case_histories Documentation

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UBCGIF

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Contents

Purpose of GeoSci Case Histories: These provide the motivation for using geophysics and show the success, or not, of their application in making an impact upon the problem at hand.

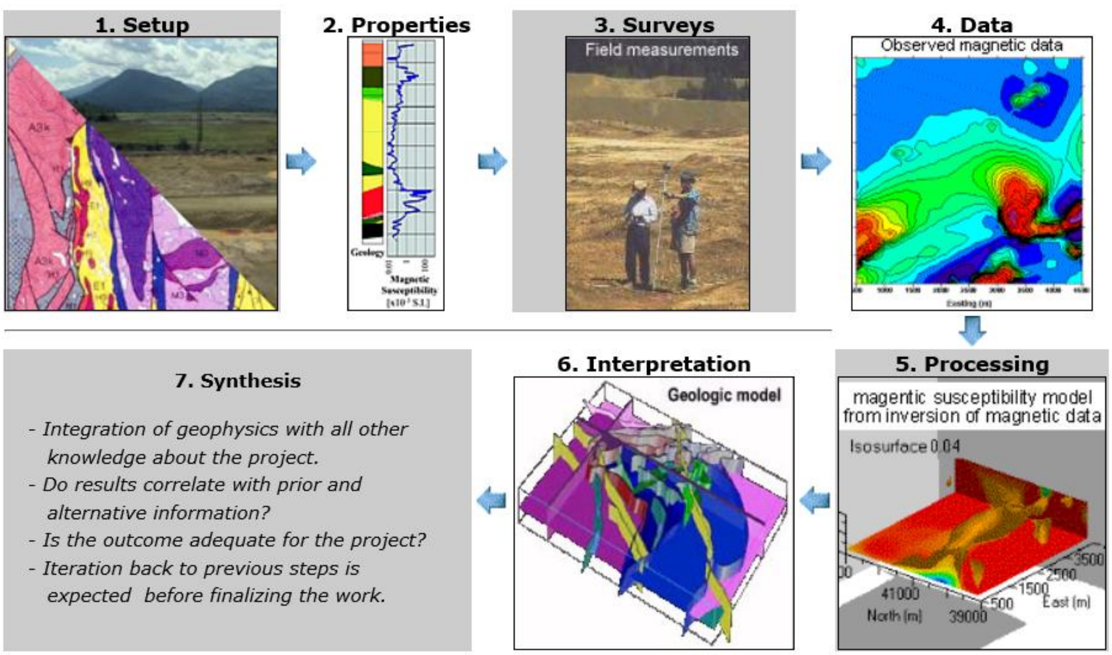
The case histories are provided in a specific *Seven Step Framework*. Hopefully this consolidation promotes understanding about how geophysics can be used effectively and also promote "good practise" when geophysics is adopted to help solve other problems

This resource is Open Source and while currently being developed by brilliant and enthusiastic graduate students and faculty at UBC, the vision is to have experts, worldwide, contribute. Join the development on github.

Contents:

Seven Step Framework

Geophysics can play an important role in helping solve resource exploration, environmental, or geotechnical problems. The application of geophysics is most effectively carried out by following a seven-step framework. Careful thought and due dilligence at each step is important to achieve a final outcome.



1.1 1. Setup

What is the Problem?

Establish the geoscience objectives, consider conventional practice, and identify how geophysics might contribute. This could include:

- Mapping geology
- Locating buried objects
- Obtaining 3D images of the subsurface

Assemble prior information that might be relevant. Details for using the seven-step procedure will depend upon what information is being sought and what is available.

1.2 2. Properties

Understand how geologic and man-made materials of relevance to the problem can be characterized by physical properties. The key is to find a physical property of the sought object/geology that is different from that of the surrounding material. This is a crucial component needed to link geophysics with the geoscience problem being investigated. Important physical properties are:

- Density
- Compressional wave and shear wave velocities
- Magnetic susceptibility
- Electrical conductivity (or resistivity)
- Electrical chargeability
- Dielectric permittivity

1.3 3. Survey

Select a geophysical survey that is sensitive to the physical property of relevance to the problem. Design an effective and efficient methodolgy for collecting the field data. This will involve forward modelling and processing of the simulated data as well as addressing issues of noise and data quality. This builds realistic expectations for what information can be expected from analysis of the geophysical data and the overall suitability of the chosen survey.

1.4 4. Data

Carry out the field survey taking all necessary actions to ensure complete, high quality, and cost effective data sets. Geophysical data can be acquired in boreholes, on the surface, or in the air using aircraft. Field procedures must permit acquisition of high quality data, yet they must be economical, and safe to obtain.

1.5 5. Processing

Interpretations from the data require that the data be processed. This can range from simply making maps of the data to inverting data to obtain 3D images of the subsurface.

1.6 6. Interpretation

Interpret results in terms of geological or geotechnical objectives.The goal is to draw conclusions or make decisions based upon the geophysical data. There are two distinct components to interpretation. The first involves estimating how physical properties are distributed. The second involves gaining some geological understanding based upon those physical property distributions. Just like much of the geosciences, non-uniqueness is a ubiquitous and persistent characteristic of most geophysical interpretations.

1.7 7. Synthesis

Correlate the interpretations with prior and alternative information, and decide if your results are adequate for the particular problem. Synthesis means making sure geophysical results agree with everything else that is known about the problem. Also a judgement must be made about the effectiveness and completeness of the geophysical results, and their impact upon the initial geological, engineering, or geophysical question.

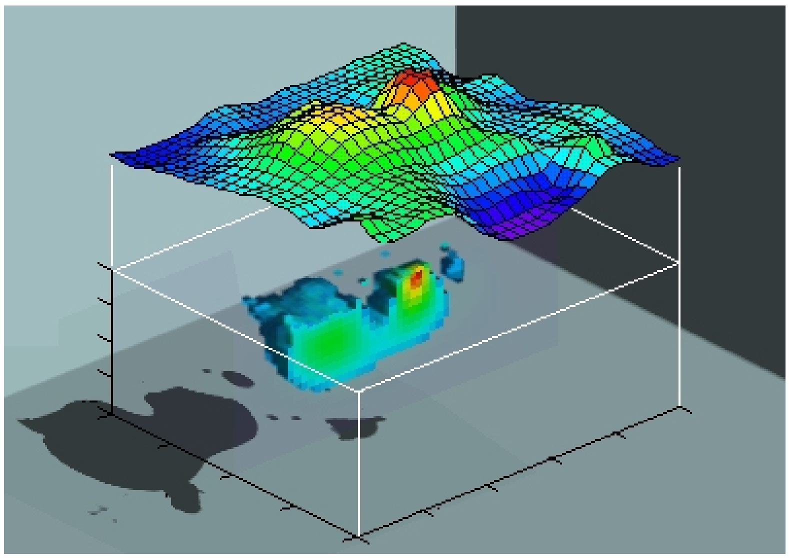
All tasks in the seven-step process are inter-related, so the distinction between the steps can become blurred. For example, the geoscience problem will determine an appropriate interpretation procedure, which in turn will place constraints upon the survey design and choice of processing steps. Also, data processing, interpretation and synthesis are often tightly related. However, it is useful to think in terms of these seven steps because they form a framework, which can be employed for any application of geophysical work to applied geoscience problems.

1.8 Summary of the Seven Steps

1. **Setup:** Establish the geoscience objectives, consider conventional practice, and identify how geophysics might contribute.
2. **Properties:** Characterize materials that can be expected and establish the likely physical property contrasts.
3. **Surveys:** Determine a suitable geophysical survey, and design an effective and efficient field survey. Identify possible sources of error, noise and mis-interpretation.
4. **Data:** Carry out the field survey, taking all necessary actions to ensure complete, high quality, and cost effective data sets.
5. **Processing:** Plot the data, and apply appropriate processing and analysis.
6. **Interpretation:** Interpret results in terms of physical property distribution, and then in terms of the original geoscience objectives.
7. **Synthesis:** Combine interpretations with prior knowledge about the problem, and with other relevant information. Decide if your results are adequate for the particular problem. Iteration is usually necessary.

CHAPTER 2

Mt. Milligan



Mt. Milligan is a Cu-Au (copper-gold) porphyry deposit situated in north central British Columbia. Like many deposits of this type, the individual rock units and alteration products have physical properties that can be detected with geophysical surveys. In particular:

- magnetite content will alter the magnetic susceptibility;
- pyrite, chalcopyrite, and bornite affect chargeability; and
- significant mineralization and fluid-filled fractures will alter the electrical conductivity.

Geophysical surveys have the potential to provide quantitative information about the distribution of these physical properties. Magnetic, DC resistivity, IP, and airborne EM data have been collected at Mt. Milligan. In this case history the focus is upon magnetic data gathered on the ground over a 1.2 by 1.0 km area, which overlies a segment of the deposit known as the MBX East deposit.

A 3D magnetic susceptibility model is obtained directly by inverting surface total field anomaly data. The resulting physical property model is compared with a rock model constructed from geologic information from 600 drill holes and with a 3D model of gold concentration. The susceptibility model has features that correlate with various geologic boundaries and rock units. Most notably, the recovered susceptibility displays an anticorrelation with the greatest gold concentration. This anticorrelation between gold concentration and susceptibility provides an important constraint that helps define the distribution and geochemical control of the orebody.

DC resistivity and IP surveys were also inverted, and the resulting 3D model of chargeability displayed a positive correlation with the greatest gold concentration. The inversion of DC and IP data are discussed in a seperate section.

Contents:

2.1 Setup

The image here identifies the geographic location. The geological setting is important because there are several known deposits throughout British Columbia in similar geological settings.

The mineralization system associated with a typical Cu-Au porphyry system is shown below, extracted from *[McMillan1991]*. Diagram (a) indicates the metallic mineral distribution. The solid line in the middle represents the initial stock. The areas of potassic and propylitic alteration are shown in (b).

2.2 Properties

Magnetic susceptibility!

2.3 Survey

Fig. 2.1 (supplied courtesy of Placer Dome Exploration) shows the regional total-field magnetic anomaly map for an area surrounding the Mt. Milligan copper porphyry deposit. This type of airborne data set is useful for identifying-large scale regional geological trends. However, exploration for a specific deposit requires more detailed information about local subsurface distributions of rock types.

The figure inset shows the ground-based total field magnetic anomaly map over the MBX structure. The area is 1.2 x 1.0 km with data gathered on lines spaced 50 metres apart. The data were re-sampled to 25 metres spacing along the lines, and then the data set was upward continued to 20 metres. This was necessary to remove features in the data that were caused by magnetic material that was smaller than the cell size used for inversion. The ambient field was (strength, declination, inclination)

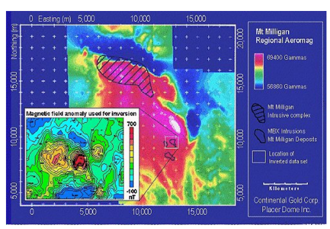


Fig. 2.1: Total magnetic field strength map for the Mt. Milligan region, gathered by airborne magnetic survey techniques. In the inset, the large scale regional magnetic field has been removed to emphasize the signature of anomalous subsurface magnetically susceptible rocks.

2.4 Data

Mag data!

2.5 Processing

Preparation of magnetic field data prior to inversion involves several steps. Locations of individual data points are shown in Fig. 2.2 and a processed image is shown in Fig. 2.3.

Fig. 2.2: Observed data

Fig. 2.3: Processed Data

- Most magnetics data sets need to be reduced to an anomaly map rather than working with raw, total magnetic field strength. For the Mt. Milligan data set, this was done by subtracting a reference field derived from the large scale airborne data set.
- In addition, the large data set was decimated to avoid having more than the necessary number of data points needed for the model cell sizes chosen. In this case, data were down-sampled to 25 metre intervals along survey lines, which were 50 metres apart. A total of 1029 data points were used in the inversion.
- The resulting data set was also upward continued to 20 metres in order to suppress anomalies caused by features smaller than a single cell.
- Data errors must also be assessed, and in this case, 5% plus 10 nT for each datum was deemed appropriate.

2.5.1 Inversion

The magnetic data used for inversion, and the predicted data based on the final 3D recovered susceptibility model are shown in Fig. 2.4 and Fig. 2.5, respectively.

Fig. 2.4: Observed data

2.6 Interpretation

2.7 Synthesis

Reference

UBC-GIF work on this deposit is published in Li and Oldenburg, 1996, *"Inversion of geophysical data over a copper gold porphyry deposit: a case history for Mt. Milligan"*, Geophysics, Vol. 62, No. 5, pg 1419-1431.

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Fig. 2.5: Predicted data

Bibliography

[McMillan1991] McMillan, W. J., 1991, *Porphyry deposits in the Canadian Cordillera, in Ore Deposits, Tectonics, and Metallogeny in the Canadian Cordillera,* W. J. McMillan et al., Eds., Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia, 253–276.