FORS - A PROTEROZOIC SEDIMENTARY EXHALATIVE BASE METAL DEPOSIT, PURCELL SUPERGROUP, SOUTHEASTERN BRITISH COLUMBIA (82G/5W)

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(Contribution No. 31, Sullivan-Aldridge Project)

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INTRODUCTION

The 1992 discovery of high-grade base and precious metal mineralization at the Fors property rekindled interest in the Middle Proterozoic Aldridge Formation and provides a new exploration target. Argentiferous lead-zinc mineralization occurs at the top of a discordant zone of pebble wacke or fragmental in middle Aldridge sandstone and mudstone.

Sulphide mineralization consists of pyrrhotite, sphalerite, galena, arsenopyrite, pyrite, chalcopyrite, and bismuthinite in stratiform, semimassive to massive lenses, as well as disseminations and veins. Scheelite is a local accessory. Gold values range up to 0.7 gram per tonne; silver to 734 grams per tonne. Drill-hole intersections of up to 25% combined lead and zinc over 1 metre have been reported; no tonnage estimates are available. The deposit is unusual in having extensive and varied alteration assemblages dominated by plagioclase, biotite, tourmaline, white mica, carbonate, tremolite-actinolite, talc and silica.

The Fors deposit is thought to be the product of sporadic hydrothermal activity along a cylindrical conduit, possibly following a growth fault, in well bedded but weakly consolidated sediments. Fluids moving along this conduit transported sediment upwards to create a "sand volcano" with a fragmental pipe in its core and a structureless sandy edifice on the seafloor. Changes in composition and volumes of hydrothermal fluid, together with ingress of sea water, account for the variety of alteration minerals. Sulphide minerals were deposited at two or three intervals during the evolution of this pipe. Timing of mineralization and alteration may coincide with the emplacement of a thick gabbroic sill 400 metres below the deposit.

This description of the geology, mineralization and alteration of the Fors discovery is based on three weeks' fieldwork in the summer of 1994 (JMB) and periodic surface exploration and drilling since 1966 (DLP). It supplements a brief earlier description by Höy *et al.* (1993). Since the discovery does not crop out, this description is based entirely on examination of drill core.

LOCATION, ACCESS AND EXPLORATION HISTORY

The Fors prospect (MINFILE 082GSW0[illegible]5) is located 17 kilometres southwest of Cranbrook, near the northern end of Moyie Lake, at latitude 49°22'N and longitude 115°53'W (Figure 1). Access is by paved and gravel roads from Highway 3/95.

Early in 1966, Helg Fors of Kimberley discovered lead-zinc mineralized float on logging roads near Little Lamb Creek. Subsequent prospecting by David Pighin and Ernest Pinchbeck on behalf of the Consolidated Mining and Smelting Company of Canada, Limited (now Cominco Ltd.) discovered the Main showing, a 1.2 by 13.7 metre lens of bedded lead-zinc sulphides (Webber, 1978b). Cominco staked the discovery as the Helg and Helg No. 1 to 4 groups comprising 158 claims (Gifford, 1966).

Follow-up work by Cominco in 1966, 1969, 1977, 1979, 1982 and 1983 included prospecting, trenching, surface geological mapping, geophysical surveys (gravity, magnetic, electromagnetics (DIGHEM, UTEM)) and soil and stream sediment geochemistry (Gifford, 1966; Currie, 1969; Fraser, 1977; Webber, 1977; Lajoie, 1979; Waskett-Myers, 1983). Anomalies were tested in 1967 and 1978 with at least five shallow and two deeper diamond drill holes totaling 944 metres (Webber, 1978a,b). No mineralization of economic interest was encountered and eventually the Helg claims were allowed to lapse.

L.D. Morgan restaked the area in 1987 and 1988 and optioned the property to Placer Dome Inc. which prospected, mapped and sampled from May to July, 1989. No further work was recommended (Maheux, 1990).

In autumn 1992, Chapleau Resources Limited and Barkhor Resources Limited optioned the property and commenced a diamond drilling program operated by Kokanee Explorations Limited (later Consolidated Ramrod Gold Corporation). The first drill hole (F92-1) was collared at the Main showing and intersected thin zones of disseminated to massive sulphide mineralization over a stratigraphic interval of 42 metres (Klewchuk, 1993). The highest grade intercept was 1 metre of massive sulphides with 9.35% Pb, 16.4% Zn, 0.09% Cd and 98 g/t Ag (The Northern Miner, December 7, 1992).

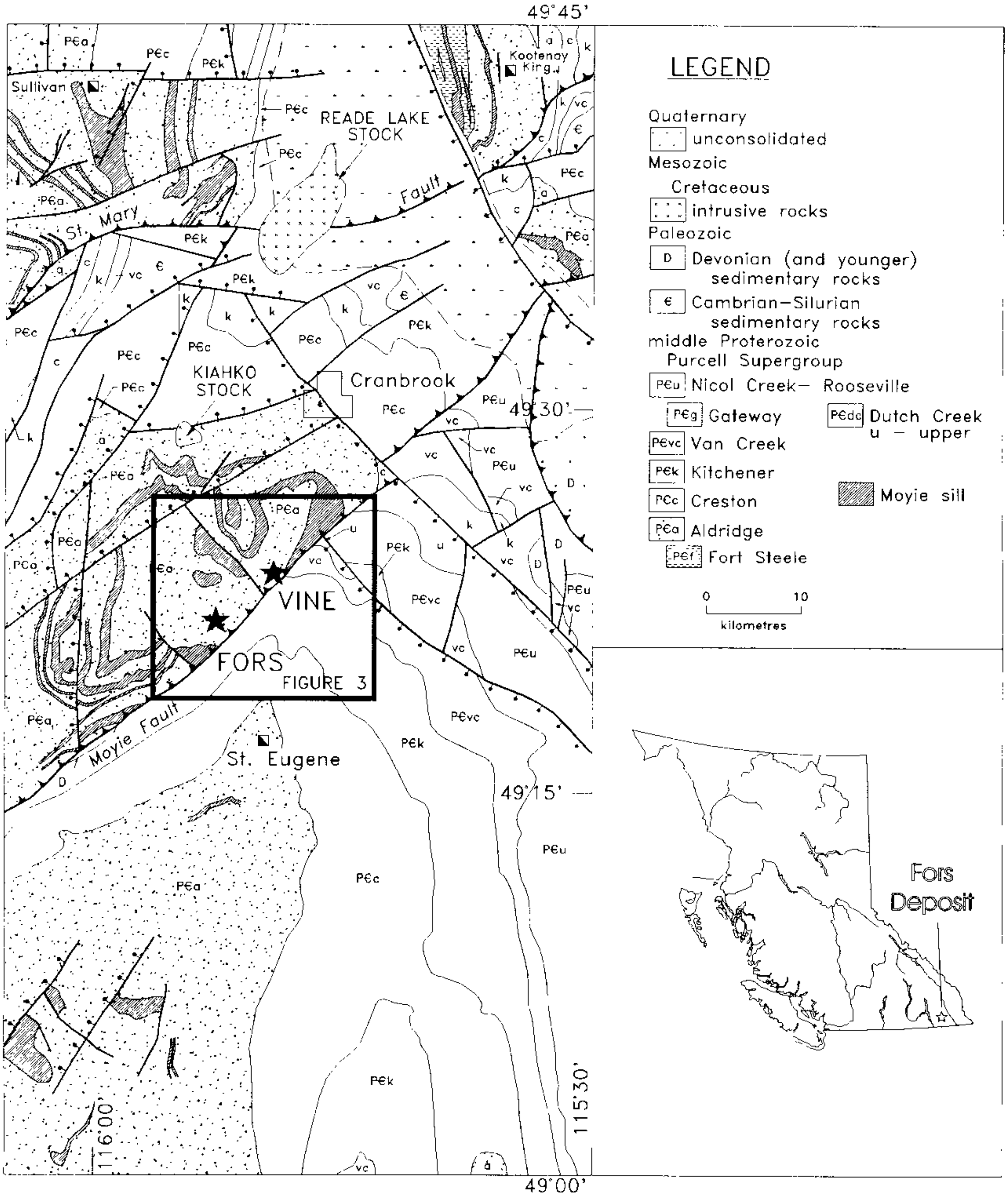

Figure 1. Regional geology and deposit location.

Diamond drilling on the Fors property continued until May 1994. Concurrent with this drilling, other exploration targets were defined by geophysical surveys (PEM and magnetometer) and geological modelling. These targets include sulphide-enriched sedimentary and concordant fragmental rocks near the lower-middle Aldridge contact (at the same stratigraphic horizon as the Sullivan deposit) and quartz-sulphide veins similar to the Vine vein located 8 kilometres to the northeast. (Höy and Pighin, 1995, this volume). A total of 12 169.7 metres (in 30 holes) has been drilled on the property to date, of which 2440 metres (12 holes) tested the extent of the 1992 discovery.

REGIONAL SETTING

The Moyie Lake area is underlain mainly by siliciclastic and lesser carbonate sedimentary rocks of the Middle Proterozoic Purcell Supergroup (Höy, 1993). They are exposed in a broad, northeasterly plunging anticlinorium that has been dissected by high-angle normal and reverse faults (Figure 1).

Earliest regional deformation occurred in Late Proterozoic time. Compressional tectonic activity during the Jura-Cretaceous Laramide orogeny that formed the Rocky Mountain fold and thrust belt, transported Purcell Supergroup strata as much as 300 kilometres eastwards (Price, 1981). Most recent tectonic activity consisted of Eocene extensional faulting.

The northeasterly trending Moyie fault bisects the area shown in Figure 2. It is a high-angle reverse fault with an estimated right-lateral displacement of 9 to 12 kilometres and dip displacement of 4 to 7 kilometres (Höy, 1993). It brings older, Aldridge Frmation strata into contact with younger, Kitchener strata. The Fors deposit is in the hangingwall of this fault.

Intrusion of gabbroic to dioritic magma nearly contemporaneous with sedimentation has resulted in the laterally extensive Moyie sills that form a significant part of the lower and middle Aldridge sections (Höy, 1993).

GEOLOGY OF THE FORS-VINE AREA

The Fors-Vine area is underlain by gently to moderately north to northeast-dipping strata of the lower and middle divisions of the Aldridge Formation that have been intruded by mafic Moyie sills (Figure 2). Three main sills occur on the property. Two of these, and a series of distinctive laminated mudstone marker beds, provide controls for stratigraphic correlation.

Deformation is mostly limited to gentle open folds. Bedding is locally deflected into the plane of crossfaults. More widespread shearing and tight folding occur along the Moyie fault zone (Höy and Diakow, 1982). The northeast-striking Moyie fault defines the southern limit of prospective ground. Minor northwest and west-striking high-angle faults break the stratigraphic sequence into a mosaic of structurally homogeneous blocks. Movement on these faults is typically in the order of tens to a few hundreds of metres.

Metamorphic grade is at most upper greenschist facies (Höy, 1993). Temperature and pressure estimates for the Sullivan mine area are 440±50°C and 300±100 megapascals (3±1 kilobars), with high carbon dioxide and low water fluids (De Paoli and Pattison, 1993), and 375°C and 450±100 megapascals (Lydon and Reardon, 1993). Metamorphism is attributed to burial. Despite metamorphic effects, primary sedimentary structures are very well preserved. Only where there has been intense hydrothermal alteration or deformation are they obliterated.

STRATIGRAPHY

The oldest rocks on the property are siltstones, quartzites and silty argillites of the lower Aldridge Formation. At Fors they crop out in a thin wedge along the Moyie fault (Figure 2) against which they have been folded. They are distinguished by rusty weathering, thin planar bedding and coarse reddish biotite porphyroblasts that parallel bedding and grow at random angles to it. Near the top of this unit (at the stratigraphic equivalent of the Sullivan horizon) is a concordant layer of pebble-wacke or fragmental up to 50 metres thick, thickening to the northeast away from the Fors deposit.

Middle Aldridge sedimentary rocks consist of fine-grained, grey or grey-green quartzofeldspathic sandstones (mostly wackes, some arenites), siltstones and argillites with variable amounts of porphyroblastic biotite and white mica (sericite or muscovite), pyrrhotite and pyrite (Leitch *et al.*, 1991). They were deposited as monotonous sequences of interbedded AE turbidites that can be broadly divided into a series of fining-upwards cycles (Höy, 1993). Coarser grained sequences tend to be medium bedded (10 to 30 cm); finer grained strata are thinly to very thinly bedded. Despite good bedding, individual layers or groups of beds lack distinguishing characteristics so that correlation between even closely spaced drill holes is very difficult.

Primary sedimentary structures in the middle Aldridge are well preserved and abundant. Bedding, the most common, is defined by mineral trains such as biotite flakes, pyrrhotite laminae, monazite, sphene and organic carbon. Fining upward sequences, interbedding and crossbedding are common. Slumps, ball and pillow structures, load and traction marks, rip-up clasts, tool marks and sole marks typical of turbidites also occur locally.

A pipe-shaped body of coarsely clastic material, referred to here as a discordant fragmental, occurs at depth (Figure 3). It consists of sand to pebble-sized clasts of sandstone and siltstone in a silty to sandy matrix. Most clasts are subrounded to subangular and matrix supported. The unit is up to 100 metres in diameter and 300 metres high.

A sequence of nearly massive fine-grained sediments, 30 to 60 metres thick, was recognized by early workers near the Main showing. It consists of "intermixed quartzitic and argillaceous material with a zone of abundant pyrrhotite" in which "bedding is either lacking or obscure" (Gifford, 1966).

We interpret both the discordant fragmental and this massive unit as products of dewatering phenomena that channeled fluids upwards in response to increasing hydrostatic and lithostatic loads. Fluid pathways may have been

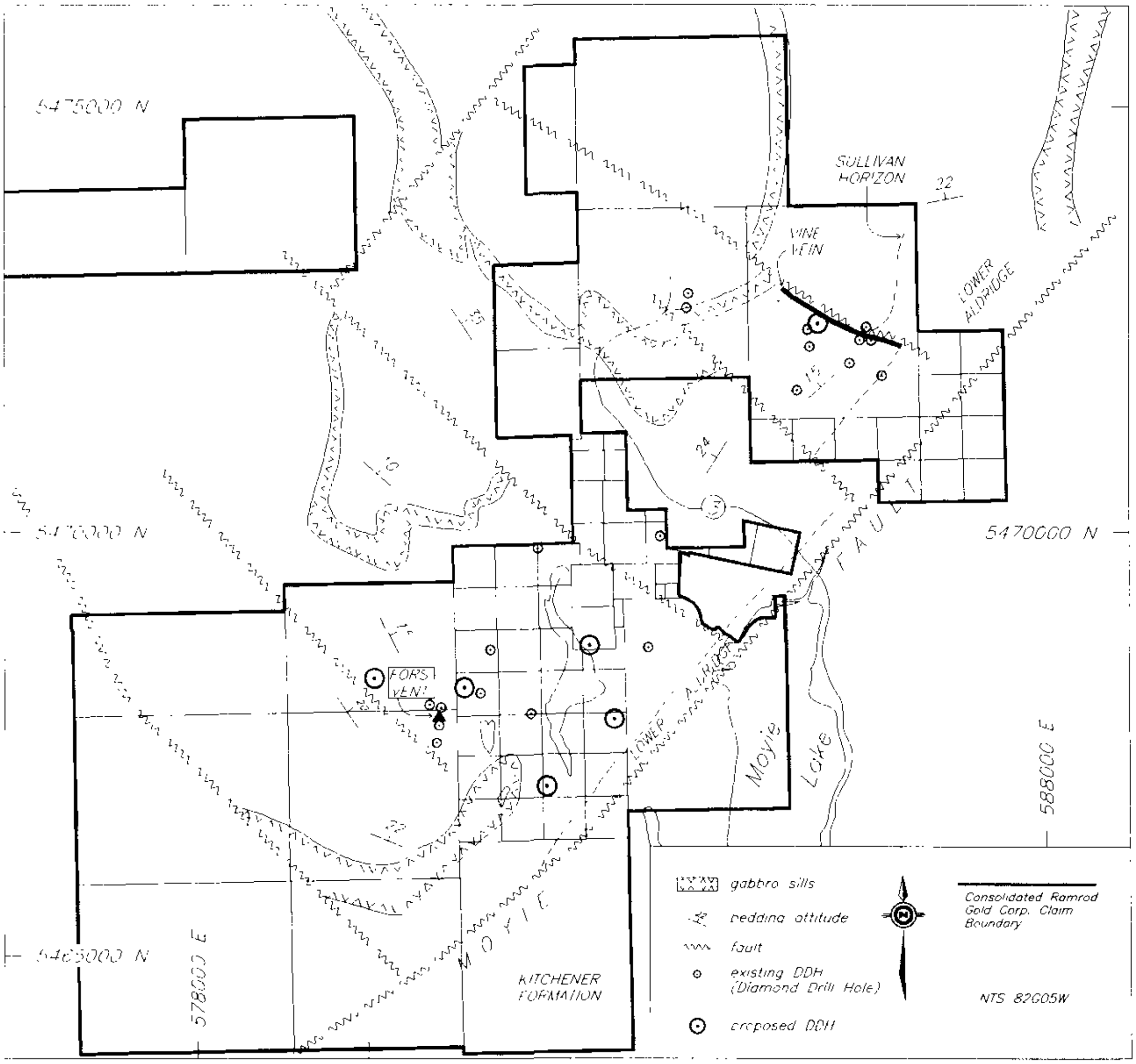

Figure 2. Geology of the Fors - Vine area.

localized by growth faults which would have provided the initial permeability. The clastic or massive fabrics result from either hydraulic milling of poorly consolidated sediments by upwelling fluids, or venting of a slurry of mud and sand onto the seafloor, forming a volcano-like edifice.

Several mafic sills intrude Aldridge Formation strata. The deepest intrudes near the lower-middle Aldridge contact and is at least 250 metres thick. At its closest it is 350 metres below the top of the Fors deposit (Figure 3). Two other sills are stratigraphically above the Fors deposit (Figure 2). All the sills are are assigned to the Moyie suite (Höy, 1993) on the basis of stratigraphic position and petrographic similarity. They are Middle Proterozoic and are thought to be penecontemporaneous with sedimentation (Höy, 1993).

Rare lamprophyre dikes, a few metres thick, have been intersected by drilling. They are dark grey with phenocrysts of coarse-grained black biotite. They are probably Early Cretaceous (Höy, 1993).

ALTERATION

A remarkable feature of this deposit is the extent and intensity of alteration assemblages, both associated with sulphide mineralization and apart from it. Most alteration effects are attributed to hydrothermal fluids interacting with unconsolidated sediments, in the synsedimentary to early diagenetic stages of the evolution of these rocks, before final lithification. Evidence for this comes from altered clasts occurring in an unaltered matrix, the strong influence of bedding and primary porosity on alteration. and ptygmatic folding in early-formed sulphide veins, due to compaction.

Alteration types are described in terms of their present (metamorphic) mineralogy. The reader should keep in mind

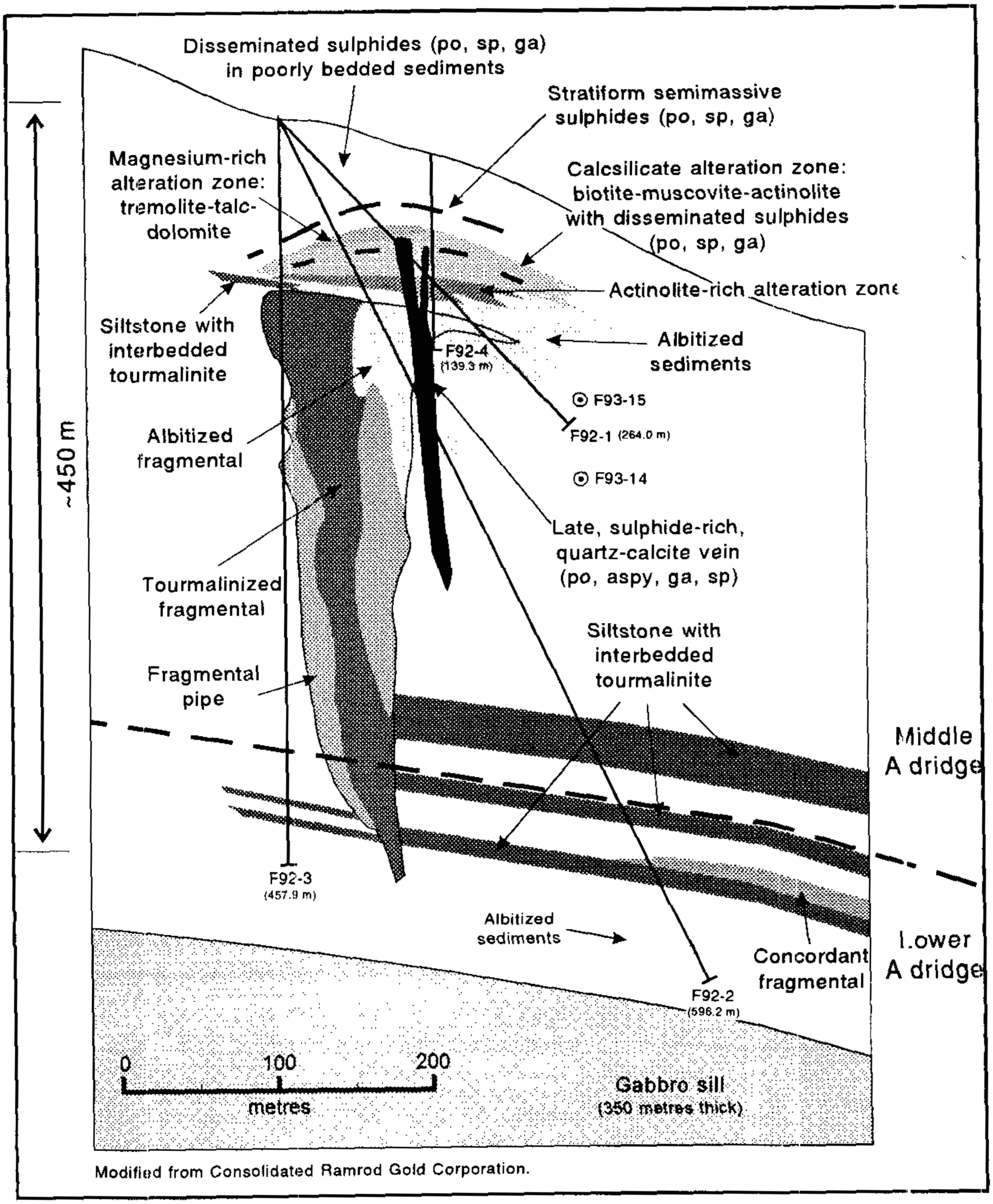

Figure 3. Fors deposit: schematic cross-section.

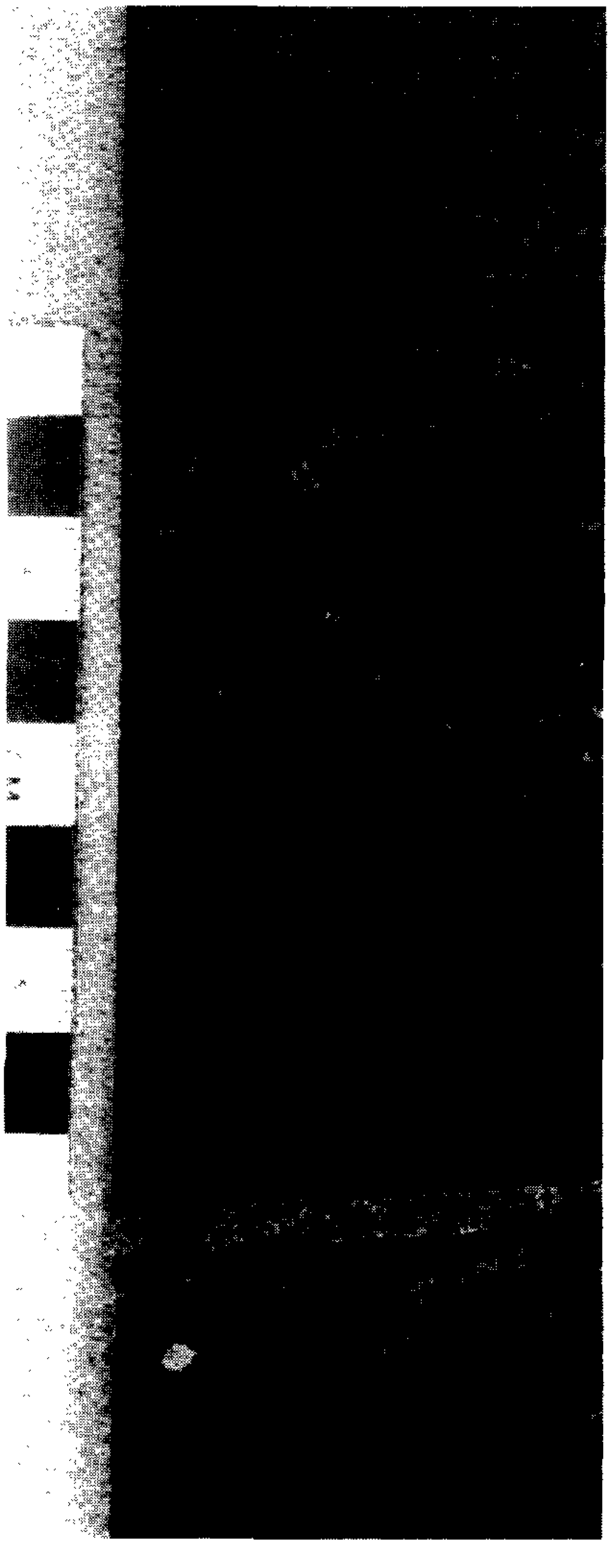

Photo 1. Bedded iron-rich tourmaline alteration in lower Aldridge mudstone with pale manganese-rich garnet porphyroblasts (ddh F93-3, 433.5 m).

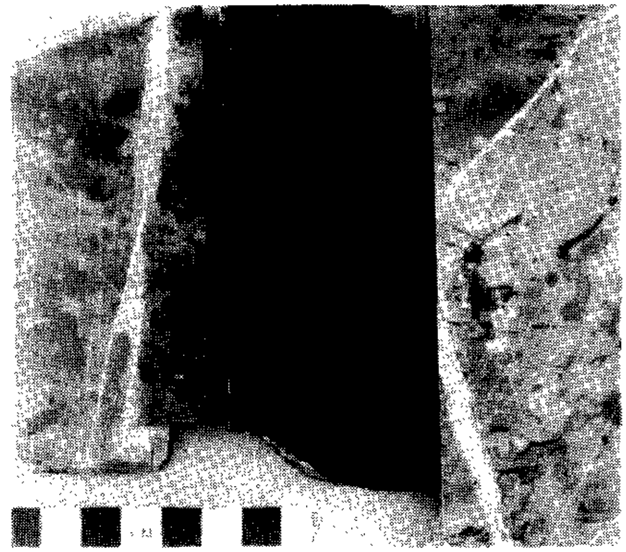

Photo 2. Tourmaline alteration in discordant fragmental, with quartz veins. Light coloured pieces have pale brown, magnesium-rich tourmaline; centre piece is unaltered (left to right: ddh F93-3, 100.2 m, 179.1 m, and 210.1 m).

the caveat of Shaw *et al.* (1993a, b) that this mineralogy probably differs from that which developed during hydrothermal activity. "Actinolite-altered" does not necessarily mean that hydrothermal fluids produced actinolite. More likely, actinolite results from the metamorphism of precursor minerals, such as sulphates, carbonates and clays, that formed during alteration.

The deposit is crudely mushroom shaped (Figure 3). Its stem consists of an alteration zone (tourmaline and plagioclase) within and around the fragmental pipe. Its cap lies immediately above the pipe and comprises plagioclase-biotite, calcsilicate and mica alteration assemblages with disseminated to bedded sulphides. Both stem and cap are cut by a thick, late-stage, sulphide-rich vein.

Based on field observations, alteration can be grouped into six main associations:tourmaline; plagioclase-biotite-garnet; biotite; calcsilicate; sericite; and silica. Figure 3 illustrates their distribution.

Tourmaline alteration consists of partial to almost complete replacement of original sedimentary material by microscopic grains of tourmaline. The resulting rock is hard and cherty in appearance, typically with a conchoidal fracture in the most altered rocks. Individual grains of tourmaline are seldom visible to the naked eye: grain size rarely exceeds 100 microns (Leitch *et al.*, 1991).

Two types of tourmaline alteration occur at Fors (Photos 1, 2). The first and probably oldest is bedded black tourmaline (iron-rich; schorl) that preferentially affects argillaceous layers. Bedded tourmalinization is volumetrically small. As much as 30% of a section may be strongly tourmalinized. More typically it affects argillite beds up to 5 to 10 centimetres per metre of section. Bedded tourmalinite is locally associated with small, white managnese-rich garnets (<0.5 mm).

Two lines of evidence indicate this is an early stage of alteration. First it is overprinted by most other types of alteration. Second, tourmalinized argillite occurs as contorted rip-up clasts in siltstone, which suggests either extremely

Photo 3. Plagioclase-biotite-garnet alteration: pervasive, texture-destructive patches and veins (left to right: ddh F92-2, 175.2 m, 228.0 m, 238.7 m).

selective replacement or else that clays were altered before being incorporated in turbidite flows. Rare, dark tourmaline clasts also occur in the discordant fragmental. A model for bedded tourmaline alteration is that ascending boron-rich hydrothermal solutions pass through coarser sediments to become trapped by less permeable clay-rich strata, reacting with them to form conformable sheets of tourmalinite (Slack, 1993).

The second type is light to dark brown (magnesium-rich; dravite). It is mainly confined to the discordant fragmental in which both clasts and matrix are altered (Photo 2). Both types are locally associated with a little pyrrhotite, more rarely with arsenopyrite, sphalerite and galena.

Plagioclase-biotite±garnet alteration affects large volumes of rock, including part of the fragmental pipe and bedded sediments surrounding it. It appears to be assymetrically distributed around the pipe, skewed to the northeast. It is pervasive and texture destructive, and results in an aphanitic to very finely granular, mottled grey, white and pink rock (Photo 3). Where biotite is common it can resemble coarse granite (Photo 4). It occurs as veins, patches, hairline fractures and broad diffuse areas. Its contacts are sharp to gradational. Garnets associated with this style of alteration are pale pink, up to 2 millimetres in diameter, and may be selectively replaced by calcite or sericite.

This form of alteration is usually referred to as albitization as, regionally, the composition of the feldspar is sodic plagioclase. However calcic plagioclase with anorthite contents up to An_{50} have been observed at Fors (C.H.B. Leitch, personal communication, 1994) and may be more widespread. Its weakest effects consist of a bleaching of the protolith and an increase in black to dark brown biotite. Strongest alteration is paper-white, finely granular, almost monomineralic plagioclase. Pink to liver-coloured zones occur as extensive patches within the mainly pale rocks. These may be areas enriched in potassium feldspar or microscopic inclusions of metamorphic biotite. The pink zones are typically cut by pale hairline veinlets, at high angles to relict bedding, of a later stage mineral, possibly albite.

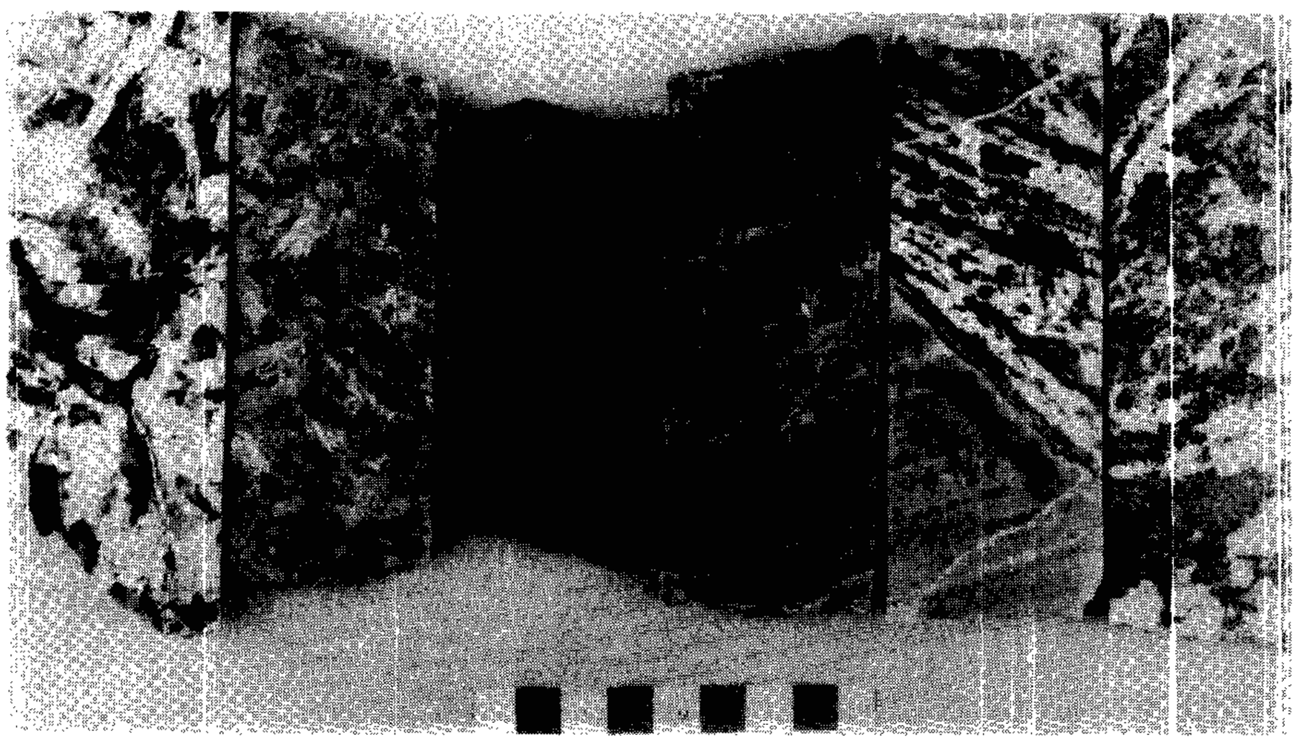

Photo 4. Alteration mineralogies and textures in the calcsilicate alteration cap ("vent horizon"). From left to right assemblages are: tremolite-talc-dolomite; massive tremolite-actinolite; massive brown biotite; biotite replaced by actinolite; plagioclase-biotite-(garnet) alteration cutting bedded, albitized sediments; and coarse, granitic-textured plagioclase-biotite alteration (left to right: ddh F93-10, 49.2 m, 54.1 m, 58.2 m, 61.0 m, 68.5 m, and 71.0 m).

Pyrrhotite is common in plagioclase-altered rocks and it preferentially replaces biotite. The paragenesis of this assemblage is uncertain. In one location pyrrhotite is pseudomorphous after biotite porphyryoblasts that grew at random angles across bedding. This indicates late, perhaps postmetamorphic, redistribution of phases.

Biotite and calcsilicate alteration are mainly confined to the cap of the deposit, which consists of complexly interlayed, coarse-grained assemblages of micas (pale to bronzy brown biotite and muscovite), amphiboles (actinolite and tremolite) and carbonate minerals (calcite and dolomite). Because these minerals form 100% of the rock it is thought that this zone may represent a hydrothermal vent area. The cap or vent horizon is crudely stratified with a nearly massive zone of actinolite at its base, a biotite-rich zone in the middle and a thin magnesium-rich zone (talc-tremolite-dolomite) at the top. The range of textures found is shown in Photo 4. The cap is up to 200 metres in diameter and 30 metres thick.

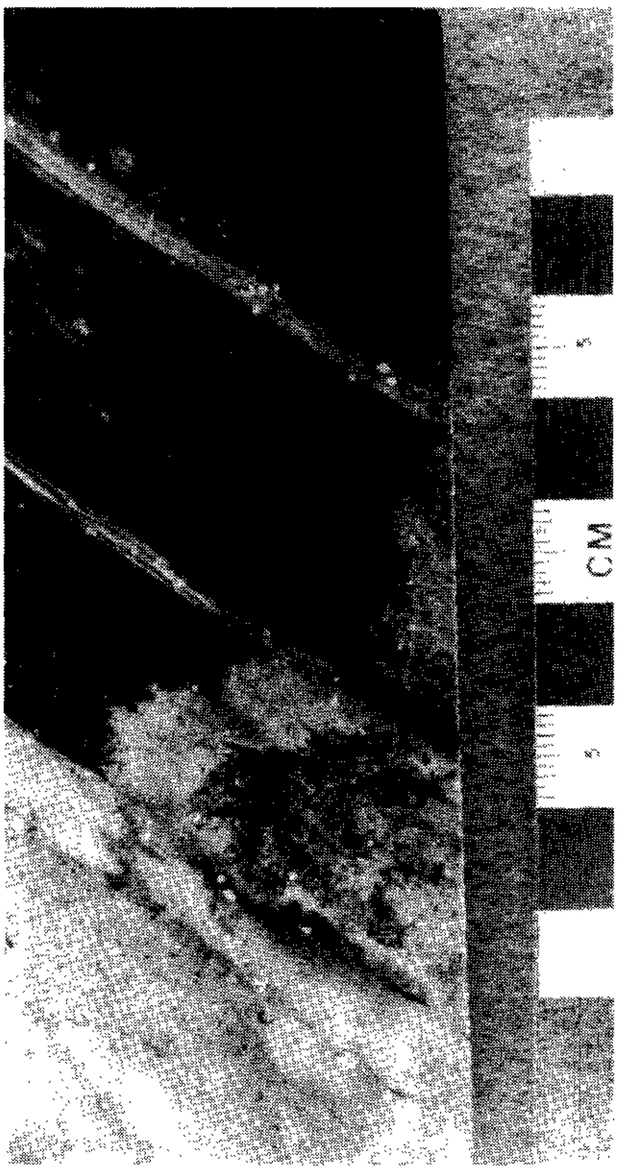

Photo 5. Sericite alteration in thinly bedded middle Aldridge mudstone showing both texture-destructive and layer-parallel styles. The small white spots are relict garnets. (ddh F92-2, 260.5 m.).

Actinolite (light to medium green, fibrous amphibole) is more widespread than tremolite (white, fibrous amphibole). It occurs as very coarse grained (up to 2 cm) monomineralic lenses, up to 3 metres thick, near the base of the calcsilicate cap. It also occurs away from the calcsilicate cap, where it always appears pseudomorphous after biotite.

Tremolite occurs mainly in association with dolomite and the talc-rich zone at the top of the calcsilicate alteration cap. It has a similar coarse-grained acicular habit, and like actinolite, also appears to be replacing biotite.

Talc occurs as dark green, irregularly shaped, soft waxy masses up to 10 centimetres long, intergrown with tremolite and dolomite (Photo 4). It appears to be confined to the upper edge of the calcsilicate alteration cap and may be partially metamorphosed to antigorite.

Sericite alteration occurs as a distal aureole around the other alteration assemblages at depth and above the bedded sulphide zone, up to and including the Main showing, where it is associated with silicification. Locally it is texture destructive and pervasive but more commonly it is confined to bedding planes in porous, feldspathic units (Photo 5). It is distinguished by its pale green colour and its softness. Pale pink garnets up to 2 millimetres in diameter also occur within sericitic alteration zones, but garnets are quite commonly replaced by sericite (note: In this report "sericite" is used for aphanitic white mica; "muscovite" for grains visible to the unaided eye).

Silica alteration occurs in two ways. First, it forms irregular zones apparently confined to strata that overlie the calcsilicate alteration cap, up to at least the stratigraphic level of the Main showing where it was identified by Maheux (1990). Second, it forms thin envelopes around late-stage quartz veins. In the first case, silicified core is blue-grey, hard, and has a diffusely granular appearance. In the second it is milky white, finely granular to aphanitic (chalcedonic). Silicification has been tentatively identified elsewhere in drill core (Klewchuk, 1993) but because of its similarities to plagioclase alteration more work is required to document its occurrence. It is noteworthy that silicification is rare to unknown at the Sullivan mine. Leitch *et al.* (1991) found no introduction of quartz due to alteration.

SULPHIDE DEPOSITS

Zones of almost massive sulphides are rare. They occur in two forms: stratiform and vein. Drilling to date has not been able to demonstrate strong lateral continuity in either. Thickest and highest grade drill intersections were encountered in hole F92-1.

Conformable massive sulphides consist of fine to coarse-grained pyrrhotite, sphalerite and galena within a plagioclase-biotite-sericite or actinolite-rich envelope (Photo 6). The sulphides locally contain coarse (to 8 mm) clasts of transparent quartz and have a cataclastic fabric. Upper and lower contacts approximate bedding in the enclosing sediments. A maximum thickness of 2 metres was intersected. The stratiform sulphide zone lies a few metres above the top of the calcsilicate alteration cap (Figure 3).

A semimassive sulphide vein almost 2 metres thick, with a calcite-quartz gangue, cuts an actinolite-rich alteration zone. The vein consists mainly of granular pyrrhotite rimmed by arsenopyrite, with variable amounts of sphalerite and galena and accessory scheelite, chalcopyrite and bismuthinite (Photo 7). One intercept returned 734 g/t Ag, 16.7% Pb, and 5.40% Zn over 0.3 metre.

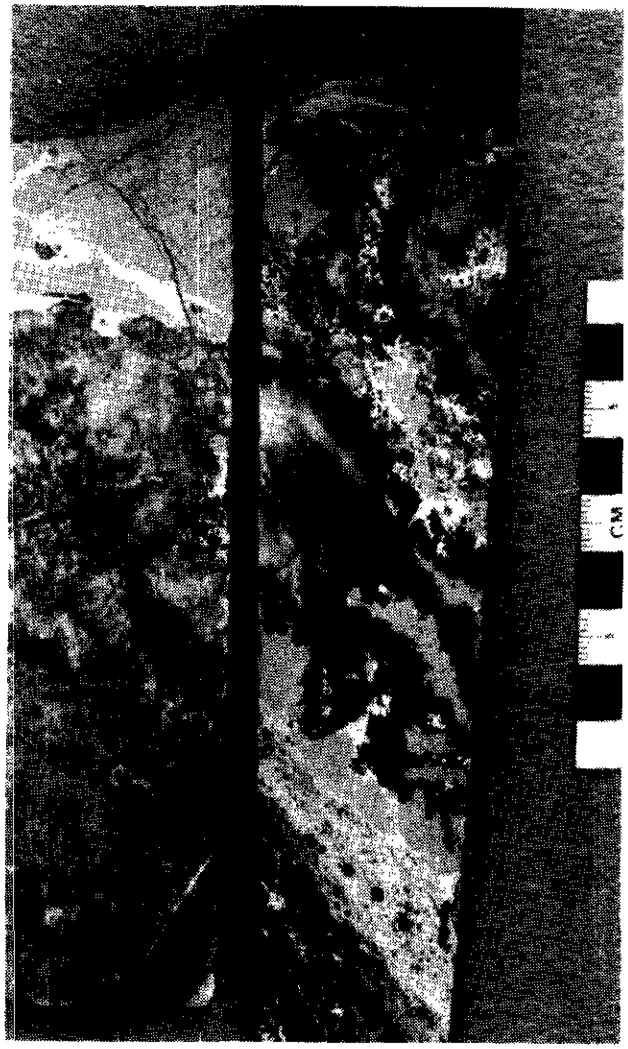

Photo 6. Massive sphalerite, galena and pyrrhotite with a quartz, plagioclase, actinolite and biotite envelope (left to right: ddh F92-1, 63.5 m and 78.0 m).

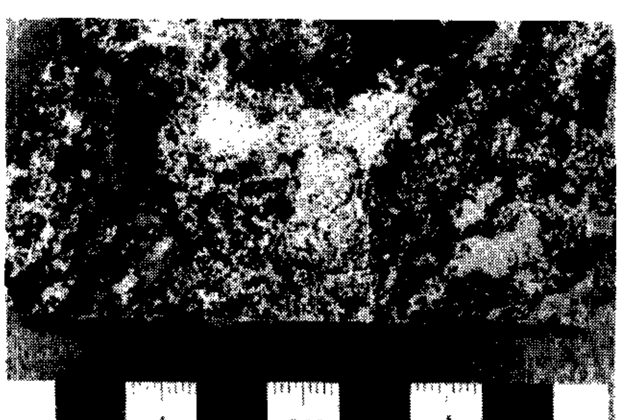

Photo 7. Semimassive arsenopyrite, pyrrhotite±scheelite, with a calcite, quartz and actinolite envelope (ddh F92-1, 101.6 m).

Low-grade zones of sulphides are, on the other hand, quite widespread. They consist of disseminations, stringers, veins, small semimassive to massive stratiform lenses and irregular patches of mainly pyrrhotite, with subordinate amounts of sphalerite, galena, pyrite, and rare arsenopyrite, chalcopyrite and bismuthinite. Pyrrhotite also occurs as ubiquitous hairline laminae that define bedding. Several generations of sulphide mineralization are required to account for the variety of habits and textures found.

DEPOSIT MODEL

In order to synthesize our field observations, we offer the following genetic model for the Fors deposit as a working hypothesis.

1) Pelagic, turbidite sedimentation with entrained organics and iron in a fault-controlled graben or half graben results in a thick sequence of poorly consolidated sediments.

2) Dewatering of the sedimentary pile in response to increasing hydrostatic and lithostatic loads results in the development of a fragmental pipe which acts as a long-lived conduit for the upward migration of fluids. The pipe may have formed in the hangingwall of a growth fault. Parallel and conjugate fractures related to this fault may have contributed additional pathways for fluid migration. The pipe functioned as a conduit at least until the time of formation of the bedded sulphides above the calcsilicate zone and probably until after the formation of the Main showing, now exposed at surface. The upper limit of coarse fragmentals appears to lie just below the calcsilicate cap which may represent a sedimentary-exhalative vent deposit. Less vigorous dewatering may have produced the massive unit near the Main showing.

3) Tourmalinizing fluids (of uncertain provenance) preferentially travel along beds and up the fragmental pipe. It appears they changed chemistry with time: most bedded tourmalinites are schorlitic (iron rich); however much of the pipe is brown to pale brown, dravitic (magnesium rich).

4) Albitizing fluids ascend. These locally overprint bedded tourmaline-altered rocks but mainly spread laterally away from the pipe to the northeast.

5) Potassium, iron and magnesium-rich fluids deposit biotite (or biotite precursor minerals) in the main part of the vent horizon.

6) Late carbonate-rich fluids flooding along parasitic or antithetic structures overprint biotite (precursors) to produce actinolite (precursor) assemblages and deposits of sulphides. At least two pulses are required: the first to produce semimassive to massive, locally stratiform lead-zinc-silver-rich mineralization with a high base metal to iron ratio. The second pulse to produce veins enriched in arsenic, tungsten, silver and bismuth, as well as zinc, lead and iron.

7) Downward circulating seawater mixes with upwelling carbonate-rich fluids to produce magnesium-en-

riched assemblages including talc, tremolite and dolomite (precursors) at the top of the alteration cap, and possibly the *magnesium-rich tourmalinites found in the upper part of the* fragmental pipe.

8) A later pulse of hydrothermal fluids causes sericite (silica) alteration with minor sulphides in the sedimentary package that overlies the bedded sulphide zone and forms the Main showing.

9) Heat and fluids for hydrothermal alteration and mineralization may have been provided by the intrusion of thick mafic sills into wet sediments.

10) Finally, regional metamorphism creates the present silicate mineralogy and redistributes some sulphides.

CONCLUSION

The Fors prospect is a well preserved example of a small, high-grade lead-zinc-silver sedimentary exhalative and vein deposit hosted by Middle Proterozoic Aldridge Formation. It is associated with an unusually strong alteration assemblage variously dominated by plagioclase, biotite, tourmaline, white mica, carbonate, tremolite-actinolite, talc and silica. It is a blind discovery that resulted from drill-testing a geological model of low-grade mineralization found at surface.

It provides a new exploration target in the Sullivan camp, having some similarities to the Sullivan deposit and some important differences. Similarities include the presence of such Sullivan indicators as bedded sulphides, fragmental units that locally carry sulphide-bearing and tourmalinized clasts, garnet porphyroblasts, and tourmaline and albite alteration. Differences are that it is located outside the Sullivan corridor, is stratigraphically higher, has unusual alteration assemblages, and has elevated silver, gold, tungsten and arsenic.

The deposit deserves further study and would make an excellent project for a graduate student interested in water-rock interactions. Very good core storage, logging and rock cutting facilities exist at the field office of Consolidated Ramrod Gold Corporation to support such work.

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REFERENCES

Currie, R.G. (1969): MX Claim Group, Gravimetric and Magnetic Survey, Fort Steele Mining Division, 49°115°SW; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 1876.

De Paoli, G.R. and Pattison, R.M.D. (1993): Metamorphic Pressure, Temperature, and Fluid Conditions of the Sullivan Mine, Kimberley, British Columbia, Using Silicate-Carbonate Equilibria (abstract); *in* Minerals Colloquium, December 1993, *Geological Survey of Canada.*

Fraser, D.C. (1977): DIGHEM Survey of Cranbrook Area, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 6498.

Gifford, R.G. (1966): Report of Geological, Geochemical and Geophysical Surveys on the Helg Groups of Claims situated Twelve Miles Southwest of Cranbrook, in the Fort Steele Mining Division, 49°115°SW; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 834, 6 pages.

Höy, T. (1993): Geology of the Purcell Supergroup in the Fernie West-half Map Area, Southeastern British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 84, 157 pages.

Höy, T. and Diakow L. (1982): Geology of the Moyie Lake Area; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Preliminary Map 49, scale 1:50 000.

Höy, T. and Pighin, D.L. (1995): Vine - A Middle Proterozoic Massive Sulphide Vein System, Purcell Supergroup, Southeastern British Columbia; *in* Geological Fieldwork 1994, Grant, B. and Newell, J.M., Editors, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1995-1, this volume.

Höy, T., Dunne, K. and Wilton, P. (1993): Massive Sulphide and Precious Metal Deposits in Southeastern British Columbia; *Geological Association of Canada, Mineralogical Association of Canada*, Annual Meeting, Field Trip A-7, Guidebook, 74 pages.

Klewchuk, P. (1993): Assessment Report on Two Diamond Drill Holes (F92-2 & 3), Fors Property; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 22817.

Lajoie, J.J. (1979): UTEM Electromagnetic Survey on the Vine Group; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 7554, 12 pages.

Leitch, C.H.B., Turner, R.J.W. and Höy, T. (1991): The District-scale Sullivan - North Star Alteration Zone, Sullivan Mine Area, British Columbia; *in* Current Research, Part E, *Geological Survey of Canada*, Paper 91-1E, pages 45-57.

Lydon, J.W. and Reardon, N. (1993): Sphalerite Compositions of the Sullivan Deposit, British Columbia and their Implications for Timing of Metamorphism (abstract); *in* Minerals Colloquium, December 1993, *Geological Survey of Canada.*

Maheux, P.J. (1990): Geology and Geochemistry Report on the Fors Property, Puma and Cougar Claims; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 19809.

Price, R.A. (1981): The Cordilleran Foreland Thrust and Fold Belt in the Southern Canadian Cordillera; *in* Thrust and Nappe Tectonics, McClay, K.R. and Price, N.J. Editors, *Geological Society of London*, Special Publication 9, pages 427-448.

Shaw, D.R., Hodgson, C.J., Leitch, C.H.B. and Turner, R.J.W. (1993a): Geochemistry of Tourmalinite, Muscovite, and Chlorite-Garnet-Biotite Alteration, Sullivan Zn-Pb Deposit, British Columbia; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 93-1A, pages 97-107.

Shaw, D.R., Hodgson, C.J., Leitch, C.H.B. and Turner, R.J.W. (1993b): Geochemistry of Albite-Chlorite-Pyrrhotite Alteration, Sullivan Zn-Pb Deposit, British Columbia; *in* Current Research, Part A, *Geological Survey of Canada*, Paper 93-1A, pages 109-118.

Slack, J.F. (1993): Models for Tourmalinite Formation in the Middle Proterozoic Belt and Purcell Supergroups (Rocky Mountains) and their Exploration Significance; *in* Current Research, Part E, *Geological Survey of Canada*, Paper 93-1E, pages 33-40.

Waskett-Myers, W.D. (1983): Report on Soil Geochemistry, Vine 3, Fort Steele Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 11732.

Webber, G.L. (1977): Geochemical Survey Report on South Vine Grid, Fort Steele Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 6543.

Webber, G.L. (1978a): Diamond Drilling Report, Vine No. 29 Claim, N.T.S. 82G/5, Fort Steele Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 6936.

Webber, G.L. (1978b): Geological Report, Vine Property 1978, N.T.S. 82G/5, Fort Steele Mining Division; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 7087.

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