Sub-basalt imaging
9-11th April, 2002
Cambridge, UK

Journal of Conference Abstracts
Volume 7(2), 178

Resolving basalt and sub-basalt geology with high precision high resolution gravity gradient data

COLM A. MURPHY (cmurphy@bellgeo.com), GARY R. MUMAW (gmumaw@bellgeo.com) and FREDERIC STALIN (fstalin@bellgeo.com)

Bell Geospace Limited, Unit 5a, Crombie Lodge, Aberdeen Science & Technology Park, Bridge of Don, Aberdeen AB22 8GU, Scotland

Introduction

Full Tensor Gradiometery (FTG), or high precision, high-resolution marine gravity gradiometery, is a multiple accelerometer system that records all 9 components or tensors of the gravity field. The result is an increased signal bandwidth that contains the full spectrum and allows identification and mapping of subtle density contrasts that arise from complex geological features. Individual tensor information allows mapping and identification of size, shape and thickness of target geology. Gradiometry essentially provides mass edge/lineament and axis definition, and so, in effect, can be used to image both structural and lithological contacts generating density contrasts.

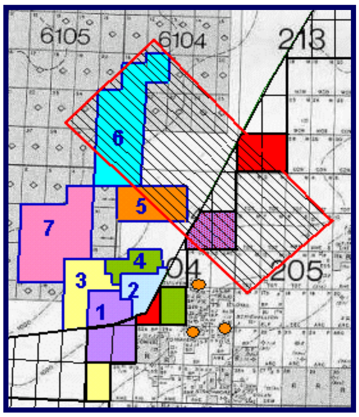

Figure 1: Location of FTG survey against License blocks in the Faroe-Shetland Basin.

FTG data were acquired in the Faroe-Shetland Basin area (figure 1) in 1999 for the purpose of resolving basalt complexity/characterisation and imaging sub-basalt geology. The survey is located where the Faroe-Shetland Basin meets the southern end of the N-S East Faroes Graben, thus presenting an opportunity for not only investigation of basalt effects, but also the interplay of structures defining these Mesozoic basins and basement architecture. Fast Fourier Transform frequency filtering of the data was performed to separate the signal arising from different frequency-depth intervals and allow investigation of the FTG response to basalt and sub-basalt geology. Subsequent lineament analyses performed on filtered images enable identification of differing structural controls on the development of the area from early Mesozoic rifting to post basalt inversion episodes.

This paper describes the application of these two methods and their ability to resolve basalt and sub-basalt geology.

Frequency filtering

Filtering potential field data in the Fourier domain is a well-documented technique in the literature. The advantages of such an approach are to enhance features of the data and extract geological information. The approach taken in this paper is that of frequency (pseudo depth) slicing. This is based on extracting slices from the data for specific frequencies. Spector and Grant (1970) published a technique for depth estimation to causative bodies that are dependent on frequency content. Typically high frequency anomalies tend to be shallow sourced, while low frequency anomalies arise from depth. The radial averaged power spectrum generated for the Faroe Shetland FTG data set is shown in figure 2. The image shows a curve decaying with increasing frequency. The vertical lines marking changes in slope indicate differing frequency content that yields the necessary coefficients for input to the frequency extraction or slicing algorithm.

A sharp break in slope of the curve (figure 2) occurs at a frequency of 20 km. This suggests that the data exhibit a marked change at this interval. A low pass Butterworth filter with cut-off wavelength of 20 km was used to filter the data. The result shows anomalies that are attributed to basement and sub-basalt sedimentary depocentres.

Cut-off wavelengths are next selected from the power spectrum (figure 2) and used to design a bandpass filter for extraction of frequency slices. The method works by first passing the data though a high pass Butterworth filter for the larger coefficient and then through a low pass Butterworth filter for the smaller coefficient. Frequency slices for the intervals, 3 to 7 km, 7 to 20 km, 20 to 30 km and 30 to 40 km were generated.

Journal of Conference Abstracts
Volume 7(2), 179

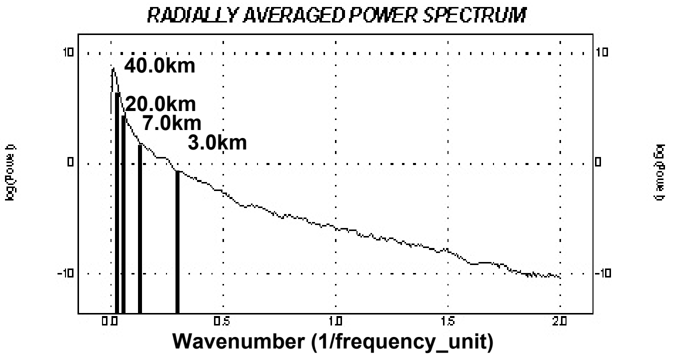

Figure 2: Radial Averaged Power Spectrum for the FTG, vertical component Gradient Tensor Tzz data.

Results show that the frequency slices 20 to 30 km and 30 to 40 km highlight the intermediate to long wavelength signal associated with pre-basalt extensional tectonics. NE-SW trends associated with the development of the Faroe-Shetland basin are overprinted by N-S structures more akin to the development of the East Faroes Graben. The shallower slice, 7 to 20 km, shows a number of trends that are ascribed to basalt structuring.

Lineament analysis

Blakely and Simpson (1986) published a technique for extracting lineament information from gridded potential field data. The routine works by passing a window over a grid and extracting grid peak (maxima) values for a set of directional criteria. The theory of FTG interpretation says that the Txz and Tyz tensor components split the target mass along the N-S and E-W central axes respectively. Assuming faults separate areas of differing density, then FTG will locate these density contrast zones with Txz and Tyz tensors presenting a means of mapping fault edge crests across any survey area. Frequency slices, 7 to 20 km, 20 to 30 km and 30 to 40 km were investigated. The results highlight structural trends akin to the area and allow inference to be made about timing of tectonic events both sub-basalt and post basalt. Lineaments generated for the shallow slice, 7 to 20 km, illustrate a series of patterns indicating either a) reactivation of underlying structure or b) compositional change within the basalt layer.

Discussion of results

The results clearly demonstrate FTG's ability to image basalt and sub-basalt geology. Differing fault trends sub-basalt identified are attributed to extensional basin tectonics that created the Faroe – Shetland and East Faroes basins. In particular, a WNW-ESE transfer fault system is indicated as a controlling structure in the integration and development of both basins.

These results offer an independent assessment of this part of the Faroe-Shetland area. FTG's identification of these density contrasts on both the regional and localised scale make it a useful independent constraint for other geophysical methods deployed in the Faroe-Shetland area, i.e. seismic (long offset, PSDM exercises), magnetic, MT data etc.

Conclusions

Regional interpretation of FTG information indicates sub-basalt imagery is possible and identifies a number of basement ridges and sedimentary depocentres. Data frequency filtering enables extraction of that part of the signal arising from the basalt interval and reveals information that may be ascribed to either internal structuring, compositional change or a combination of both. Lineament analyses enhance these findings and enable a tectonic synthesis to be developed. These results offer an independent constraint for other geophysical methods deployed in the area.

References

Blakely, R.J. & Simpson, R.W., 1986. Approximating edges of source bodies from magnetic or gravity anomalies, *Geophysics*, **51**, 1494 - 1498.

Spector, A. & Grant, F.S., 1970. Statistical models for interpreting aeromagnetic data, *Geophysics, Soc. of Expl. Geophys.*, **35**, 293-302.