Proton Magnetometer Signatures over Mineralized Basal Windsor Group Transects in Hants and Halifax Counties, Nova Scotia

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Introduction

Regional Economic Geology

The Carboniferous (Mississippian) Windsor Group has been the most consistent source of economic minerals in Nova Scotia, hosting many thick deposits of evaporates mined for gypsum, limestone and salt. The basal unit of the Windsor Group (Macumber Formation), however, is also of particular economic importance as it hosts large deposits of massive sulphides and barite. The Macumber Formation consists of thinly bedded, slightly limy, often dark-banded mudstones and is often hard to identify. This can be attributed to the fact that in the synclinal sub-basin where this formation is found (in the vicinity of the Kennetcook Basin, Fig. 1), there existed many different depositional environments. This resulted

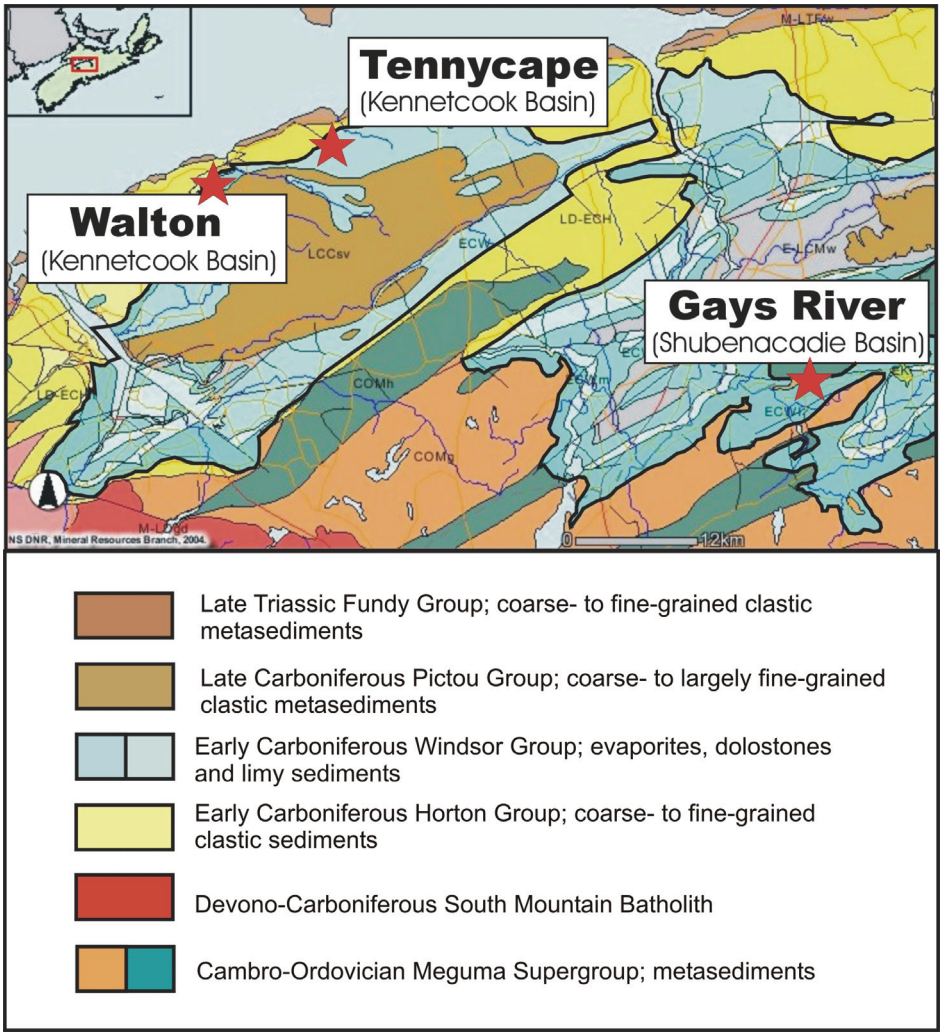

Figure 1. Major locations of reference in this report.

Mills, R. F. 2009: *in* Mineral Resources Branch, Report of Activities 2008; Nova Scotia Department of Natural Resources, Report ME 2009-1, p. 103-110.

in facies changes within the formation that were complicated tectonically, chemically and spatially. The Macumber Formation is usually poorly exposed and barely traceable over any of its strike length.

This has led to a great deal of academic argument as to where the Macumber Formation begins and ends, where facies boundaries (e.g. between the Gays River Formation and Macumber Formation) should be placed, or whether these boundaries should exist at all.

The former Tennycape manganese mine, hosted by Macumber Formation rocks, was once the largest deposit of manganese in the nation (Flynn, 1940) and world-class specimens of pyrolusite have been found at the former mine site. Manganese occurs as pyrolusite and psilomelane along a conformable contact between reddish sandstone and shale with limestone and limestone breccia of the basal Windsor Group. The east-west lithological control also has a strong structural component at the former mine, as it is cut by northwest-trending faults associated with alteration and mineralization (Mills and O'Reilly, 2002).

The former Walton barite mine was the largest single deposit of barite in the world. It accounted for 90% of all barite produced in Canada when in production (Fowler, 1988). It has produced 4.3 million tons of the commodity with an estimated 1.4 million tons still in the deposit, making the remaining ore, statistically, one of the world's largest deposits of barite. Walton was also an important producer of base metals and silver. Indeed, silver concentrations often measured in pounds per ton of ore mined. Walton's geology is very complex. The main deposit at Walton consists of minerals of barite, copper, lead, zinc, silver, carbonates and hematite in faults, shattered zones and easily replaceable porous zones and vuggy carbonate strata (Boyle, 1972). Mineralizing fluids were hypogene in origin, forming from ionic exchange between deep-seated brines and meteoric water (Ravenhurst, 1987).

The Gays River zinc-lead mine (also hosted in the basal Windsor Group unit) is recognized as an "Irish Type" base metal deposit (Kontak, 1996). Mineralized zones lie along the contact of the fossiliferous limestone of the Gays River Formation where it is unconformably overlain by evaporates. This sequence represents an ancient emerging reef bank. The main ore minerals are sphalerite and galena.

Magnetic data gathered by Northstar Energy in the Kennetcook Basin have also attracted exploration effort. Evaluation of the subsurface data available for the Kennetcook Basin could indicate buried channels in the region, as postulated by Stea (personal communication).

Theoretical Magnetometer Signature for Mineralized Macumber Formation

A theoretical model is proposed here for the mineralized Macumber Formation (Fig. 2), which should offer a recognizable signature when such rocks are surveyed by a ground proton magnetometer. When transecting an interval from Windsor Group toward Horton Group (down section) rocks, one should start out in a low (threshold level) background, rising steadily as one approaches basal Windsor Group units (Fig. 3). Karst terrain may or may not be present, which will reflect a dataset inversion. Where the mineralized Macumber Formation lies closest to the surface there should be a spike in magnetometer data, followed by higher background levels corresponding with disseminated sulphides in the underlying Horton Group sediments.

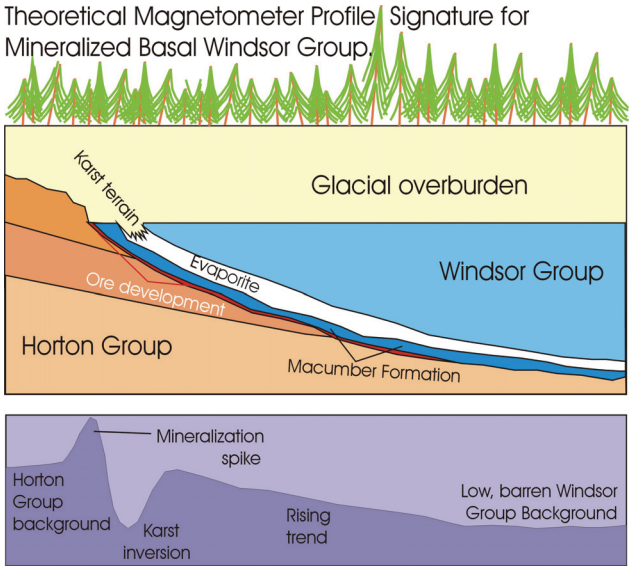

Figure 2. Theoretical magnetometer profile for mineralized basal Windsor Group.

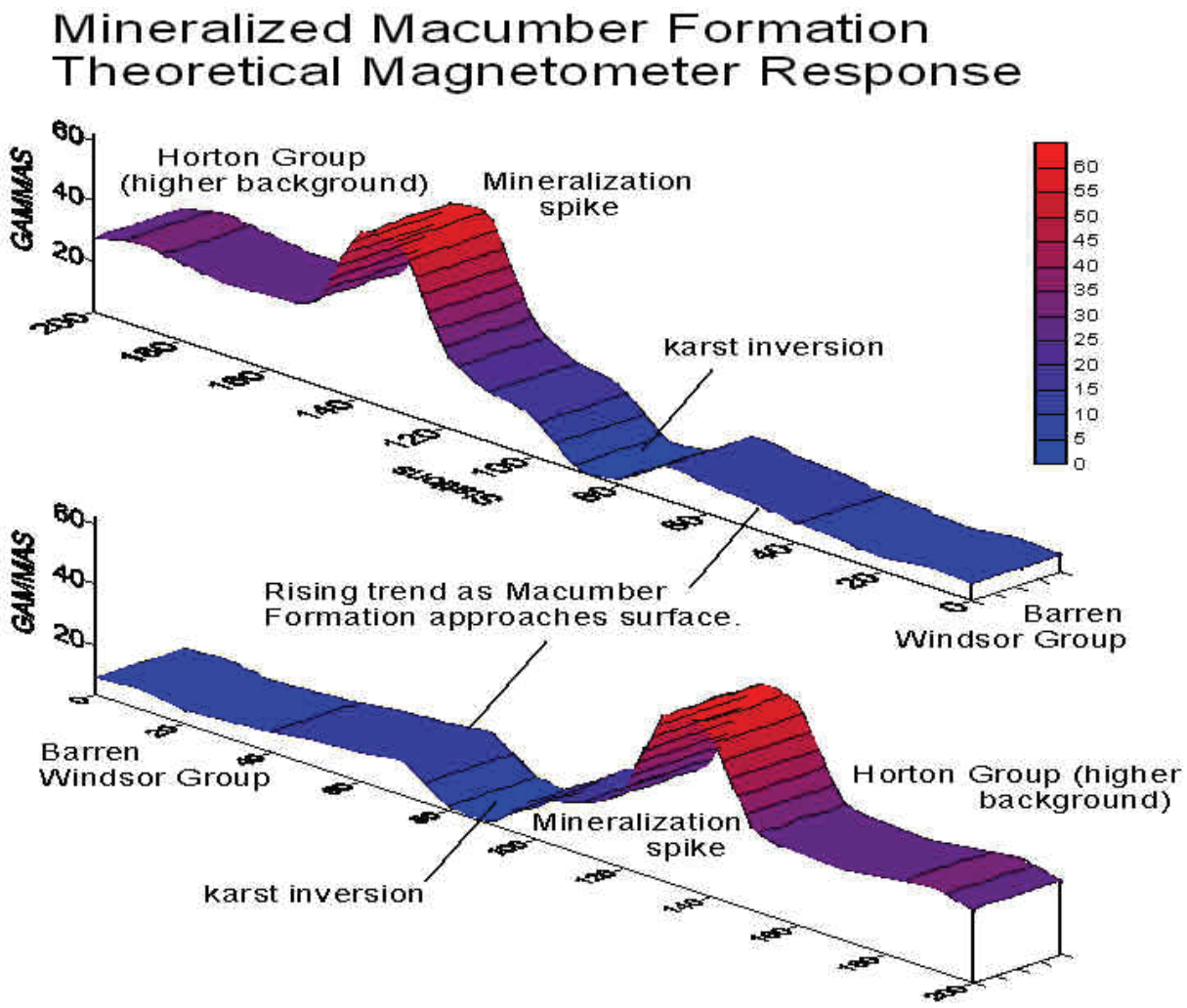

Figure 3. Expected signature to be encountered for the theoretical profile using a proton precession magnetometer.

Methods

Two mineralized sites in the basal Macumber Formation were tested for magnetic response with a Scintrex MP-2 proton magnetometer. A line was surveyed across strike and across the mineralized zone in the Macumber and Gays River formations. One line was surveyed close to the former Tennycape manganese mine and across strike. Three lines were surveyed in the vicinity of the Gays River zinc-lead deposit at Gays River, Halifax County, over a zone of ore well defined by past drilling (Hannon, 1973; Fig. 4). This survey provided a magnetometer signature recognizable for the mineralized basal Windsor Group.

Survey lines were laid out as loops with base station readings taken for the purpose of correcting diurnal variation (daily fluctuations of the Earth's magnetic field). Proton magnetometers measure the total magnetic field using a method of proton precession measurement. Airborne magnetometers and boat-borne magnetic measurements are usually made with fluxgate units, which are less accurate but take measurements instantaneously.

Measurements along the lines were taken at 12.5 m intervals and the georeferenced locations of each station were recorded using a Garmin 12X GPS so that the data may be included as part of a GIS dataset. Readings that appeared to be anomalous in the field were checked with more than one reading to be sure that they were not spurious data or the result of an atmospheric anomaly. Spurious data could be caused by encountering discarded metal in the field. Nova

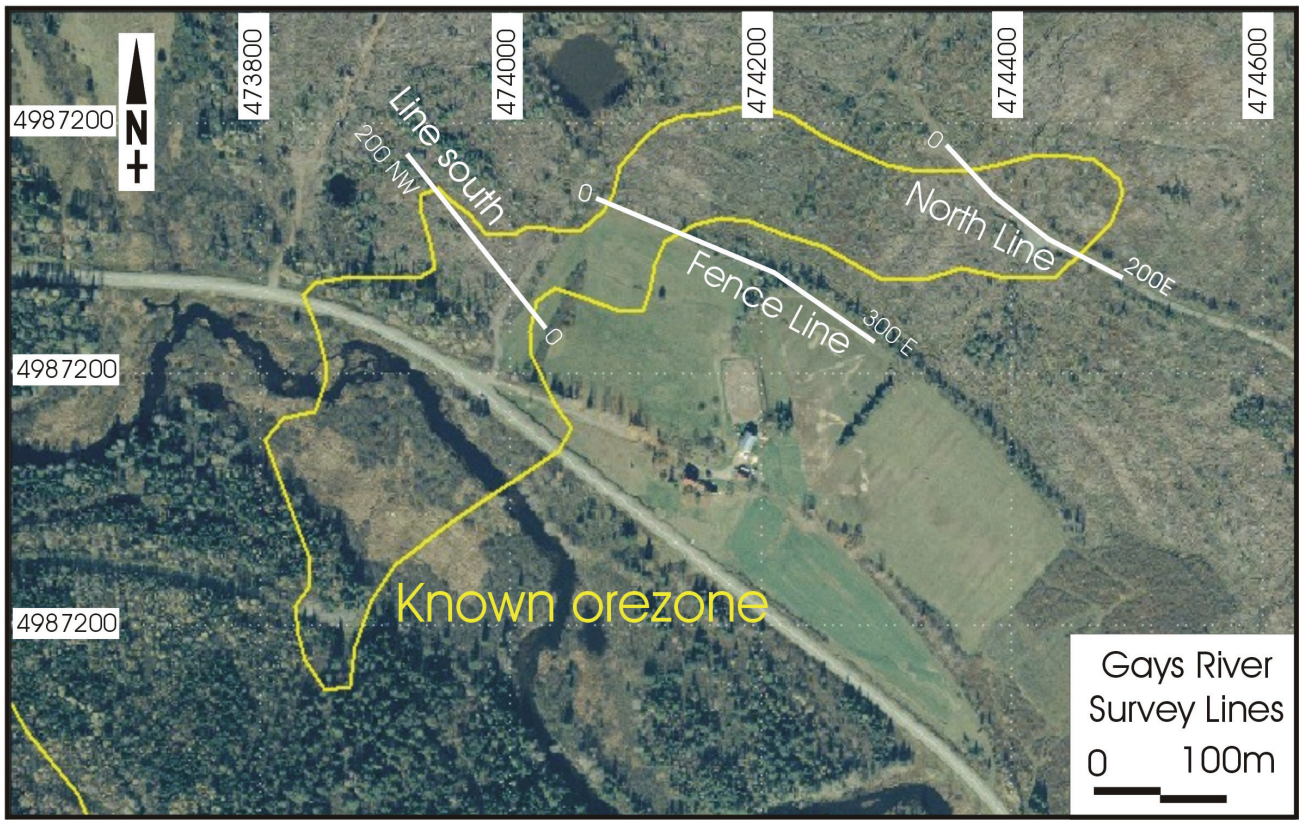

Figure 4. Transects across the known Zn-Pb orebody at Gays River.

Scotia is well covered by roads and is very accessible. Forests are cut on regular 20 to 30 year cycles so small bits of metal junk are common, such as cans for hydraulic oil used on Timberjacks and heavy equipment. Localities of high spikes are searched for such interference in the field. Atmospheric interference such as lightning can interfere with readings, as can interaction between the Earth's magnetic field and coronal mass ejections from the sun.

Data corrected for diurnal variation were plotted using the data plotting package Surfer. Each line was plotted as a separate dataset.

Results

Tennycape

An outlier within the Tennycape dataset flattened most of the response to the point that there was very little pattern detected. Once this single outlier was removed, the line at Tennycape provided good response and behaved according to the theoretical model for proton magnetometer response postulated in the methodology section (Figs. 5 and 6). The profile displays a rising trend as the basal Windsor Group approaches the surface, a (presumed) karst inversion approaching the contact, a data spike as the Macumber Formation nears the surface, and a higher background threshold for Carboniferous sediments beyond the buried contact. In reality, the site has been mined and the 'karstic' data inversion may be still attributable to magnetic void, despite the outliers having been removed. Flynn (1940), however, noted in his study of the Tennycape manganese mine that ore zones at Tennycape were direcly related to underground water movement, which was described as "substantial".

Gays River

The south line at Gays River (Fig. 7) exhibits a small peak in the vicinity of the known ore zone, from stations 62.5 to 87.5.

The fence line at Gays River (Fig. 8a) exhibited a single high response at station 62.5. When this one gamma high was removed (Fig. 8b), response on the line was weak.

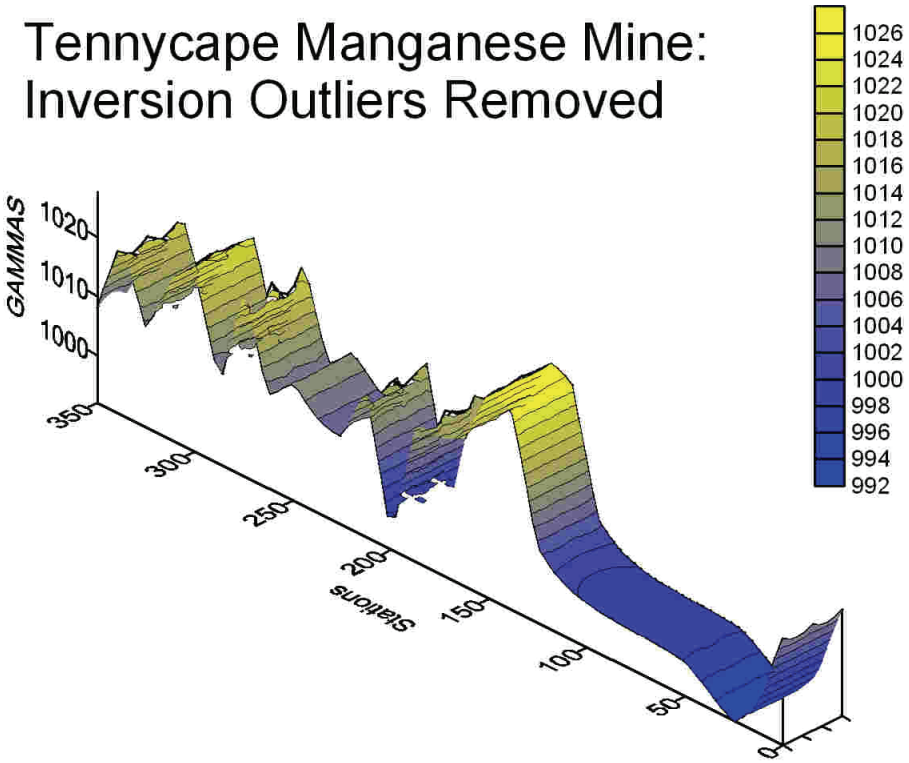

Figure 5. Signature exhibited at Tennycape on line surveyed with proton magnetometer.

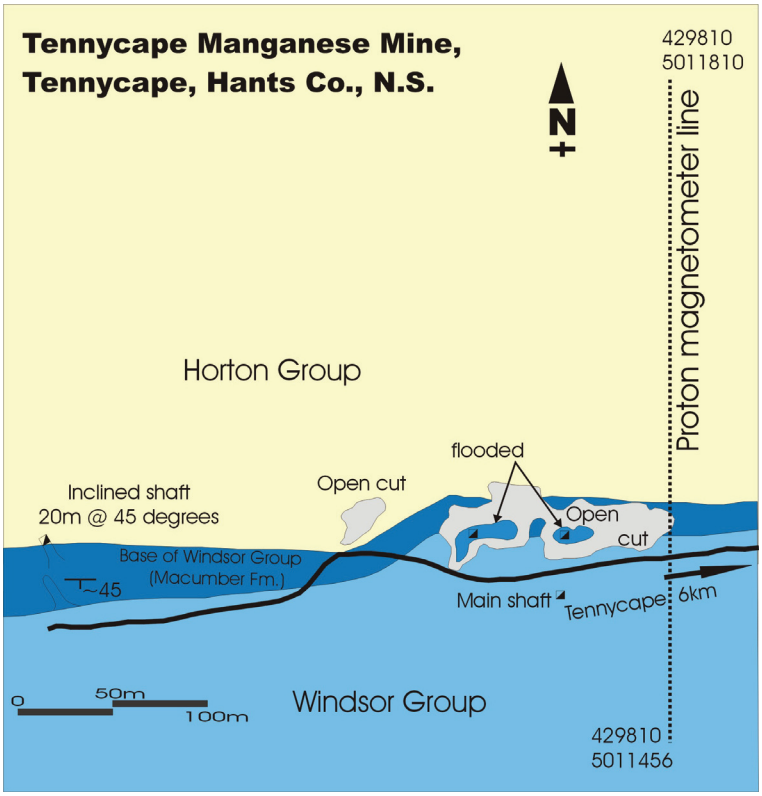

Figure 6. Location of survey line at the former Tennycape manganese mine, Tennycape, Hants County, Nova Scotia.

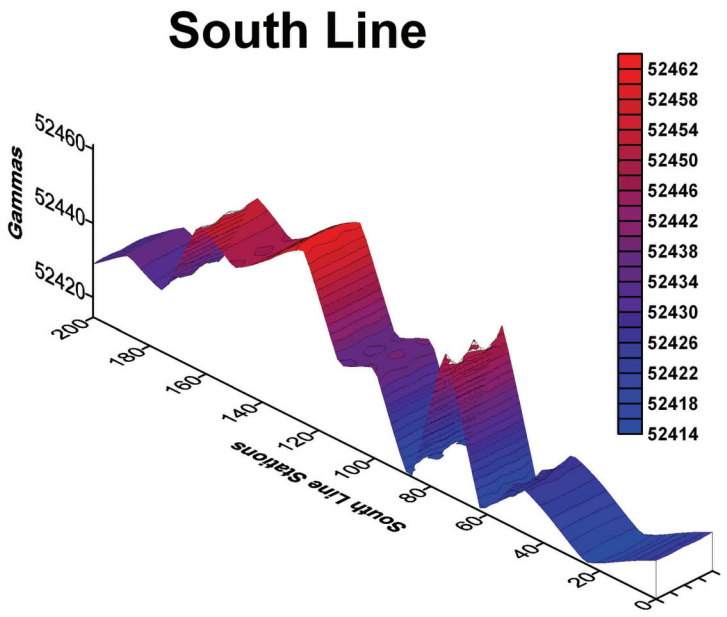

Figure 7. South line magnetometer signature for Gays River Zn-Pb deposit, Gays River, Halifax County, Nova Scotia.

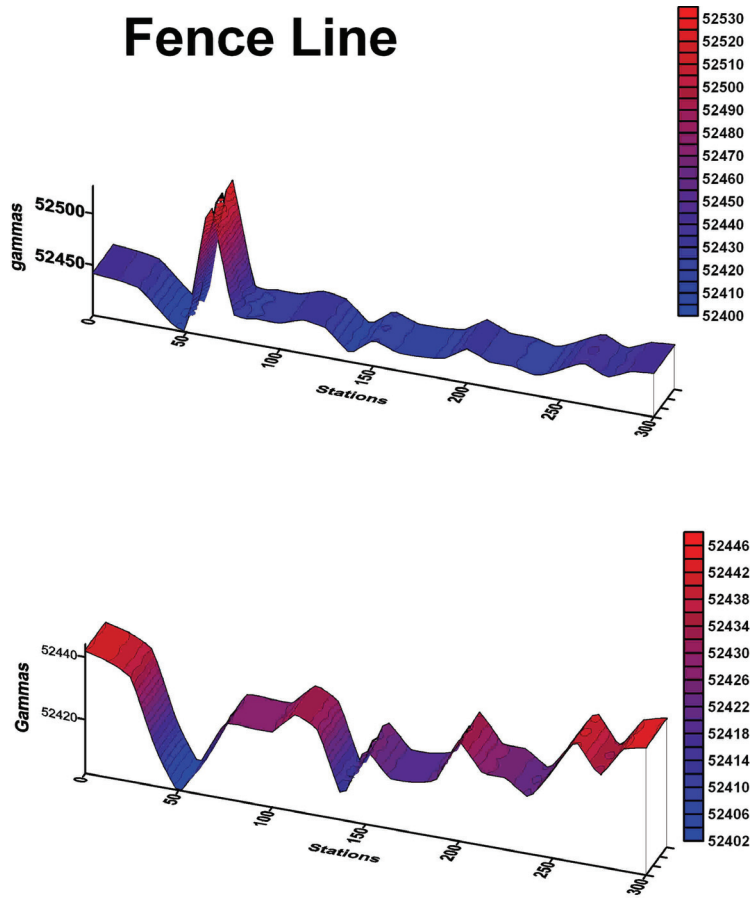

Figure 8. Fence line magnetometer signature for Gays River Zn-Pb deposit.

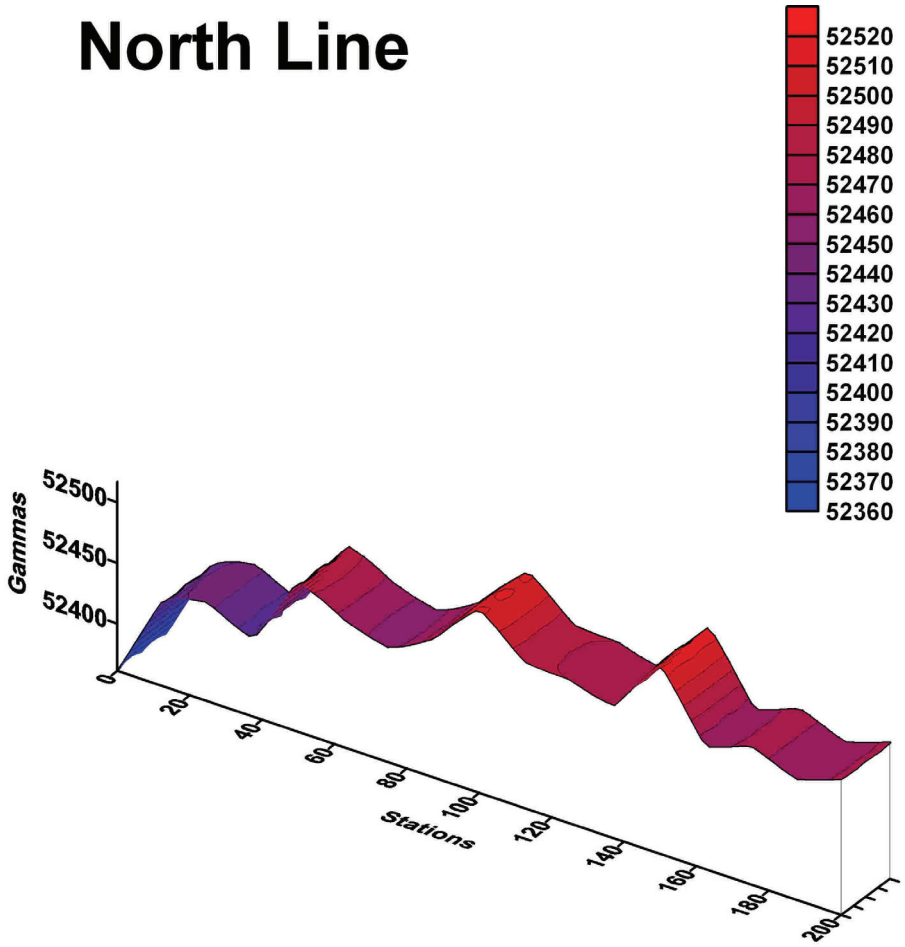

Figure 9. North line magnetometer signature for Gays River Zn-Pb deposit.

Response on the north line at Gays River (Fig. 9) was moderate and revealed a low gamma response at the western extremity of the line.

Discussion

The line at Tennycape (Figs. 5 and 6) exhibited a response consistent with the theoretical model. Horton Group rocks, presumably enriched with iron in the Kennetcook Basin, had a higher background response than Windsor Group Rocks, as the model predicted.

The lines at the Gays River deposit did not exhibit a response that might be interpreted as model responses. The fence line did exhibit a slightly elevated gamma response close to the theoretical model prior to the removal of a particularly high reading in the vicinity of the known ore-evaporite contact (Hannon, 1973).

The south line exhibits a peak from stations 62.5 to 87.5, but a higher background in the evaporitic terrain west of the ore zone than the Meguma basement to the east cannot presently be explained.

The fence line also exhibits a higher background in the evaporitic terrain west of the ore zone than the Meguma basement to the east, which can not be explained at this time. The response over the ore zone exhibits a single high reading, which could be interpreted as an outlier adjacent to a data inversion, existing at a point where one would expect a low gamma response. However, the response is considered weak. Extending the line further west may improve resolution of the gamma data pattern.

The north line exhibits low gamma response at the west end of the line. This could be a low response related to the presence of evaporate but, the placement of the line does not extend far enough west to draw such a conclusion at this time,

hence no conclusive relationship to the theoretical model could be drawn. Extending the line further west may improve resolution of the gamma data pattern.

Stea (personal communication) postulated that the high magnetic responses could be due, in part, to paleochannels filled with sand and gravel derived from magnetic rocks and the low responses correlatable with limestones.

The basal unit (Macumber and Gays River Formations) of the Windsor Group are known to be structurally complex, broken by local unmapped faults and discontinuities. Barren rocks make up the vast majority of any mineral exploration property. Low responses could be due, in part, to buried karst terrains, horizons of gypsum or barren evaporate and finally, barren sediments.

References

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