Interpretation of FTG data using Tensor Axis Realignment

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SUMMARY

Full Tensor Gravity Gradiometry (FTG) data measures the 5 independent tensor components, providing us with a measurement of the complete gravity field; standard visualisation techniques do not always allow us to extract the best from this dataset.

Tensor axis realignment allows us to visualise the data in an alternative reference frame, rather than the typical East-North-Down system used for gravity gradiometry which is chosen because it conforms to mapping conventions rather than for any geological reason.

With axis realignment, the coordinates are rotated about the z-axis, so we are effectively visualising the potential field from a different orientation. In doing this we highlight different geological trends which were not so prominently visualised in the typical END coordinate frame.

By using tensor axis realignment we are able to draw out further geological information from FTG data and hence produce a better interpretation of the dataset. Tensor axis realignment provides a way to visualise the three-dimensionality of FTG data and gain more geological insight into the survey area.

Key words: Gravity Gradiometry, visualisation, 3D Gravity.

INTRODUCTION

Full Tensor Gravity Gradiometry data (FTG) measure the complete gravity field, this gives us additional information compared with conventional gravity data (Murphy 2010). This information enables us to gain a better understanding of the geology.

The tensor axis can be realigned to best image the features of interest giving a better understanding of the local geology and thus assisting with target selection.

METHOD AND RESULTS

Since it was first introduced commercially in 1998, the FTG system has been used successfully on a number of platforms in oil and gas and minerals surveys. The system is a multi-component gravity surveying technology which records the 5 independent tensor components.

The gravity components allow us to accurately image geological structures; therefore, FTG is a viable tool for exploration in both the minerals and oil and gas industries.

Generally the FTG is imaged using an East-North-Down (END) coordinate system, this was chosen historically to conform to mapping conventions. However, because we have measured the complete field, through a simple linear transformation we can choose an alternative reference frame. This is advantageous because we can select a reference frame which best images target geology.

The typical reference frame is shown in figure 1 where we have an END coordinate frame. This is then, in this case, rotated about the z-axis in a clockwise direction to give us the new version of the tensor axes shown in figure 2.

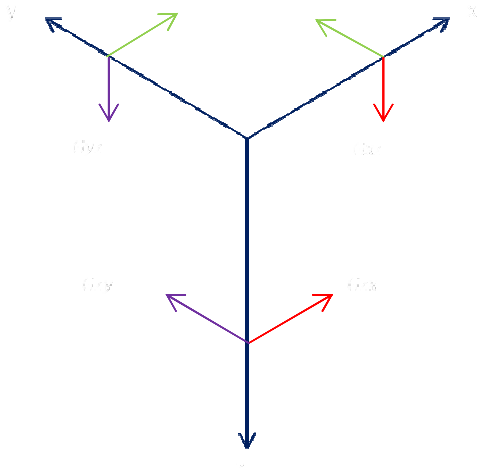

Figure 1. END Coordinate frame 0degree rotation

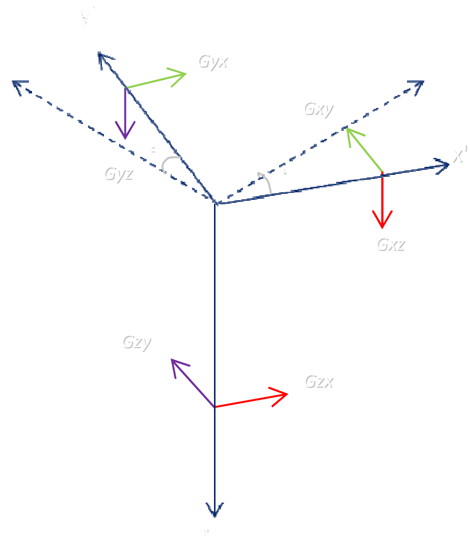

Figure 2: END coordinate frame □ degree rotation

In practice we can rotate about any of the axes, in this case we look at the most simple case, the z-axis.

The rotation equations for each of the tensor components are:

$$Txz' = Txz\cos\theta + Tyz\sin\theta \quad (1)$$

$$Tyz' = -Txz\sin\theta + Tyz\cos\theta \quad (2)$$

$$TyyMxx = (Tyy - Txx)/2 \quad (3)$$

$$Txy' = Txy\cos 2\theta + TyyMxx\sin 2\theta \quad (4)$$

$$TyyMxx' = -Txy\sin 2\theta + TyyMxx\cos 2\theta \quad (5)$$

$$Txx' = -\frac{Tzz}{2} - TyyMxx' \quad (6)$$

$$Tyy' = -Tzz - Txx' \quad (7)$$

These are applied to the dataset to recalculate the components at any angle, clockwise about the z-axis. At each angle all of the tensor components are recalculated so we maintain a complete tensor product. A full suite of angles is calculated and the optimum angle or angles selected to highlight target geology.

In figure 3 we have a data example from Uruguay, where a ring dyke is shown for component Txz, this is then rotated from zero (END coordinates), through 90, 120 and 180 degrees.

As we rotated about the z-axis the fault through the ring dyke is more clearly displayed and the feature to the north of the dyke shows more detail. Of particular interest are the details of the intrusives within the centre of the ring dyke, whose character is revealed through this rotation.

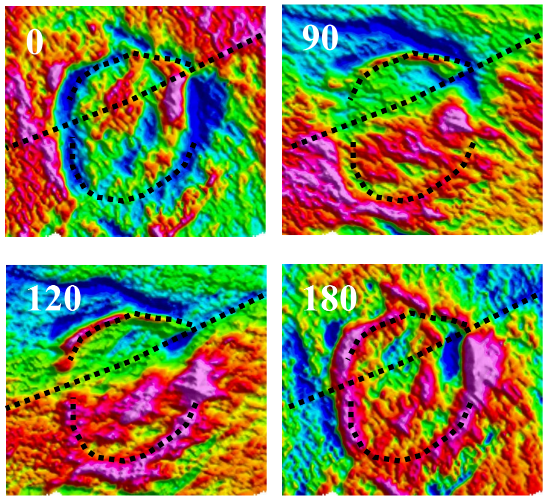

Figure 3: Tensor axis realignment of Txz component from Uruguay data: 0degrees, 90degrees, 120 degrees, 180 degrees

CONCLUSIONS

Tensor axis realignment is a visualisation technique for full tensor gravity gradiometry. It is possible because with FTG data we measure the full gravity field, the data can then be realigned using a simple linear transform to better highlight target geology.

REFERENCES

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