested by its presence over wider areas (Kerr, *this volume*).

Future Potential

Compared to the Browning Mine and the Simms Ridge prospects, the Unknown Brook prospect has better gold grades over a wider area, with a strike length of almost 800 m. However, the high-grade intersections are narrow and they lack continuity. In her compilation report, Scott (1990) notes that the mineralized zone is not closed off to the north, and recommended more drilling. Similarly, drill coverage to date does not close off any mineralization in the third dimension. Recommendations for additional work were also made by Burton (1987). Despite these views, and the persistent efforts of Mr. Lewis Murphy, attempts to interest major or junior companies in optioning the property have proved unsuccessful. For now, the true mineral potential of Unknown Brook remains at least partly unknown.

THE FREEMAN'S PROSPECT

The Freeman's prospect (Figure 3) is named for its discoverer, Mr. Arch Freeman of Norris Arm, who located mineralization in 1935. The prospect has not yet been visited;

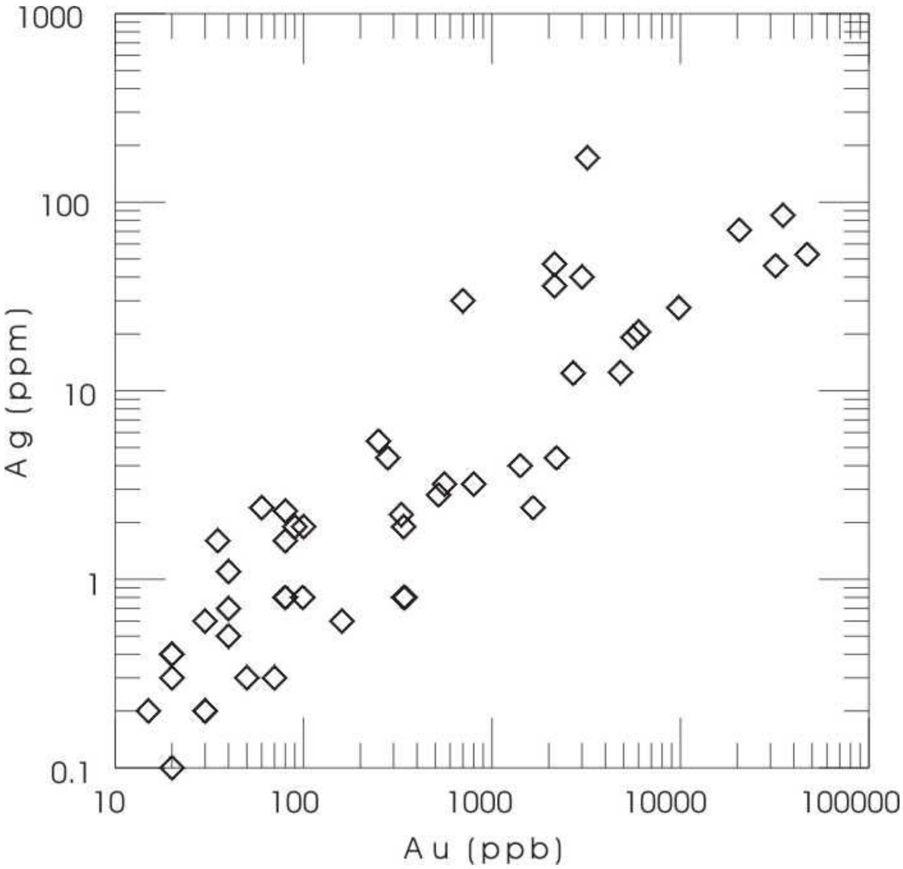

Figure 10. *Relationship between Au and Ag in assays completed by U.S. Borax on four drillholes at the Unknown Brook prospect. Data from Burton (1987), analytical methods not specified. Note that original assay certificates were unavailable.*

given the distance from any access (>5 km), the gruesome nature of the terrain and some uncertainty over the exact location, it presently has a low priority. The following description is adapted from Heyl (1937) and MODS file 12H/10/Au004.

Mineralization is located within the Simms Ridge Formation, not far from its presumed structural contact with volcanic rocks of the Pollards Point formation (Figure 3). Dykes and sills of “keratophyre” are reported in the area, and the mineralization is stated to occur in these, and also in limestone units, in both cases associated with quartz-carbonate veins. Pyrite and chalcopyrite are reported by Heyl (1937). Betz (1948) reports an assay of 0.0125 oz/ton Au (<0.5 ppm Au) from a vein at the site. Heyl (1937) also discusses several other occurrences under the general heading of “Freeman’s prospects”, because Mr. Freeman apparently held claims over a wider area. Some of these may actually correspond to granite-hosted gold occurrences later reported in the Big Davis Pond area (*see* Saunders, 1991). Some of these occurrences were later resampled by BP-Selco, with negative results (McKenzie, 1986).

THE WIZARD PROSPECT

In the early and mid-1980s, Esso Minerals completed work in several parts of western White Bay. These efforts were for the most part unsuccessful, but some new auriferous zones were defined in the Sops Arm group and other units. The most promising of these was the Wizard prospect, located a few kilometres south of Sop’s Arm, adjacent to highway 420 (Figure 3), within volcanic rocks of the Pollards Point formation. The outcrops at the showing are described by O’Sullivan (1986), Tuach (1987b), and Saunders (1991); the description below is adapted from a recent field trip guide (Kerr *et al*., 2004).

The roadcut outcrop containing the Wizard prospect reveals green, chloritic, schistose rocks that are probably derived from mafic volcanic or tuffaceous rocks of the Pollards Point formation of the Sops Arm group. There are no obvious primary volcanic features, and the rocks are suspected to be tuffs. At the south end of the roadcut, a strongly foliated, 3-m-wide, sericite (felsic ?) tuff unit is exposed within more mafic tuffs on both sides of the road, and was

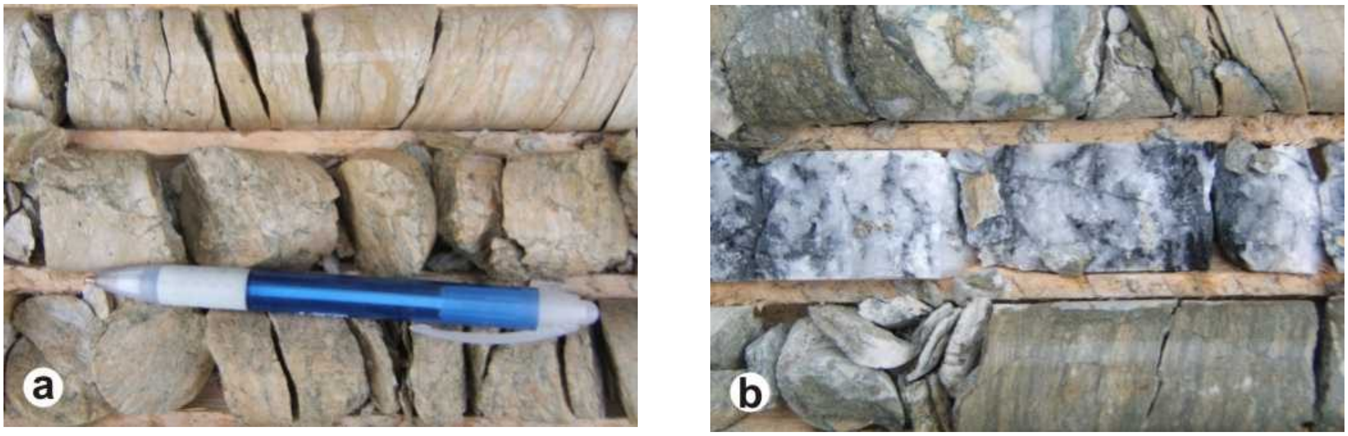

Plate 6. *The Wizard prospect. (a) Sericitic felsic volcanic host rocks, showing strong brittle deformation related to the proximity of the Doucers Valley fault zone. (b) Sulphide-bearing quartz vein cutting altered felsic volcanics, and containing a dark mineral identified by O'Sullivan (1986) as tourmaline. This particular vein contained no gold.*

intersected by drilling (Plate 6a). The sericitic unit contains minor disrupted and tightly folded quartz veins that contain minor pyrite and traces of galena; grab samples of vein material assayed 5.3 ppm and 6.1 ppm Au, and a channel sample gave 2.3 ppm Au over 2.4 m (O'Sullivan, 1986). The veins are also reported to contain black tourmaline. The location is very close to the trace of the Doucers Valley fault zone, and everything is subjected to later brittle deformation. The Wizard prospect was tested by diamond drilling, but results were not encouraging, as the best intersection gave only 1.7 ppm Au over 0.7 m (O'Sullivan, 1986). The veins intersected in the drillholes contain the distinctive black mineral identified as tourmaline, associated with pyrite (Plate 6b), but not all such veins in the holes proved to be auriferous.

BROWNING WEST PROSPECT

The Browning West prospect is located to the west of the former Browning Mine (Figure 3). It was originally defined as an area of interest by soil surveys, and subsequent prospecting revealed altered volcanic rocks, containing quartz-carbonate veins and lenses, some of which carried gold. Trenching and sampling produced assays up to 4.8 ppm Au (McKenzie, 1987). Diamond drilling was limited to two holes, from which the best assay was 2.7 ppm Au over 2 m, and no further work was conducted (McKenzie, 1987). In a review of exploration opportunities in the area, Scott (1990) suggested that further work was warranted. Portions of one drillhole were briefly examined in 2005, and reveal a complex assemblage of mafic and felsic metavolcanic rocks.

OTHER GOLD AND SILVER PROSPECTS

The prospects described above are the most important examples of gold mineralization in the Sops Arm group, but several other minor examples of gold, silver and copper mineralization also exist in the area. For some of these, little can be added to previous summaries by Tuach (1987b) and Saunders (1991), and they are briefly reviewed below. Examples of gold mineralization noted in plutonic rocks of the Gull Lake Intrusive Suite and metavolcanic rocks of the Southern White Bay Allochthon are not discussed here; for information on these, see Saunders (1991). The occurrences noted below are all indicated on Figure 3.

Park Showing and Road Showing

The Park and Road showings are located along highway 420 and are described by Tuach (1987b) and Saunders (1991). The Park showing consists of quartz veins containing minor sulphides (grab samples up to 2.7 ppm Au) and the Road showing appears to be a pyritic, sericitic zone in felsic metavolcanic rocks. Both are hosted by rocks of the Pollards Point formation. The style of mineralization resembles that seen in other prospects described above.

The Post Office Adit

At around the same time as the adit at the West Corner Brook prospect was excavated, a similar short adit was developed close to the shoreline in Pollards Point, located above the road just west of the post office (Figure 3). The adit was targeted on quartz veins in volcanic rocks; the veins contain minor specular hematite, but no obvious sulphides. A sample collected by BP-Selco from one of these veins contained 0.23 ppm Au, so there is at least a trace of gold at this spot. Not surprisingly, the location is generally referred to in the community as "the mine". It has so far eluded reclamation efforts by the Mineral Development Division.

The Schooner Cove Silver Showing

Schooner Cove is located a few kilometres north of Sops Arm, and is accessible by boat. It should not be confused with another Schooner Cove, which is actually in the community of Sop's Arm. A prominent ridge behind the cove is formed by a resistant fine- to medium-grained plutonic rock that forms a sill-like body within the Natlins Cove Formation (Figure 3). According to Snelgrove, the sill contains seven thin quartz veins, which carry pyrite and galena. A wider quartz vein (0.4 m across) was said to contain pyrite, chalcopyrite, dyscrasite (Ag_3Sb), galena and covellite. Assays from veins were stated to contain between 1 and 2 oz/ton Ag (34 to 78 ppm Ag), but no gold (Snelgrove, 1935). The site was visited in 2004 and 2005, and several quartz veins were indeed found in the felsic sill. However, the only sulphide mineral found was galena, in trace quantities, and no samples were collected.

Frenchman's Cove Gold Showing

Maps indicate a small gold showing a short distance inland from the shore of Frenchman's Cove, north of Jackson's Arm, within the Coney Head Complex immediately adjacent to its contact with the Sops Arm group (Figure 3; MODS file 12H/15/Au002). Disseminated sulphides (pyrite) were found in trondhjemites on the shoreline very close to this spot, and appear to be associated with a quartz vein that contains clots of pyrite and chalcopyrite. This is suspected to be the showing referred to in the MODS file. An assay of 1.8 ppm Au is attributed to O'Sullivan (1986), although it is not clear if this represents exactly the same location. Although this showing is not strictly within the Sops Arm group, the style of mineralization is similar to other examples.

Natlins Brook Copper Showing

The Natlins Brook copper showing (Figure 3) consists of a narrow quartz vein (15 to 25 cm wide) that cuts mafic volcanic rocks within the Natlins Cove Formation adjacent to a woods road near Anstey's Pond, south of Sop's Arm. The vein contains large masses of chalcopyrite, but these are irregularly distributed. According to Mr. Tom McLennon, who holds the mineral rights to the area, grab samples contained up to 10% Cu, but have low Au contents of 0.1 ppm or less.

Northern Sops Island Gossans

The volcanic rocks of the Natlins Cove Formation are largely devoid of sulphides or sulphide-bearing veins. However, disseminated sulphides are widespread around the northern tip of Sops Island (Figure 3), notably between Open Head and Rosemary Cove. There is no sign of quartz veining here, but the rhyolites are cut by many minor faults. Some of the gossans exhibit greenish staining suggestive of copper. These rusty zones have been described in several reports, but there is no record of assay results. They were sampled during the 2005 season, but no results are presently available.

DISCUSSION

The gold mineralization of the Sops Arm group is important from several perspectives. Although the gold produced here is a minuscule part of historic provincial production, which is dominated by byproduct gold from VMS deposits, it is an important part of our history, and the development of our minerals industry. From a geological viewpoint, it is important because it remains the best example of gold mineralization in a Silurian cover sequence in Newfoundland. Although gold mineralization in Newfoundland has long been viewed as Siluro-Devonian in timing, the majority of occurrences are in Ordovician rocks of the Dunnage Zone (Wardle, 2004). A full discussion of the information presented in this report must await additional data and synthesis, but a few key points can be expressed in preliminary form.

Early workers in the area did not concern themselves overly with the origin of the gold, although links were suggested to granitoid plutons. Tuach (1986) proposed an "epithermal-fumarolic" model for the Sop's Arm gold mineralization, in which a key ingredient was widespread sericitization and "pyrophyllitization" of the type observed at the Browning Mine and at Unknown Brook. In her review of the area's potential, Scott (1990) also considered models of this general type most applicable. In contrast, Saunders (1991) pointed to several features of the gold mineralization that are far more characteristic of mesothermal, or "orogenic" gold mineralization (e.g., Groves *et al*., 1998, 2003). The recent thesis study by Currie (2004) presents limited fluid inclusion and stable isotope data that also support such a conclusion. Based on previous work and observations in 2004 and 2005, the author agrees with this general conclusion. No evidence for epithermal-style quartz veins or related gold mineralization was seen.

The known gold mineralization is not scattered throughout the area, but lies mostly in the region south of Sop's Arm, where it occurs in the volcanic rocks of the Pollards Point formation and adjacent sedimentary rocks of the Simms Ridge Formation (Figure 3). The suggestion that the base of the latter formation represents an important structural break within the Sops Arm group implies a large-scale structural control in which gold is spatially linked to the Long Steady fault zone (Figure 3). Relationships of this type are also common in orogenic gold belts, where major structures act to focus fluid flow and aid in the development of structural traps (e.g., Groves *et al*., 1998, 2003). Previous workers suggested that the major structural break defined by the Doucers Valley fault zone exerts a regional control on gold and other mineralization (e.g., Tuach, 1987a), and this may still hold true, but the Long Steady fault zone may be the specific controlling structure in the Silurian rocks. It is also interesting that tight folding is developed mostly in the Simms Ridge Formation and lowermost Natlins Cove Formation adjacent to this structure. Dilational effects related to such folding are also seen as important local controls on the locations and thicknesses of mineralized veins (e.g., Horne *et al*., 2005). This view implies that other regions adjacent to this structure, such as the segment between Sop's Arm and Jackson's Arm, could have potential for gold. However, the controls on mineralization may not be structural alone.

The assessment of alteration signatures that are broadly associated with gold mineralization in the Sops Arm group is problematic. Previous workers have pointed to sericitization and chloritization as examples of genetically associated alteration systems, but there is limited evidence to support this contention. Sericitization occurs on a regional scale in both felsic volcanic and sedimentary rock types, and the sericitic rocks seen at the Browning Mine occur along strike for several kilometres. It is certainly possible that sericitic alteration is associated with the Long Steady fault zone on a regional scale, but this could be much earlier than any gold-related alteration. Similarly, chloritization is a common feature in mafic metavolcanic rocks. The only alteration that can be directly linked to gold-bearing quartz veins on the basis of field evidence is the iron carbonate alteration in the Browning Mine area, which forms haloes around individual veins. The same problem applies to the "siderite spots", which have similarly been linked to the gold in previous treatments (e.g., Tuach, 1986). These also occur on a regional scale and, if anything, appear to be overprinted by iron carbonate alteration at the Browning Mine. Saunders (1991) considered them to be a regional feature developed in the south of the area. Iron carbonate is a common alteration type in mesothermal, "orogenic" gold settings (Groves *et al*., 1998, 2003; Poulsen *et al.,* 2000).

A final point of interest concerns possible spatial and genetic relationships between gold-bearing veins and plutonic rocks such as those of the Gull Lake Intrusive Suite (Figure 3). Several of the gold prospects lie within 2 to 3 km of these granitic rocks in the area south of Sop's Arm. On a regional scale, quartz veining (with or without associated sulphides) is notably more abundant in the Simms Ridge and Natlins Cove formations of the Sop's Arm area than around Jackson's Arm, where there are no regionally extensive plutonic rocks. Saunders (1991) reports the presence of mineralized quartz and quartz-carbonate veins in granitic rocks of the Big Davis Pond area, suggesting that some mineralization actually postdates the granites. Broad spatial relationships between plutonic rocks and gold-bearing veins are reported from many mesothermal gold provinces, but these do not necessarily indicate that auriferous fluids were of magmatic origin. The plutonic rocks and the meseothermal veins are more likely separate manifestations of high heat flow related to melting and dehydration at much deeper levels, which drove fluids to higher crustal levels where gold was precipitated in chemical or structural traps (Groves *et al*., 1998, 2003; Poulsen *et al.,* 2000).

To summarize, the most likely first-order controls on gold mineralization in the Sops Arm group are the presence of an important regional structure (the Long Steady fault zone) and (perhaps) relative proximity to plutonic centres, themselves indications of increased heat flow and fluid activity. This is certainly not a new conclusion, for in many respects it was expressed over a century ago by James P. Howley, who stated:

> *"The porphyritic intrusions, being composed chiefly of alkaline substances, would have the effect first of heating the aqueous solutions and then precipitating, or causing to be precipitated their metallic contents. Assuming that the gold may have been originally contained in the country rock, or more probably in the pyrites disseminated through it, the chemical action which would appear to have taken place, resulted in the dissolving out of the gold therefrom, and its redeposition by the precipitative action of the injected alkaline substances. Whether either of the above be the correct solution of the modus operandi by which Nature in her grand laboratory brought about the deposition of the precious metals or not, it is a noted fact that in the vicinity of the most prolific gold bearing leads, porphyritic intrusions seem to have exerted a marked influence upon the character of the auriferous deposits"*

In many respects, these words written so many years ago contain several elements of the modern models for mesothermal gold deposits.

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Note: Geological Survey file numbers are included in square brackets.