A Prospecting Model for Recognition of VLF-EM Signatures in Macumber Formation Rocks in the Walton Area (NTS 21H/01), Hants County

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Introduction

There is little published information regarding geophysical signatures for mineralized Macumber Formation rocks in the vicinity of base metal and barite occurrences at Walton, Nova Scotia. The Walton Ba-Cu-Pb-Zn-Ag deposit yielded 4.5 million tons of 90% BaSO₄, 2.8 million oz. Ag, 1.3 million kg Cu, 9.5 million kg Pb, and 4.4 million kg of Zn (Boyle, 1972). The area remains one of the most important base metal and barite exploration targets in the province.

There are several other known mineral occurrences in the area (Fig. 1). These include two former producers, the Tomlinson Mn mine, approximately 3.6 km south of the Walton mine site in the vicinity of Wade Lake (Hughes, 1995a), and the Sturgis Mn mine (Hughes, 1995b), approximately 1.2 km south of the Walton mine site. The Sturgis manganese mine produced 26 tons of high grade manganese ore prior to 1820. The Feuchtwanger mine was a small producer as well, producing 15 tons of high grade pyrolusite in the early 1800s (Hughes, 1995c). This showing is also documented as a barite occurrence (MacLeod, 1995). The Three Kilometer showing, named for its position 3 km south of the Walton mine site, was discovered during the 1999 field season by prospector John Mails (Mills, 1999). Recent trenching of the site revealed abundant, massive, Fe-Mn zones in north-trending fractures in Horton Group sediments. It appears the fractures were conduits for fluid migration and siderite deposition in the coarse- to fine-grained (Horton Group) sandstone.

In the fall of 1999 several lines were surveyed to collect very low frequency - electromagnetic (VLF-EM) data in the vicinity of the Walton Mine. Data from these lines were examined for a geophysical signature that could be attributed to the Macumber Formation and thus used when prospecting for this important host rock. Distribution of the Macumber Formation is largely inferred and exposure in the area is very poor (Moore, 1986). Therefore, lines were run in the vicinity of the former Walton Mine, where the position of the Macumber Formation is known from past work (Boyle, 1972). The Macumber Formation is the main target of this study since this rock formation hosted the mineral deposit which was the focus of historical production from Walton. It consists largely of finely interbedded to amorphous, dark limy shale, void of fossils. It represents deposition of pelagic organic material mixed with fine-grained suspended sediment that settled out in a (relatively) deep water, near-shore basin, which developed in a warm (Carboniferous) climate.

Field Methods

Two survey lines (line zero and line 50 east) approximately 190 m north of the edge of the Walton open pit mine site were run for 200 meters at an azimuth of 320° over a former ore dump (Fig. 1). A third line was surveyed following the same grid, 200 m east of line zero (line 200 east) in the vicinity of Rainy Cove Brook. Two lines were surveyed southwest of the open pit with the northern extension of the lines terminating near the main shaft of the former (Walton) mine. These lines ran for 150 m at an azimuth of 345°. The reason for this (azimuth) difference is the strike of bedding in the Macumber Formation, which is known to be slightly different in this locality. All survey lines were flagged and measured for distance with a thread meter. The actual location of mineralized Macumber Formation rocks away from the immediate area of the Walton mine site is largely unknown. This is due to a cover of thick glacial drift, which is common to Nova Scotia in general and Hants County in particular (Stea et al., 1992). Recording stations along these lines were 10 m apart to provide high resolution VLF-EM data. If a distinct signature could be recognized, it could be applied to other areas for the purpose of prospecting.

Signature information from this test was compared to information collected on two grid lines surveyed in the immediate vicinity of the Three Kilometer showing where two lines were run on at an azimuth of 110° for a distance of approximately 1 km (tie lines 1000 and 1380; Fig. 1). Stations on these lines were placed 25 m apart. The Macumber Formation is assumed to underlie this area (Fig. 1).
Figure 1. Simplified geological map of the Walton area showing location of survey lines (after Moore et al., 2000).
Readings were taken with a Geonics VLF-EM (EM-16). Data recorded included the in-phase dip angle in degrees (the "dip") and the quad-phase dip angle in degrees (the "quadrature"), components of the vertical magnetic field.

**Data Processing**

Raw data were analyzed using Quattro Pro® spreadsheets (Appendix, “A”) and charts. Data were plotted with the survey line length represented along the x axis and the angle of the in-phase and quad-phase dip represented on the y axis. True crossovers appear as rises in quadrature past the dip angle or, conversely, falls in the dip angle past the angle of quadrature values. The opposite of this (a fall in quadrature past the dip or a rise in dip past the quadrature) is a false crossover, or the result of the EM pointing away from a field of diminishing strength toward a new field of greater strength as a line is traversed, as opposed to crossing over a true magnetic target.

**Results**

The results of the three survey areas are discussed below and the data are presented in Figures 2, 3 and 4.

**Walton Mine Site North**

In the vicinity of the Walton mine site north, the first in-phase crossover on line zero east occurs at station 40 north as a relatively weak crossover (Fig. 2). This is accompanied by a weak quadrature crossover at the same station. A second positive quadrature crossover occurs on station 150 north. The quadrature and in-phase dip angles are similar to one another between stations 70 and 120 north as well. The quadrature crossover to accompany the in-phase crossover on line 206 east is also separated by 15 m (quadrature crossover at station 55 as opposed to station 70 north for the in-phase reading). The quadrature response exhibits a similar pattern as the in-phase data, but with an exaggerated response and lower dip angles than the in-phase data.

**Walton Mine Site South**

In the vicinity of the Walton mine site south, there is a strong crossover on line 700 west at station 70 south (Fig. 3). On line 750 west a moderate crossover spans the line between stations 90 and 120 south. Data for stations on line 750 west follow the same pattern between the in-phase and quadrature dip angles for line 700 west, considering that the in-phase and quadrature dip angles also crossover. However, data for line 700 west display more variability and complexity in the signature for that line.

**Three Kilometer Showing**

Data from the 3 kilometer showing (Fig. 4) show tie line 1000 displaying two crossovers at stations 925 and 1550 south. Tie line 1380 exhibits a quadrature crossover that spans the length of the line from stations 1550 to 1700 south. The in-phase and quadrature data also exhibit a strong affinity for readings between stations 1300 and 1550 south and between 1900 and 2000 south, as well as an in-phase crossover at station 1950 south.

**Discussion**

Plots of the VLF-EM data reveal relatively complex patterns composed of signals from numerous sources. In the vicinity north of the Walton mine site there is an in-phase crossover signature for line zero east at station 40 north. This signature is presumably mineralized Macumber Formation, as it is accompanied by a negative quadrature response, a feature indicative of sulphide enrichment (Geonics, 1980). However, this type of signature could also be received in an area where there is an abrupt, severe change in the depth of overburden (Telford et al., 1977). It is recommended that resistivity data be collected over these lines in future to clarify this possibility. It has been suggested that flooded underground workings could also be the cause of such data. However, there is no record of underground workings in the vicinity of lines 700 and 750 west (Boyle, 1972).

On line 50 east, another in-phase crossover is noted at station 55, as well as on line 200 east at station 65. In these cases, quadrature data on both lines follow a pattern for the in-phase response, although there are differences in the dip angles for the quadrature data. In the case of line 50 east, for example, the quadrature data indicate a positive crossover at station 10 north. This is indicative of a buried conductor (Geonics, 1980). The lower dip angles for quadrature response on lines 50 and 200 east are indicative of swampy ground along those lines. This is certainly the case on both of these lines, which run through low-lying ground around Rainy Cove Brook.

In the vicinity south of the Walton mine an excellent crossover, believed to represent a mineralized Macumber Formation signature, was obtained in the vicinity of line 700 west. This strong quadrature crossover at station 75 south represents the best example
of a Macumber Formation signature in this survey. The strength of the crossover is probably due to the line traversing a steeply dipping, tabular sulphide body in the vicinity of the shaft and oriented at right angles to the survey line. Line 750 west also shows a strong in-phase response for two conductors at stations 30 and 110 south. Quadrature data on these lines exhibit consistently lower angles than the in-phase data. This can also be attributed to drainage patterns in the area. Both lines in this vicinity cross a small drainage valley between stations zero and 100 south.

At the Three Kilometer showing, tie line 1000 has a complicated VLF-EM signature. The in-phase data indicating two weak conductors at stations 925 and 1550 south are not reflected by similar data for the quadrature at these stations. This is indicative of surficial response only and may be caused by supergene enrichment of small fault planes similar to those observed in the aggregate quarry that exposed the Three Kilometer showing. Tie line 1380 also reveals a complicated pattern. However, there is a crossover noted at the southern extremity of the line, near station 1950 south.
where both the quadrature and in-phase dip angles display a positive crossover. This may reflect buried Macumber Formation rocks. The Macumber Formation has been noted in the vicinity of Wade Lake (Black, 1984). This is (roughly) along strike with this crossover, considering the high degree of fracturing in the area. However, conductors are relatively weak on both tie lines, and probably reflect either low-grade mineralization or deeply buried conductors. The long, flat negative quadrature crossover for tie line 1380 between stations 1550 and 1700 south is probably indicative of sulphide enrichment in a flat-lying body, or minor enrichment, over the length of the section.
Conclusions

This pilot study was successful in illustrating a VLF-EM signature for the Macumber Formation in the vicinity of the Walton mine site. Data will be compared to other work in the area when targeting potential drill sites. The survey will be augmented with data from a proton magnetometer and resistivity survey in future, to see if relationships exist between the VLF-EM signature and other geophysical surveys. This will provide investigators with a simple model for ground geophysical work, with the most common instruments used in prospecting, which can be used when exploring for Walton-type mineralization in the Macumber Formation of Hants County.

References


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