GS-22

GEOLOGY AND GEOCHEMISTRY OF THE RUTTAN AND DARROL LAKE DEPOSITS (NTS 63B5), MANITOBA

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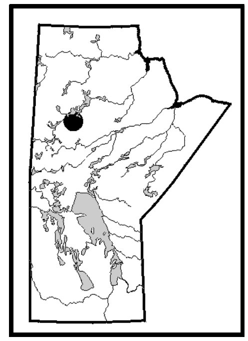

Gale, G.H., McClenaghan, S.H. and Yaworski, R. 2002: Geology and geochemistry of the Ruttan and Darrol Lake deposits (NTS 63B5), Manitoba; *in* Report of Activities 2002, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 198–204.

SUMMARY

Drill cores were logged in detail to establish the stratigraphic position and setting of ‘ore equivalent’ strata at the Ruttan and Darrol Lake deposits. Alteration mineral assemblages in the Ruttan deposit are extensive and can be used to distinguish crosscutting and stratabound (exhalite) alterations, but are insufficiently understood to establish reliable exhalite strata within the deposit. The drill-core studies have established that rocks previously mapped as ‘quartz-feldspar intrusion’ are felsic volcaniclastic rocks, thus casting some doubt on the stratigraphic position of the ‘important ore equivalent’ rocks northeast of the mine. In addition, none of the rocks occurring at the northeastern extremity of the Ruttan mine are rhyolite, but are altered rocks derived, in part, from felsic volcanic rocks, such as rhyolite or dacite, and exhalite (?chert).

Geochemical data from drill cores within an upper Zn-rich zone of the Ruttan mine show REE profiles with well-defined $Eu^d>0$[3] anomalies in both layered sulphides and associated quartz-sericite schist. Preliminary data suggest that positive Eu^d anomalies extend off the end of the deposit for a distance of more than 1 km. In addition, an unexplained $Eu^d>0$ anomaly in drillhole 96-02 occurs approximately 150 m stratigraphically above known mineralization.

The Darrol Lake deposit occurs in a sequence of volcanosedimentary rocks similar to those hosting the Ruttan mine. Sulphide mineralization in this deposit occurs predominantly as veins and veinlets of pyrrhotite and sphalerite at several stratigraphic levels in the sequence. Layered magnetite is present adjacent to the sulphide mineralization in many drill cores. Minerals typically found in alteration zones appear to be predominantly stratabound, and clear evidence of crosscutting footwall-type alteration was not observed. Gahnite, a common constituent of several sulphide-bearing sections, also occurs at different stratigraphic positions within the deposit. Quartz-rich chert-like rocks are rare and occur in only several closely spaced drillholes; semimassive pyrite and chert layers occur together in only one drill core.

INTRODUCTION

Regional setting

The Ruttan and Darrol Lake deposits are located in the Paleoproterozoic Rusty Lake greenstone belt (Fig. GS-22-1). The Rusty Lake belt comprises four structurally bound supracrustal blocks: Karsakuwigamak Block, Northern Block, Eastern Block and Ruttan Block (Baldwin, 1988). The constituent blocks are separated by major faults that truncate the stratigraphy defining the respective blocks. The Ruttan and Darrol Lake deposits are hosted within the westernmost Ruttan Block, which is characterized by a northern south-younging and a southern north-younging supracrustal succession (Baldwin, 1988), separated by the composite Corner Lake pluton (Ames, 1996).

Project description

This project is a continuation of one undertaken in co-operation with the Ruttan mine geology staff to document the rare earth element (REE) geochemistry in and around a massive sulphide deposit. Samples collected from underground workings and surface drill cores in previous years indicated that there are strong Eu depletions ($Eu^d < 0$) in intensely altered rocks and strong Eu enrichment ($Eu^d > 0$) in rocks considered to be the ‘ore equivalent’ or distal exhalite to the mineralization (cf. Gale et al., 1997).

The unexpected announcement of the Ruttan mine closure required an acceleration of the documentation project while drill core and pulps were still available. An evaluation of available drill core along the northeast extension of the mine was also undertaken to establish if residual exploration potential exists in that part of the property. Drill cores from

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[3] Eud=% deviation chondrite normalized Eu from Eu* (see Gale et al., 1997)

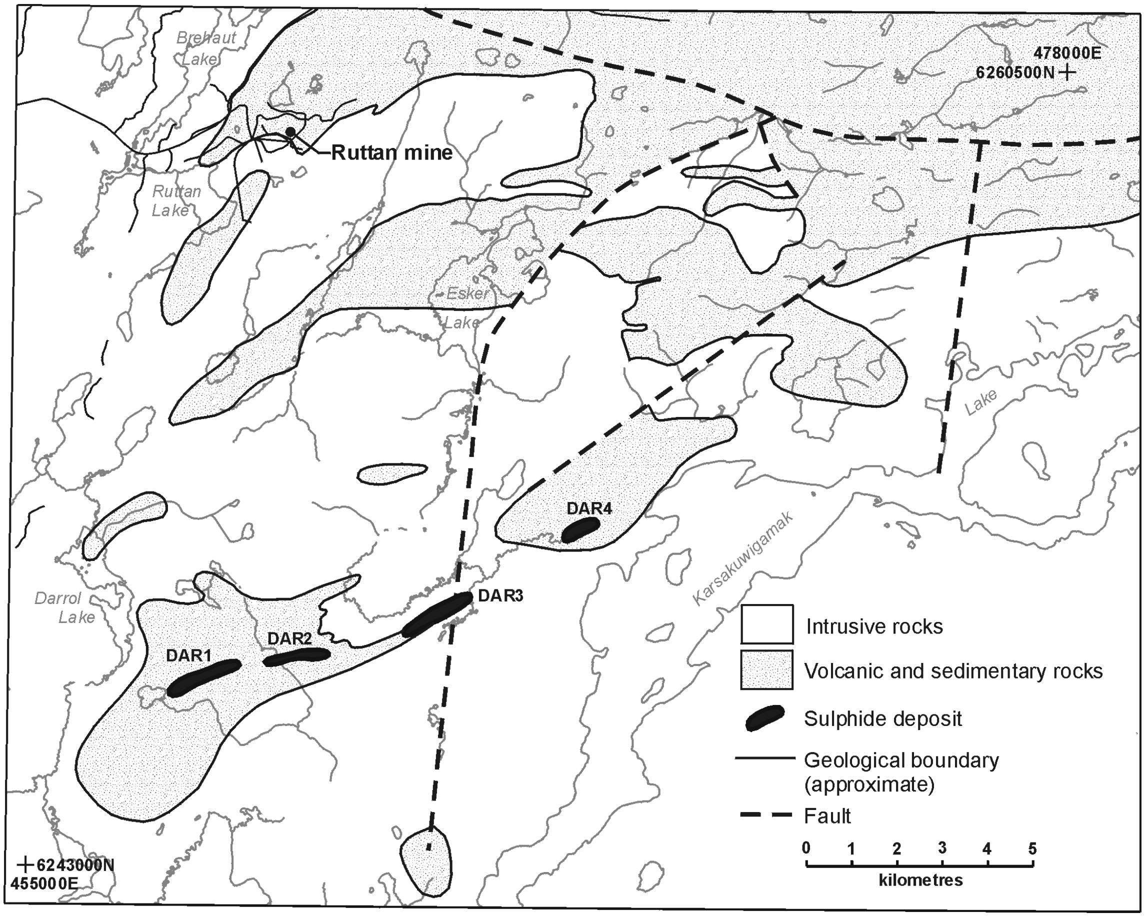


Figure GS-22-1: Location of the Ruttan mine and Darrol Lake deposits.

the northeastern part of the deposit were examined in detail and sampled to establish if distal exhalite could be identified using REE data, and to establish the stratigraphic framework of the previously identified Eu-anomalous samples. These studies will enable a refinement of previously published geological maps and reports (Ames, 1996) and provide a better understanding of the geology and residual potential of the Ruttan area.

The Darrol Lake area, approximately 12 km south of the Ruttan Mine, contains several small, low-grade sulphide deposits (Ferreira, 1994). These deposits have been extensively drilled, but there are few geochemical data available to establish the nature of the mineralization. It has been suggested that the geological setting and mineralization are similar to those of the Ruttan mine. Consequently, cores were relogged and sampled to determine if new insights gained into the geological setting and geochemistry could assist in evaluation of mineral potential in this 10 km long belt of volcanosedimentary rocks with abundant electromagnetic conductors.

GEOLOGY OF THE RUTTAN MINE AREA

The Ruttan volcanogenic massive sulphide (VMS) deposit occurs within a thick sequence of felsic to intermediate volcaniclastic rocks that consist predominantly of volcanic sandstones, but include volcaniclastic rocks with recognizable angular to subrounded rhyolite and basalt fragments 2 to 30 cm in length (Baldwin, 1988; Ames, 1996). The deposit and its altered footwall rocks are separated from the predominantly mafic rocks to the northwest by the North Wall Shear, which is a late, brittle deformation zone that has brought low-sulphide, weakly altered volcaniclastic rocks to the northwest in contact with rusty-weathered, sulphide-rich, intensely altered and mineralized rocks. It appears that rocks on the southeast side of the North Wall Shear are displaced upward.

Speakman et al. (1982) described the deposit in detail. Ames (1996) and Ames and Taylor (1996) reported on the geology of the West Anomaly zinc mineralization and the geochemistry of country rocks and alteration. The oldest rocks recognized in the footwall to the deposit are massive, pillowed and volcaniclastic basalt. These are overlain by Footwall Volcaniclastic rocks and altered Footwall Volcaniclastic rocks that are dacitic to rhyolitic in composition where examined by the authors in the northeastern part of the deposit. These rocks are overlain by the 'Mine Rhyolite', a (?)silicified volcaniclastic rock that hosts the massive sulphide lenses (Speakman et al., 1982). These rocks and the ore lenses are overlain by a 50 m thick unit of chemical and clastic sedimentary rocks referred to as the 'Exhalite Horizon' (Speakman et al., 1982). The Exhalite Horizon is overlain by the Powder Magazine volcaniclastic unit (Speakman et al., 1982; Baldwin, 1988). The present studies and sampling have focused on rocks northeast of the Ruttan mine open pit, including Footwall Volcaniclastic rocks, Exhalite Horizon and Powder Magazine unit, which were also the focus of a study of the 'Ruttan Extension' (Ames, 1996; Ames and Taylor, 1996).

Ruttan sulphide deposit

Drill cores from northeast of the Ruttan open pit were logged to identify marker units and mineralized sections. In general, the oldest rocks observed in drill cores at the eastern end of the Ruttan mine are a thick sequence of visually altered felsic volcaniclastic rocks that occur predominantly northwest of the projected position of the North Wall Shear. These rocks are overlain by a 200 m thick sequence of altered and mineralized rocks that consists of at least three units of exhalite-derived rocks, separated by visually unaltered felsic and intermediate volcanic sandstone and greywacke.

The lowermost of these 'exhalite' units is characterized by quartz-rich rocks, coarse-grained chlorite-biotite schist and minor base metals, whereas the uppermost 'exhalite' unit is characterized by abundant chert, quartz-sericite schist and minor pyrite. These rocks and the associated sulphides constitute the Exhalite Horizon of Speakman et al. (1982), and appear to overlie the low-grade, main, Cu>>Zn sulphide ore bodies, such as the East lens. The uppermost unit of exhalite is probably the stratigraphic equivalent of the hanging wall zinc zones. These high-grade, sphalerite-rich, Zn>>Cu lenses occur in the hanging wall to the main, pyrite-rich, sulphide orebodies, such as the East lens.

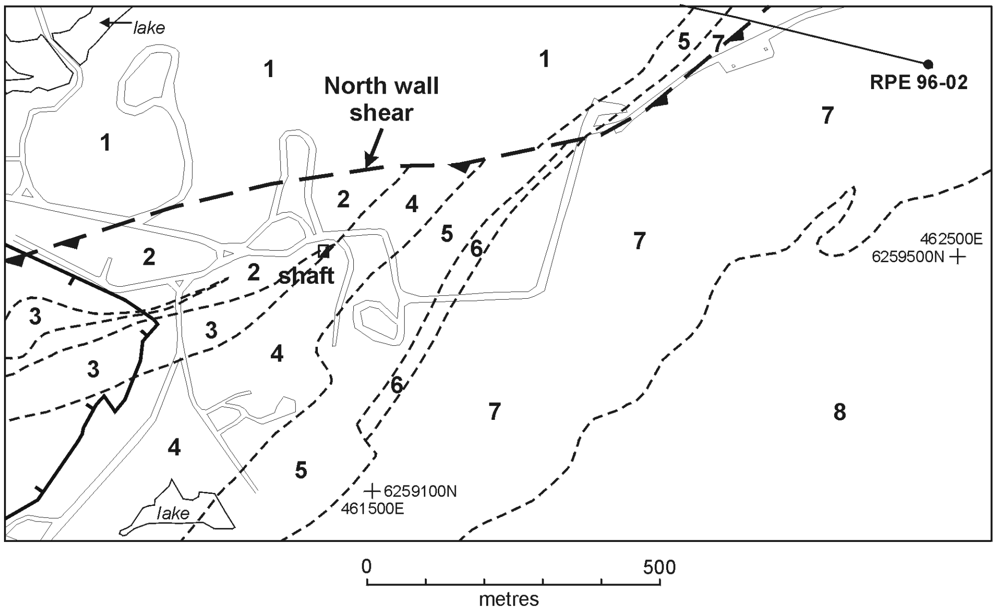
The exhalite-bearing rocks are stratigraphically overlain by an approximately 125 m thick unit of well-bedded, felsic to intermediate volcanic sandstone. Locally, the unit contains beds, less than 1 m thick, of mafic and intermediate volcaniclastic rocks, with less than 1 to 10 cm fragments. These rocks occur between the 'exhalite' unit, or mine sequence, and an overlying distinctive unit of layered quartz- and feldspar-bearing, felsic volcaniclastic rocks that also has a thickness of approximately 125 m. These felsic volcaniclastic rocks, where exposed on surface, are well bedded, contain either mafic and felsic fragments or only felsic fragments, and consist of interlayered felsic sandstone and sandstone-supported breccia. The base of the unit, observed in drill core, is chararacterized by quartz crystal–rich, poorly layered sandstone and grit. The central part of the unit is similar to the surface exposures and consists of interlayered felsic sandstone and sandstone with angular 1 to 10 cm fragments; locally, there are quartz-rich and quartz-feldspar–rich beds. The uppermost part of this unit consists of several tens of metres of well-layered felsic sandstone with distinctive 10 to 30 cm thick beds of medium- to coarse-grained, subrounded quartz. The top of the unit is marked by felsic siltstone that is bedded on a millimetre to centimetre scale and has a distinctive brown colour; several of the siltstone beds are characterized by coarse-grained hornblende porphyroblasts.

Although preparation of a final map must await further mapping and analysis of geochemical data, it is possible now to confirm that the felsic volcaniclastic unit is a distinctive marker horizon within the Powder Magazine formation. The upper contact of this unit could easily be confused with that of 'ore equivalent' felsic rocks. It is anticipated that further structural and geochemical studies may assist in refining the northeast extension of the Ruttan mine strata within the Powder Magazine unit (Fig. GS-22-2; cf. Ames [1996], who identified the felsic volcaniclastic unit as a quartz-plagioclase porphyry intrusion).

Stratigraphic tops

Although the Powder Magazine unit has been considered to be a folded homoclinal sequence (Baldwin, 1988; Speakman et al., 1992), there is some concern about whether the present shapes of the ore lenses can be attributed to stacked ore lenses or the result of tight to isoclinal folds and brittle-ductile deformations. Although a number of top reversals defined by graded bedding are present in the hanging wall sedimentary rocks, these reversals occur in debris-flow deposits, where reverse size grading may preclude reliance on graded beds as reliable determination of facing direction. In complexly deformed deposits, the sulphide lens morphology, metal zonation and relationship to alteration can provide reliable criteria for determining stratigraphic tops.

Drillhole UX5730, which was drilled upwards into the structural hanging wall in the East lens, provides a clear definition of stratigraphic tops through sulphide metal zoning, sulphide morphology and position of alteration (Fig. GS-22-3a, GS-22-3b). This hole intersected stringer sulphides in altered quartz-rich rocks in its lower portions, followed upwards by 1) black chlorite schist with abundant chalcopyrite and pyrrhotite vein mobilizate, 2) near-solid pyrite and chalcopyrite, 3) near-solid pyrite and minor sphalerite, 4) near-solid pyrite, 5) pyritic quartz-sericite rock, and 6) quartz-rich rocks derived from chert. This sequence represents a 'classic' alteration and sulphide-chert zonation



8 Mafic intrusion

7 Powder Magazine unit

6 Fine grained felsic sandstone

5 Felsic volcaniclastic rocks

4 Mafic to felsic sandstone and breccia

3 Sulphide lens

2 Intensely altered rocks

1 Footwall volcaniclastic rocks

------ Geological boundary (approximate)

RPE 96-02 Drillhole

Figure GS-22-2: Geology of the northeast end of the Ruttan mine (modified after Ames, 1996).

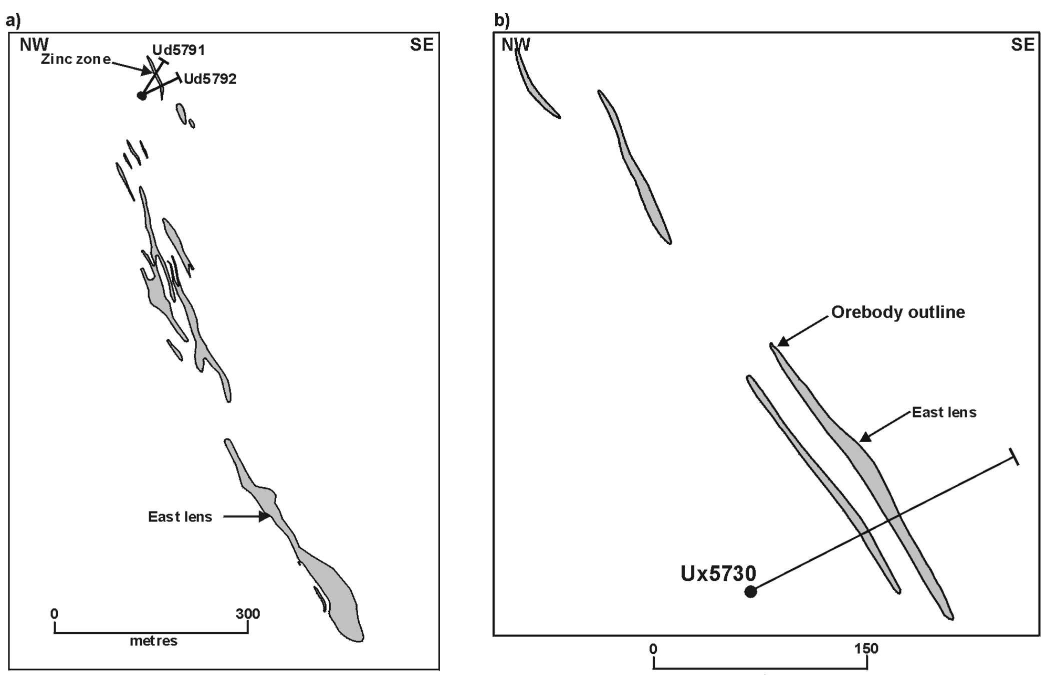


Figure GS-22-3: a) Outline of ore lenses, section 49+00, Ruttan mine. Note relative positions of Zinc zone and East lens. b) Location of drillhole UX5730, projected onto section 57+00E. Note that the ore lens shown is the along-strike continuation of the East lens shown on Figure GS-22-3a.

pattern within a VMS deposit that proceeds from a basal stringer zone to chert. This hole (Fig. GS-22-3b) indicates that this part of the deposit is right side up, and tops in this sulphide zone are towards the structural hanging wall.

Anhydrite, gahnite and staurolite

Several authors have emphasized that the presence of abundant anhydrite at the Ruttan mine has a bearing on deposit genesis and/or should be investigated further (Ames and Taylor, 1996; Barrie and Taylor, 2001). Coarse-grained euhedral anhydrite occurs throughout the deposit in footwall alteration zones, ore zones and hanging wall rocks. It occurs as crystals, up to 20 cm in size, filling tensional fractures and extremely late shear zones in various rock types that postdate folding, metamorphism and intrusion of granite. Although there may be some increase in anhydrite content toward the stratigraphic top of the deposit (Ames and Taylor, 1996), there is also a pronounced increase westward within the mine toward the late, postmetamorphism intrusion. The authors contend that the anhydrite in this deposit is a late mobilizate (Fig. GS-22-4), is clearly related to postmetamorphic events and has no bearing on deposit genesis. It may also be related to late deformation events because it occurs in some shear zones (C.J. Beaumont-Smith, pers. comm., 2002).

Gahnite is commonly observed in the silicate-rich portions of metamorphosed distal exhalite. Gahnite crystals, up to 1 cm in diameter, occur throughout the Ruttan deposit but are most common in quartz-sericite schist, where they clearly overgrow the main foliation. The gahnite also occurs in crosscutting alteration that has recrystallized to chlorite-biotite-cordierite rocks. These crystals, although locally constituting over 10% of the rock, are clearly not restricted to exhalite layers in this deposit and cannot be used as a guide in the delineation of marker units in 'ore equivalent' strata.

Staurolite occurs in altered rocks and exhalite throughout the deposit. It varies in colour from reddish brown to pale yellow, and in crystal habit from euhedral to ragged-edged aggregates. An unusually pale yellow occurrence (Fig. GS-22-5) illustrates the late nature of this mineral, in that it occurs along cleavage planes in quartz-rich sericitic (?exhalite-derived) alteration.

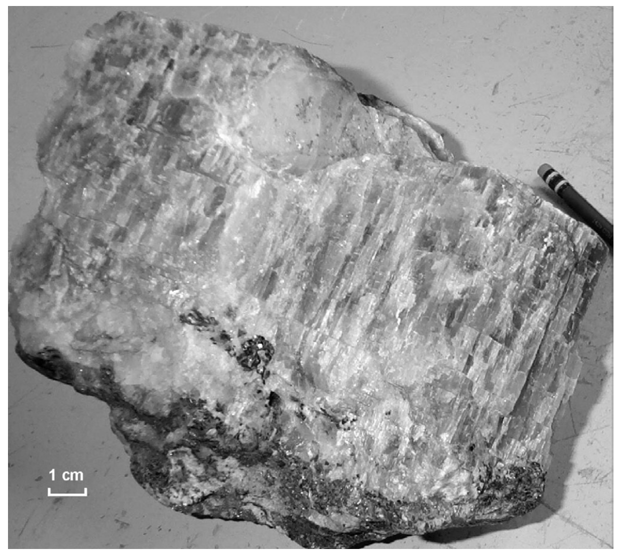


Figure GS-22-4: Typical euhedral anhydrite crystals from a late fracture, Ruttan mine.

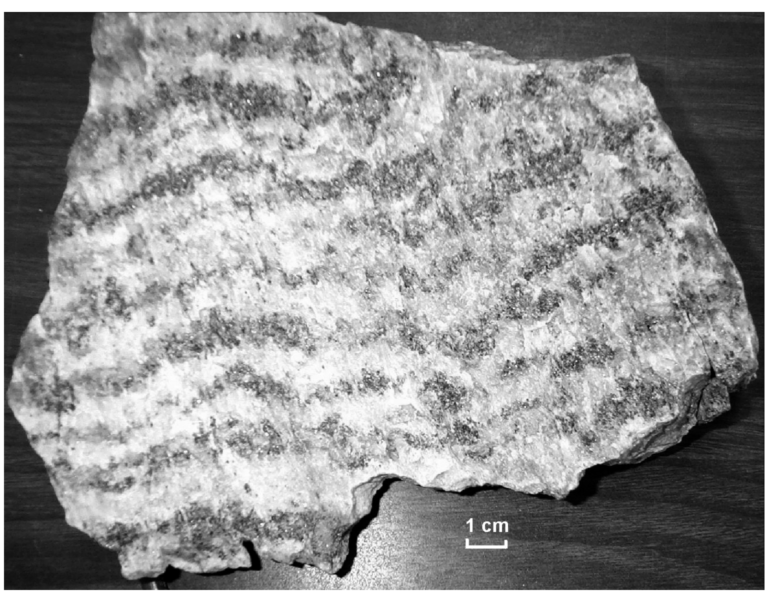


Figure GS-22-5: Quartz-sericite schist alteration with staurolite and biotite growth along early (?)cleavage planes. Photo from Ruttan mine sample collection. Similar rocks are present in footwall alteration zone, structurally below the East lens sulphide orebody.

GEOLOGY OF THE DARROL LAKE DEPOSIT

The sulphide mineralization at Darrol Lake consists of minor pyrrhotite, pyrite, ±sphalerite ±chalcopyrite, in at least four different zones (Dar 1, Dar 2, Dar 3 and Dar 4; Ferreira, 1994) at several different stratigraphic levels along a strike length of approximately 10 km (Fig. GS-22-1). The sulphide zones are delineated by strong electromagnetic conductors. The mineralization at the Dar 2 zone is structurally (and apparently stratigraphically) underlain by rhyolitic volcanic rocks, and overlain by intermediate to mafic volcanosedimentary rocks that are similar to the sandstone portions of the Powder Magazine formation at the Ruttan mine. Rocks in the mineralized zone are dominantly felsic and include felsic sandstone, quartz-sericite schist, quartz-rich intermediate sedimentary rocks and oxide facies iron formation; pelitic and semipelitic rocks with up to 50% phlogopite are present in a number of drill cores. Granitic and pyroxene-rich intrusions are present in both hanging wall and footwall rocks. A number of intersections of pyroxene-rich rocks in the hanging wall sequence have quite variable pyroxene crystal contents that resemble crystal tuff; however, surface exposures have not been examined to determine if there is a volcanic component to these pyroxene-rich rocks.

The Dar 2 deposit contains up to three zones of disseminated and veinlet mineralization within an approximately 60 m thick zone of predominantly felsic (?)sedimentary rocks. Pyrrhotite and sphalerite are the dominant sulphide minerals, but together rarely constitute more than 10 to 20% of the rock. Both occur mainly as sulphide veinlets in conformable to semiconformable zones in association with quartz-rich sericite schist and quartz-rich rocks considered to be chert. Semimassive pyrrhotite, where present, is associated with late deformation zones and the margins of mafic intrusions. Gahnite, a common constituent, is frequently associated with both sericite- and biotite-rich rocks.

Only one drillhole intersected bedded semimassive pyrite, but a number of drillholes intersected intervals of chert several metres thick. None of the drillholes appears to have intersected crosscutting alteration typical of that commonly found underlying VMS-type mineralization. However, several sections of quartz-rich sericite schist and chert-like rocks resemble exhalite-derived material. Consequently, this mineralization is presently considered to represent mobilization of distal exhalite units, deposited from a long-lived mineralized system into late fractures. Geochemical studies are directed at elucidating their geological setting and depositional environments.

RARE EARTH ELEMENT GEOCHEMISTRY OF THE RUTTAN ZINC ZONE

Assay pulps from two drill cores from a hanging wall zinc lens orebody at the Ruttan mine (Fig. GS-22-3) were analyzed to establish if $Eu^d > 0$ values are associated with the Ruttan ores and associated exhalite. The data, presented in Figure GS-22-6, confirm observations from other studies (Gale et al., 1997) that both VMS sulphide ores and their associated exhalite commonly have $Eu^d > 0$. These data provide a basis for further studies and interpretation of exhalite

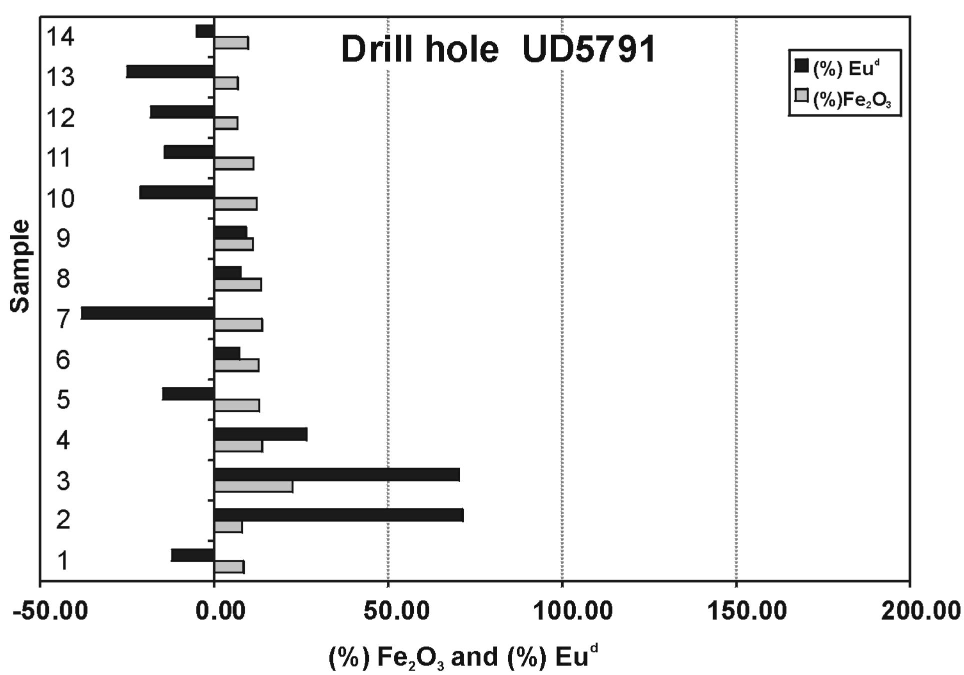


Figure GS-22-6: Eu^d, Zn and Fe (as Fe_2O_3) values within a hanging wall Zinc zone, section 49+00E, Ruttan mine.

distal to the sulphide bodies. They also confirm that the hydrothermal system forming the deposit contained abundant Eu^{+2} ions, which may provide a reliable vector to VMS deposits in this area.

EUROPIUM AS A VECTOR TO THE RUTTAN VMS MINERALIZATION

Preliminary data from grab samples of drill core (RPE 96-02) from northeast of the Ruttan mine headframe indicate the presence of a $Eu^d > 0$ anomaly, approximately 1000 m distal to the deposit, but the stratigraphic position of this exhalite relative to the 'ore equivalent' rocks is uncertain. Drill core from the area between the northeast end of the ore deposit and drillhole RPE 96-02 has been relogged and extensively sampled in order to establish the variability of Eu^d anomalies and their utility in vectoring to further VMS mineralization in this area.

ACKNOWLEDGMENTS

This project was made possible through the co-operation of Hudson Bay Mining and Smelting Co. Ltd. (HBMS). The authors thank the management of HBMS and staff at the Ruttan mine for their assistance and in-kind support. Chris Beaumont-Smith and Alan Bailes kindly reviewed drafts of the manuscript.

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