

Geophysical Corner

Geology Should Rule Interpretation

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Last month's "Geophysical Corner" was the first part in a two-part series on "interpreting Magnetic Data." In it, "rules of thumb," methodology, interpretation concept, and depth-to-magnetic source analyses were discussed.

This month's column continues with techniques for interpreting magnetic data including: modeling, trend and lineament analyses, and filtering.

Modeling

A two-dimensional magnetic model (Figure 1) can be created along a seismic line in order to check, for example:

- If an interpreted depth to magnetic basement is reasonable.
- If a sedimentary structure is supported by a basement structure.
- If a feature on a seismic section is salt or igneous, etc.

This type of modeling is called forward modeling.

For inverse modeling, the observed data and a starting model are used. Then either model geometries or magnetic susceptibilities are modified until the calculated field produced by the model "fits" the observed field.

Three-dimensional modeling is similar, utilizing gridded data and surfaces.

Two variables are involved in modeling: magnetic susceptibility and

geometry of source bodies. Using control such as seismic, gravity and well data, geometries may have little variability – thus modeling involves adjusting magnetic susceptibility. If there is no control other than magnetic data, then it is best to keep susceptibilities constant and modify geometries.

Magnetic data also can be used to constrain interpretations of other data sets. For instance geological cross-

sections are interpretations, and magnetic interpretations can improve such work in areas of ambiguous geology.

It is easy to create a complex model, with an excellent match between computed and observed magnetic anomaly profiles, that far exceeds available control. Therefore, it is:

- Not appropriate to modify geometry and susceptibility in magnetic models randomly with no control.

- Not appropriate to model using filtered data, because we do not know if the component of the magnetic field removed by the filter is also removed in our model.

Trend and Lineament Analyses

Depth-to-magnetic source

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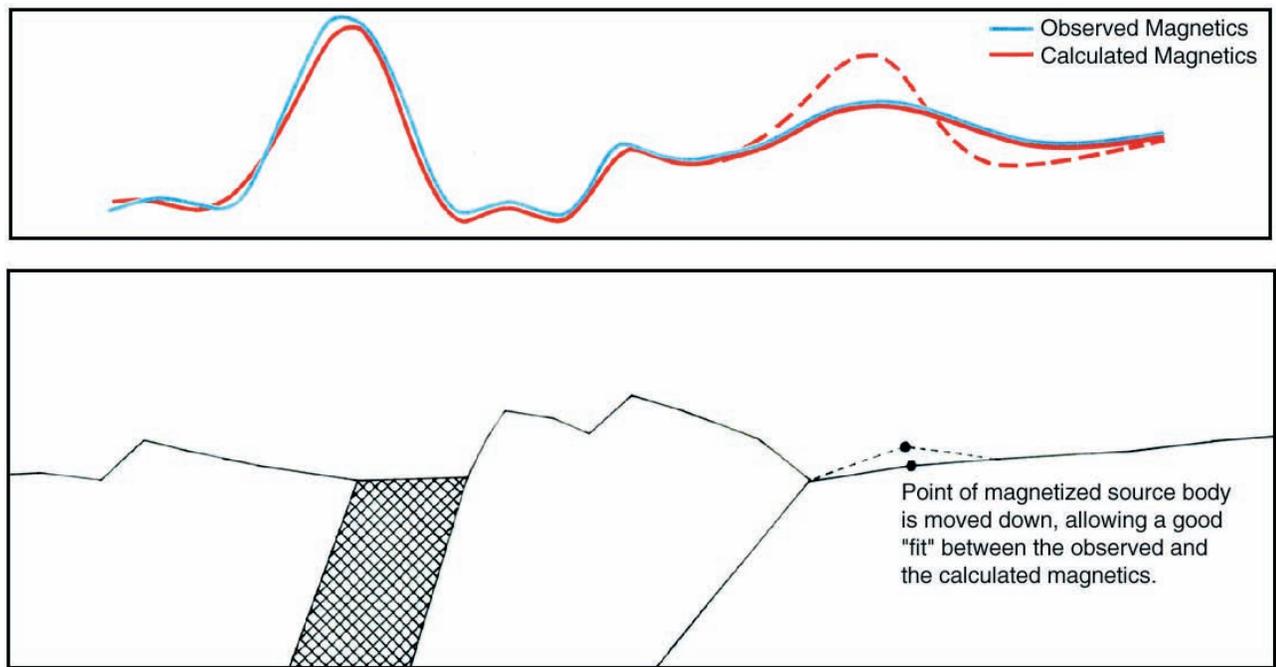


Figure 1.

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estimation and modeling are quantitative techniques. An important qualitative technique is analyses of trends and linears.

Trends can be analyzed using profiles or gridded data and generally consists of drawing lines on a map that may correspond to edges of structures, faults, or partitions of the data character (Figure 2).

Subtle linear breaks in magnetic data, especially when correlated with features identified from other data sets, may indicate positions of complex structures in the prospective section.

For example, part of the data may be characterized by short wavelength, high amplitude anomalies, and another part of the data may be characterized by longer wavelength anomalies.

Geologic examples are accommodation zones in rifts, wrench anticlines in convergent settings and even zones of fracturing.

Trends also may be defined as the termination of linear anomalies.

Filters

Filtering magnetic data is also a qualitative aspect of interpretation (Figure 2). The objective of filtering data is to separate anomalies by wavelength, and this operation can be performed several ways through manual and automated techniques. The most effective way to filter is with an understanding of the geologic control and an idea of the desired filtered results.

A typical process involves producing suites of filtered maps and assessing their character with geologic control.

Filtering data is a powerful tool and often leads to important conclusions,

but its use should be driven by the nature of the geologic problem to be solved.

Recent advances in navigation (Differential GPS positioning), computer systems and processing now allow extremely subtle anomalies to be resolved. For example, anomalies produced by small magnetization contrasts within sedimentary rocks can be confidently mapped.

Filtering and trend analyses are techniques especially suited for interpreting these subtle anomalies.

Summary

Interpretation of magnetic data should include elements of both qualitative and quantitative analyses, which in turn should be guided by geologic concepts. This does not mean that the interpretation should be forced to a rigid concept, but that the end result must be geologically plausible given the control.

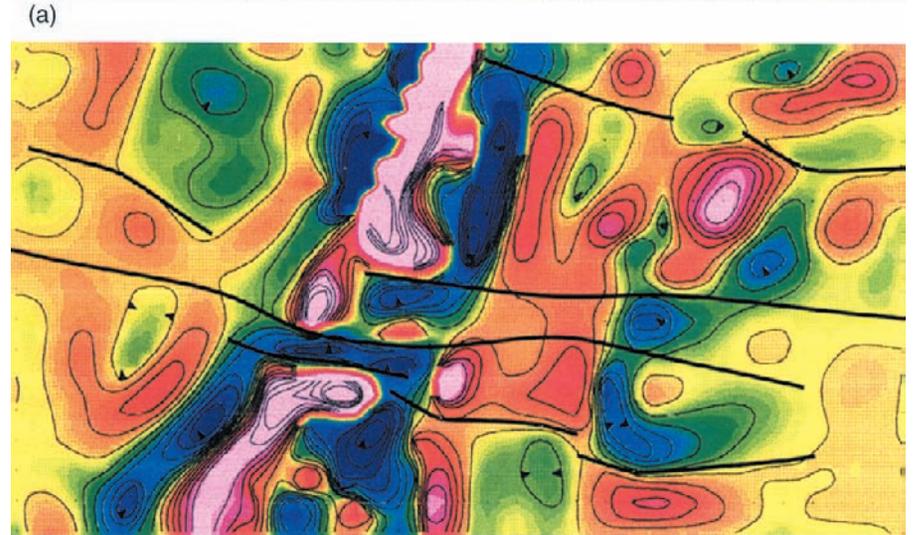
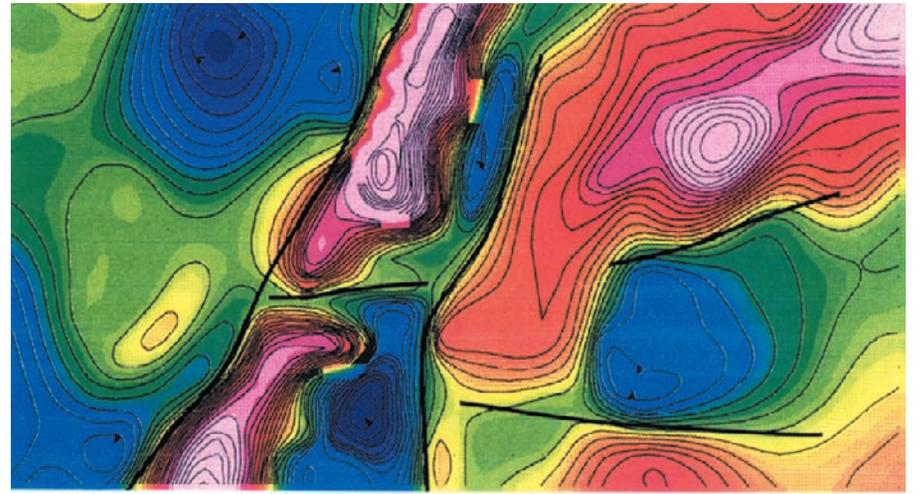
The interpretation should contribute to the overall geologic picture, and our understanding should be modified and improved by the data.

On the other hand, quite often we generate more questions that may be as useful as the geologic questions already answered by our interpretation of magnetic data.

Fundamental understandings of magnetic data and interpretation techniques, as outlined here, are valuable tools that geoscientists can use to gain insight and improve their geologic knowledge of an area.

As with geology, often the subtle features of the data – and their meaning – are most important.

(Editor's note: Dale Bird is general manager of Aerodat Inc., in Houston.)



Graphics courtesy of Dale Bird

Filtering magnetic data is a qualitative aspect of interpretation. Graphic (a) shows total intensity magnetic anomalies, with major trends identified. Graphic (b) shows filtered magnetic anomalies, with additional – more subtle – trends identified.