Delineation of ore-bearing deposits in Bathurst Mining Camp, NB, based on lineament analysis and 3D FTG data inversion

Pei Yang[1], Alexander L. Peace[1], Colm Murphy[2], Liam Clark[2]

1. School of Earth, Environment & Society, McMaster University, Hamilton, ON, Canada
2. BellGeospace, Edinburgh, UK

Motivations

The Bathurst Mining Camp (BMC) in New Brunswick is one of Canada's oldest mining areas for volcanogenic massive sulphide (VMS) deposits (Figure 1). Although numerous previous works on VMS within the BMC have performed by using various geophysical data in the region, the distribution, geometries, and dimensions of the VMS deposits in the BMC, as well as their evolution through time remain uncertain due to the limitations of vintage geophysical datasets and the complicated tectonic evolution. Integration of multiple high-resolution geophysical datasets is needed to gain a better understanding BMC ores to instigate more targeted exploration success. In this study, a regional-scale lineament analysis of the BMC using Full-Tensor Gradiometry (FTG) is conducted. Then, 3D FTG data inversion is carried out to obtain subsurface density distribution. Next, key signature patterns that are diagnostic of specific ore-bearing geological features (e.g., VMS) are established by integrating lineament analysis and 3D FTG data inversion. This study not only reveals more detailed lineament patterns related to the tectonic evolution of BMC, but also demonstrates the advantages of FTG data for mineral exploration.

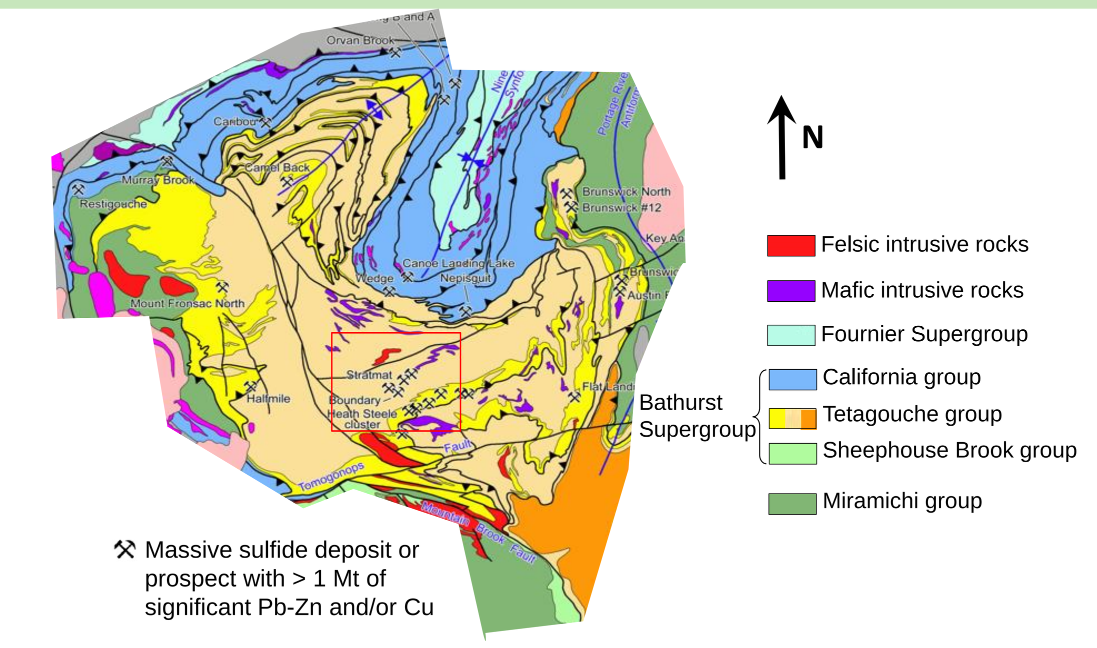


Figure 1: Geology, structure and mineral deposits of the Bathurst Mining Camp, NB. Figure is adapted from www.portergeo.com.au. The red rectangle indicates the area of interest for geophysical inversion.

Datasets

The data types:
1) Magnetic & ground gravity data
2) Borehole data
3) Full-Tensor Gradiometry (FTG: Txx, Txy, Txz, Tyy, Tyz, Tzz)

- FTG data processing by Bell Geospace is updated in 2022 and includes both Full Tensor Noise Reduction (FTNR) and Source Body Migration (SBM, Brewster and Murphy, 2020).

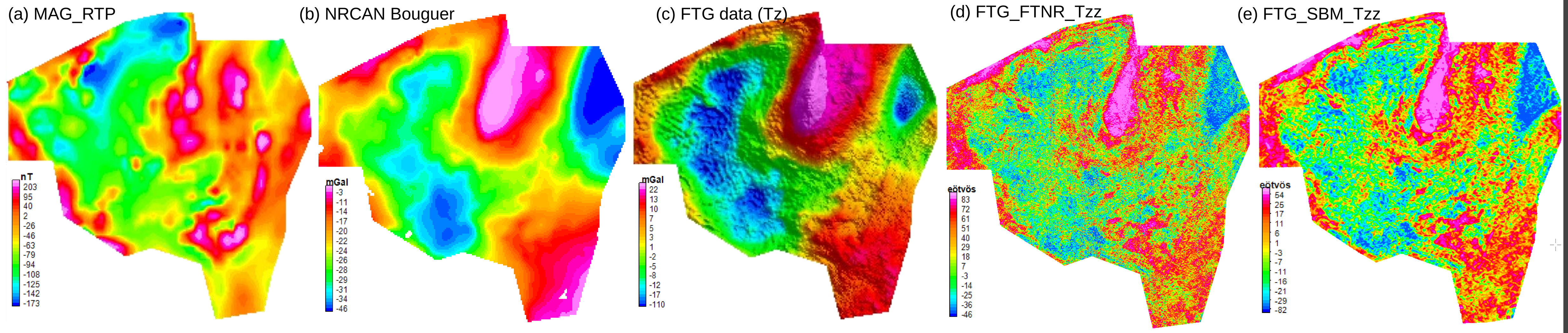


Figure 2: magnetic, ground and airborne gravity data over the Bathurst Mining Camp, NB. NRCAN indicates gridded NR Canada ground gravity data..

Lineament Analysis

- Horizontal invariant lineament (Dickinson et al., 2010)

$$\mathrm{InVar\_}TxzTyz = \sqrt{Txz^2 + Tyz^2}$$

- Horizontal invariant lineaments enhance linear features, displaying a good match with structure
- Lineament pattern from FTG data more striking, particularly in the southwestern area of the survey

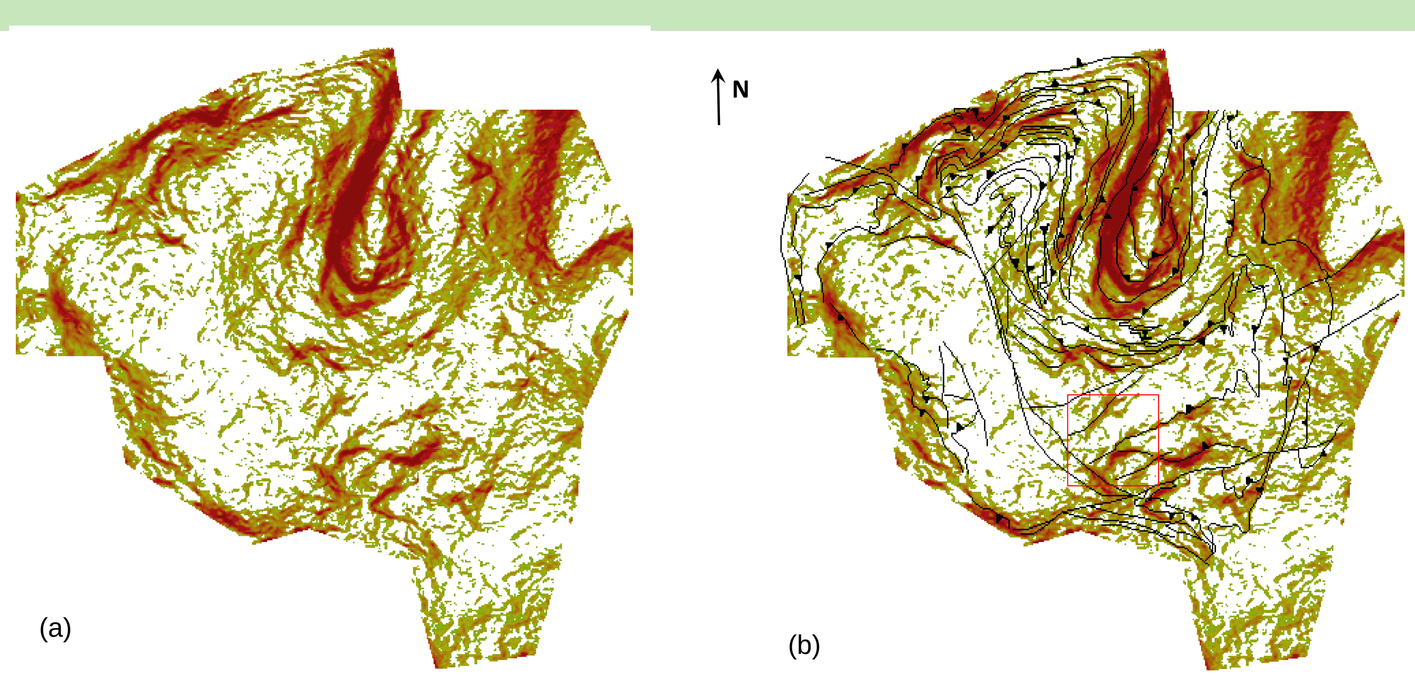


Figure 3: Horizontal invariant lineaments calculated from FTG data over BMC. The red rectangle indicates the area of interest of the Stratmat and Heath Steele areas for geophysical inversion (shown in Figure 1).

Inversion results

Area of interest for inversion (red rectangle in Figures 1 and 3b):

- Stratmat:
  - -massive sulfide mineralization hosted in sequences of felsic volcanic and sedimentary rocks belonging to the Flat Landing Brook Formation
  - -mineralized units experienced tectonic thickening & repetition (Van Staal et al., 2003)
- Heath Steele
  - -volcanic sediment-hosted massive sulfide deposits (Peter and Goodfellow, 2003)
  - -hosted by felsic volcanoclastic rocks and tuffaceous sediments of the Nepisiguit Falls Formation during Middle Ordovician

Source: Trevali, technical report 2017

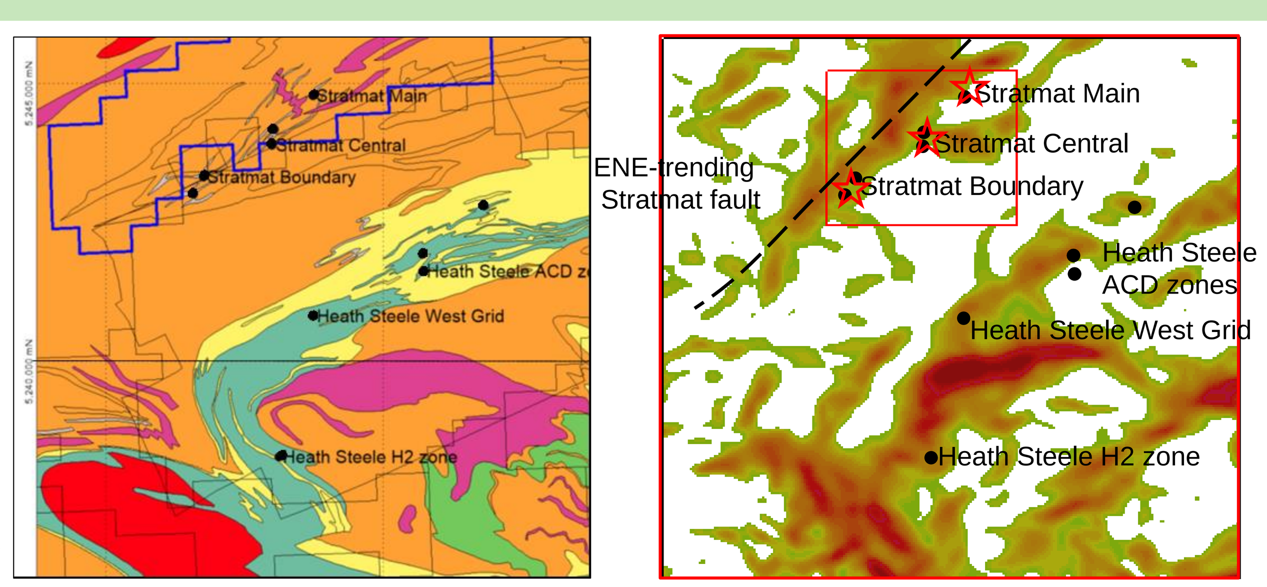


Figure 4: (a) geology of the Stratmat and Heath Steele areas. (b) enlargement of the red rectangle in Figure 3b.

Inversion results

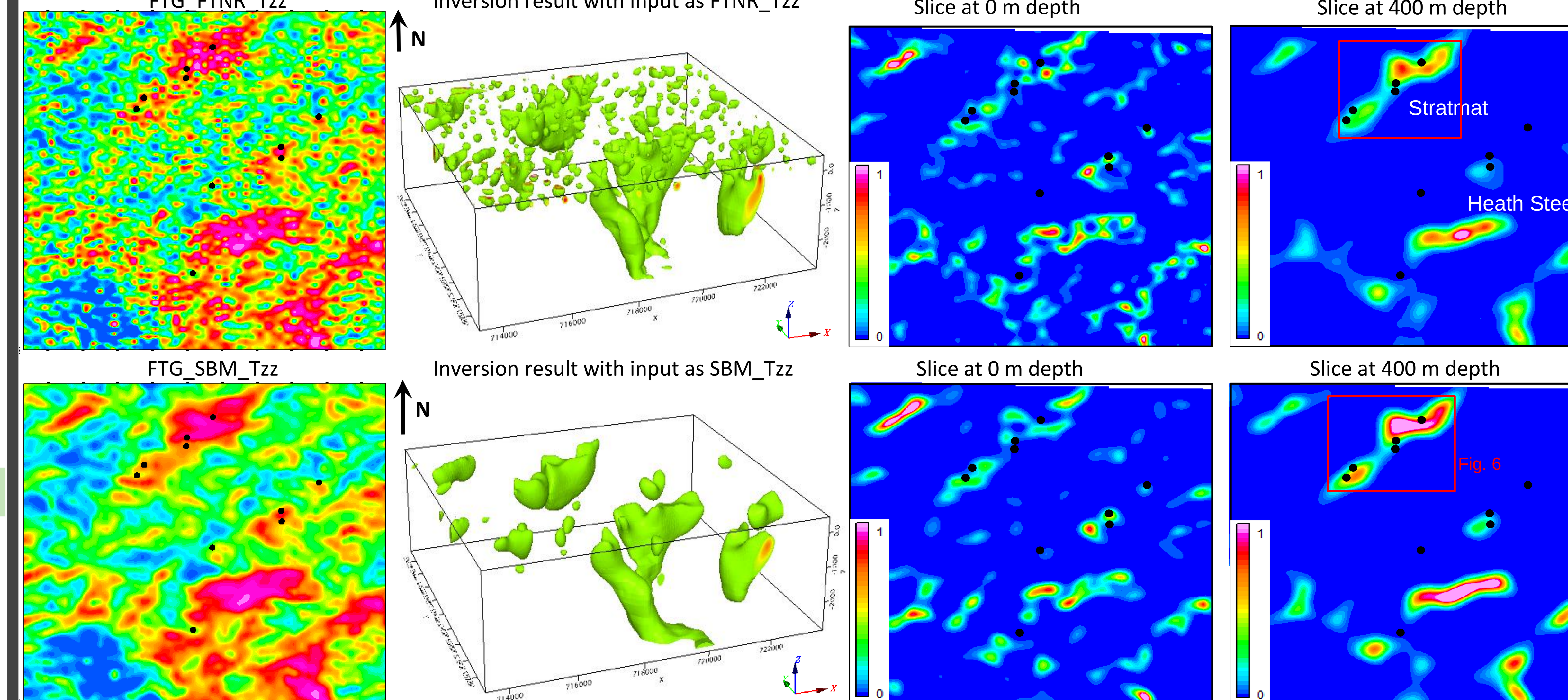
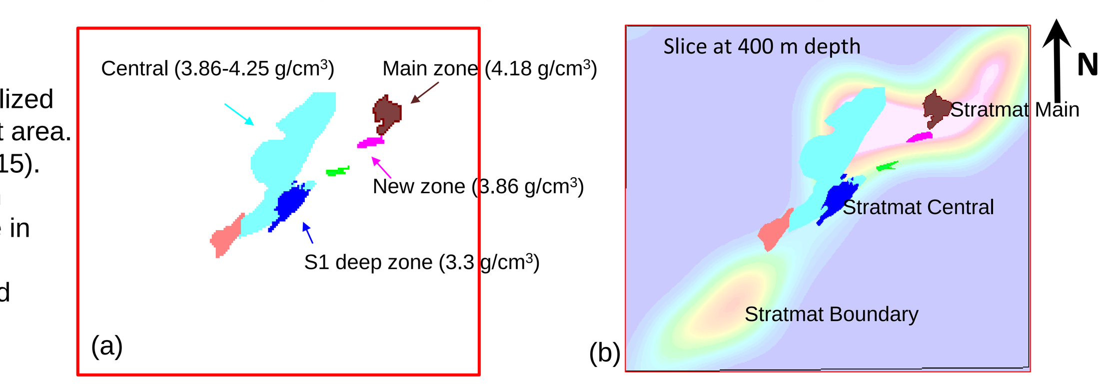


Figure 5: the left panel shows enlargement of FTG_FTNR_Tzz and FTG_SBM_Tzz (the red rectangle in Figures 1 and 3b). The solid black dots indicate mineralized zones. The middle panel shows inversion results with different input data. Density contrast ranges from 0.2 to 0.65. The right two panels indicate slices of inverted results at 0m and 400 m depths, respectively.

Figure 6: (a) Mineralized zone in the Stratmat area. SOURCE: SRK (2015). (b) slice of inversion result (red rectangle in Fig. 5), overlain by modeled mineralized zones.



- Density model from FTNR data near the surface is noisy
- Inversion results at depths show similar features from different types of processed data
- Mineralized zones distribute around the edge of anomalous density area in the Stratmat zone
- The VMS deposits typically form lenses of massive sulphide.

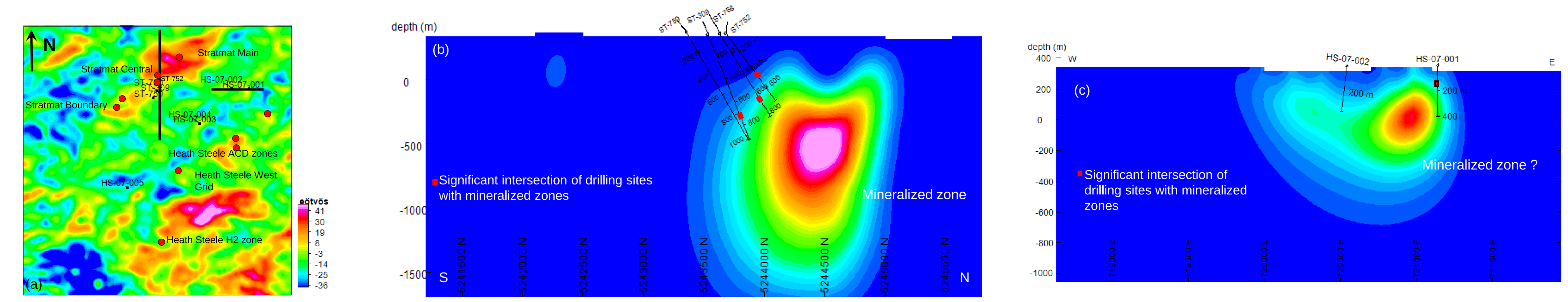


Figure 7: (a) FTG_SBM_Tzz overlain by some drillholes. (b) and (c) show sections from inversion results across the drillholes, corresponding to the S-N and W-E black lines in panel a, respectively.

Conclusions

- FTG data has a higher resolution compared with conventional gravity data. Horizontal invariant lineament brings a more detailed understanding of BMC, particularly in the southwestern region of the survey.
- 3D FTG data inversion results based on FTNR and SBM processed data show their similarities and difference, demonstrating the more applicability of SBM processing regarding the noise sensitivity of gravity inversion.
- Geometry, depth, and distribution of potential ore-bearing bodies (e.g., VMS) in the Stratmat and Heath Steele zones based on FTG data inversion are identified. Significant intersection of drilling sites within mineralized zones in the Stratmat area is consistent with FTG data inversion results, facilitating to use FTG data to place exploration targets within the complex structural and stratigraphic framework of the local geology.

References

Brewster, J. and Murphy, C., 2020. Source body migration as a method of depth separation for gravity gradient data. In *SEG Technical Program Expanded Abstracts 2020* (pp. 945-949).

Dickinson, J.L., Murphy, C.A. and Robinson, J.W., 2010. FTG Data Imaging Techniques for Geological Interpretation. ASEG Extended Abstracts, 2010(1), pp.1-4.

Peter, J.M. and Goodfellow, W.D., 2003. Hydrothermal sedimentary rocks of the Heath Steele belt, Bathurst mining camp, New Brunswick: part 3. Application of mineralogy and mineral and bulk compositions to massive sulfide exploration..

Van Staal, C.R., Wilson, R.A., Rogers, N., Fyffe, L.R., Langton, J.P., McCutcheon, S.R., McNicoll, V. and Ravenhurst, C.E., 2003. Geology and tectonic history of the Bathurst Supergroup, Bathurst Mining Camp, and its relationships to coeval rocks in southwestern New Brunswick and adjacent Maine—a synthesis.

Acknowledgements

We are grateful to Bell Geospace for providing the FTG data. This project is funded by both Mitas Accelerate and Bell Geospace. We also acknowledge the technical report by SRK Consulting for Trevali Mining Corporation.