The Gangue
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Fors: a Proterozoic Sedex Deposit, SE British Columbia

James M. Britton,
B.C. Geological Survey
David L. Pighin,
Consolidated Ramrod Gold Corp.

Introduction

The 1992 discovery of high-grade base and precious metal mineralization at the Fors property, 17 km SW of Cranbrook, rekindled interest in the Middle Proterozoic Aldridge Formation (Pritchard equivalent) and provides a new exploration target. Ag-Pb-Zn mineralization occurs at the top of a discordant zone of pebble wacke, or "fragmental", in middle Aldridge sandstone and mudstone. Pyrrhotite, sphalerite, galena, arsenopyrite, pyrite, chalcopyrite, and bismuthinite occur in stratiform, semi-massive to massive lenses, as well as disseminations and veins. Scheelite is a local accessory. Gold values range up to 0.7 gram per metric ton; silver to 734 grams per metric ton. Best drill intersections were up to 25% combined Pb and Zn over 1 m. 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.

Geology of the Fors Area

The Fors 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 three mafic sills (Figure 1). The lowest 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 2). The two other sills are above it.

The northeast striking Moyie fault (a reverse fault of regional significance) 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. Deformation is mostly limited to gentle open folds. Near faults bedding can be deflected into the plane of the fault. Shearing and tight folding occur only along the Moyie fault zone (Hoy and Diakow, 1982).

Metamorphic grade is at most upper greenschist facies (Hoy, 1993), and is attributed to simple 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 1) 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), thickening to the NE away from the Fors deposit, is a concordant layer of pebble-wacke or "fragmental" up to 50 m thick (Figure 2).

Middle Aldridge consists of thick, monotonous sequences of mostly AE turbidites: fine-grained quartzofeldspathic sandstones (mostly wackes, some arenites), siltstones and argillites with variable amounts of biotite, white mica, pyrrhotite and pyrite. Coarse and fine units are commonly interbedded.

A pipe-shaped body of coarsely clastic material, referred to herein as a "discordant

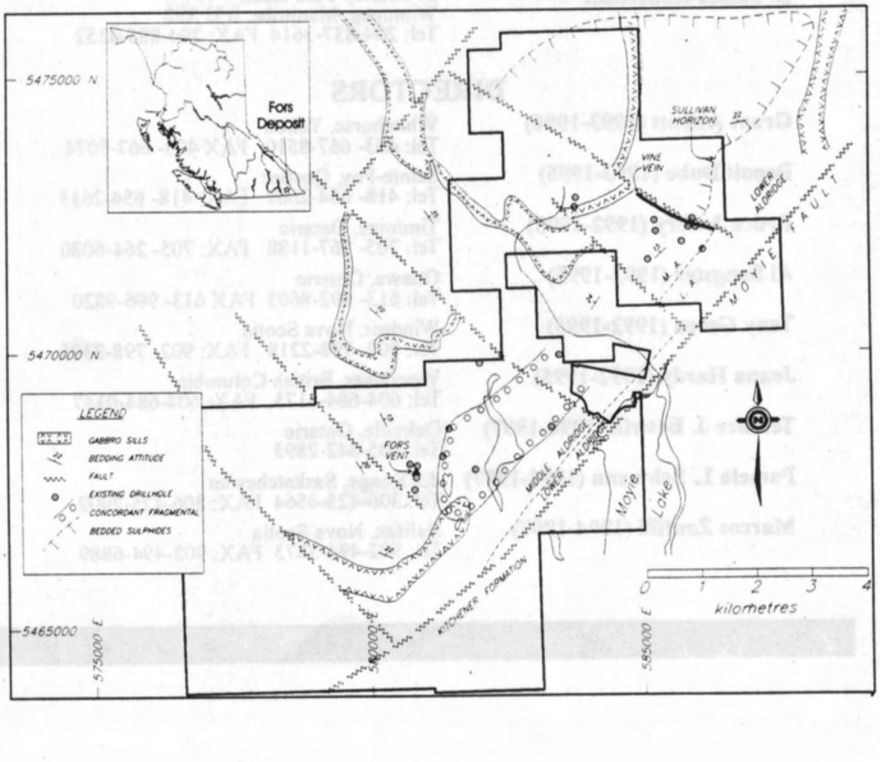

Figure 1. Geology of the Fors -Vine area.

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SUBMISSION DEADLINE	PUBLICATION DATE
December 15	January
March 15	April
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The objective of this newsletter is primarily to provide a forum for members and other professionals to voice new ideas, describe interesting mineral occurrences or expound on deposit models. Articles on ore deposits, deposit models, news events, field trips, book reviews, conferences or other material which may be of interest to the economic geology community are welcomed. Reprints of presentations given to companies, mining groups or conferences are particularly welcome.

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For Information Contact:

Brian Grant
Editor - THE GANGUE
PO Box 8076, Victoria, BC, V8W 3R7
Tel: 604-952-0454 FAX: 604-952-0451
E-Mail: bgrant@galaxy.gov.bc.ca

Dani Alldrick
Contributing Editor

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The MDD encourages geoscientists to join the division and contribute to the various programs and activities.

fragmental", occurs at depth (Figure 2). 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 meters vertical.

A sequence of nearly massive, fine grained sediments 30 to 60 m 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 the massive unit as products of dewatering phenomena that channeled fluids upwards in response to increasing hydrostatic and lithostatic loads. Fluid pathways may have been localized by growth faults which could have provided the initial permeability. The clastic or massive fabrics result from either hydraulic milling of poorly consolidated sediments by upwelling fluids or venting a slurry of mud and sand onto the sea floor, forming a volcano-like edifice.

Alteration and Mineralization

The deposit and its associated alteration envelope are crudely mushroom shaped (Figure 2). Its stem consists of an alteration zone within and adjacent to the fragmental pipe; its cap 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.

Alteration can be grouped into the following main associations: 1) tourmaline; 2) plagioclase-biotite-garnet; 3) biotite; 4) calcsilicate; 5) sericite; and 6) silica. (N.B. Alteration types are described in terms of their present metamorphic mineralogy)

Tourmaline alteration consists of partial to complete replacement of original sedimentary material by microscopic grains of tourmaline. Two types of tourmaline alteration occur at the Fors. The first and probably oldest is bedded black tourmaline (Fe-rich; schorl) that preferentially affects argillaceous layers. A model for this form of 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 bedded tourmalinite (Slack, 1993). Bedded tourmalinite is locally associated with white Mn-rich garnets (<0.5 mm). The second type is light to dark brown (Mg-rich; dravite). It is mainly confined to the discordant fragmental in which both clasts and matrix are altered. Both types are locally associated with a little pyrrohtite, more rarely with arsenopyrite, sphalerite and galena.

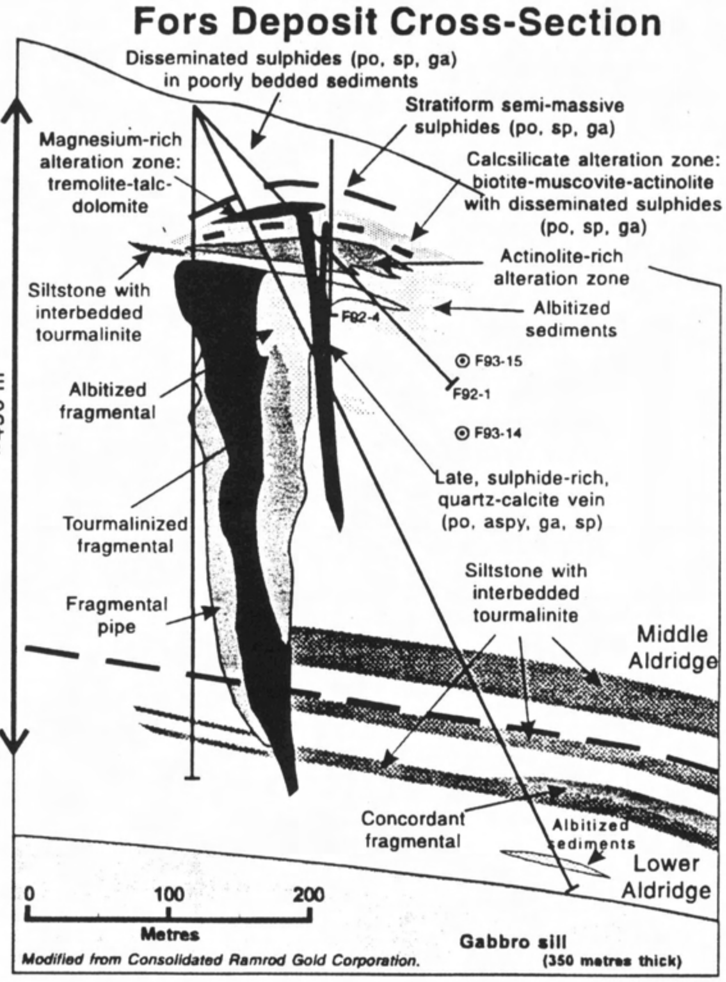

Figure 2. Schematic NE-SW cross section of the Fors deposit.

Plagioclase-Biotite-Garnet alteration (albitization) affects large volumes of rock, including part of the fragmental pipe and bedded sediments surrounding it. It appears to be asymmetrically distributed around the pipe, skewed to the NE. It is pervasive and texture destructive, and results in aphanitic to finely granular mottled grey, white and pink rock. It occurs as veins, patches, hairline fractures and broad diffuse areas. Its contacts are sharp to gradational. Garnets in this zone are pale pink and up to 2 mm in diameter. Pyrrhotite is common in these areas, preferentially replacing biotite.

Biotite and calcsilicate alteration are mainly confined to the "cap" of the deposit. It consists of complexly interlayed, coarse-grained assemblages of micas (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.

Actinolite also occurs away from the calcsilicate cap. It always replaces biotite.

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. Locally it is texture destructive and pervasive but more commonly it is confined to bedding planes in porous, feldspathic units.

Silica alteration is mainly confined to strata immediately overlying the bedded sulphide horizon that overlies the calcsilicate alteration cap. Core is blue grey, hard, with a diffusely granular appearance. This alteration also occurs as thin envelopes around late stage quartz veins.

Mineralization

Zones of semi-massive to massive sulphides are rare. They occur as stratiform and vein types.

Conformable massive sulphides consist of fine to coarse-grained pyrrhotite, sphalerite, and galena within a plagioclase-biotite-sericite envelope. The sulphides lo-

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cally 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 m was intersected. The zone lies a few meters above the top of the calcsilicate alteration cap.

A semi-massive 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.

Low-grade zones of sulphides are quite widespread. They consist of disseminations, stringers, veins, small semi-massive to massive stratiform lenses and irregular patches of pyrrhotite, with subordinate amounts of sphalerite, galena, pyrite, and rare arsenopyrite, chalcopyrite and bismuthinite.

Deposit Model

A simplified genetic model for the Fors deposit is as follows:

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) development of a fragmental pipe which acts as a long-lived conduit for upward migration of fluids 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 at surface. The upper limit of coarse fragmentals appears to lie just below the calcsilicate cap which may represent an exhalative vent deposit. The pipe may have formed in the hangingwall of a growth fault. Parallel and conjugate fractures related to this fault may have provided subsequent pathways for fluid migration.

3) tourmalinizing fluids ascend, preferentially travel along beds, but also change chemistry with time: most bedded tourmalinites are schorlitic (Fe rich); however much of the fragmental pipe is brown to pale brown, dravitic (Mg rich).

4) "albitizing" fluids ascend, react with bedded tourmaline alteration locally, but mainly spread laterally away from the pipe to the northeast.

5) potassium, iron and magnesium rich fluids deposit biotite (pale brown to bronze brown) in the main part of the vent horizon.

6) late carbonate-rich fluids "flooding" along parasitic or antithetic structures overprint biotite to produce actinolite assemblages and deposits of sulphides. Two pulses are possible: the first produced semi-massive to massive, locally stratiform Zn-Pb-Ag rich mineralization with a high base metal to iron ratio. The second pulse produced veins enriched in As, W, Ag & Bi, as well as Zn, Pb & Fe.

7) upwelling carbonate-rich fluids mix with downward circulating seawater to produce Mg enriched assemblages including talc, tremolite, dolomite at the top of the alteration cap, and possibly the Mg-rich tourmalinites found in the upper part of the fragmental pipe.

8) later fluids yield sericite (-silica) alteration with minor sulphides that enrich the overlying sedimentary package and form 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) regional metamorphism creates present silicate mineralogy and redistributes some sulphides.

Conclusion

The Fors prospect is a well preserved example of a small, high-grade Pb-Zn-Ag sedimentary exhalative and vein deposit hosted in 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 near-blind discovery that resulted from drill-testing a geological model in the vicinity of low-grade mineralization found at surface.

It provides a new exploration target in the Sullivan camp, having some similarities with 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.

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