Advances in sub-basalt imaging

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Abstract

In autumn 2012, EMGS acquired several MultiClient surveys west of the Shetlands and in the Vøring basin. Both marine controlled source electromagnetic (CSEM) and marine magnetotelluric (MT) data were collected to image a layer of basalt overlaying a thick sediment package. Some of the sediment layers are potentially hydrocarbon bearing. An overview map showing the location of the survey areas is shown in Figure 1. CSEM and MT inversion results will be available in early 2013.

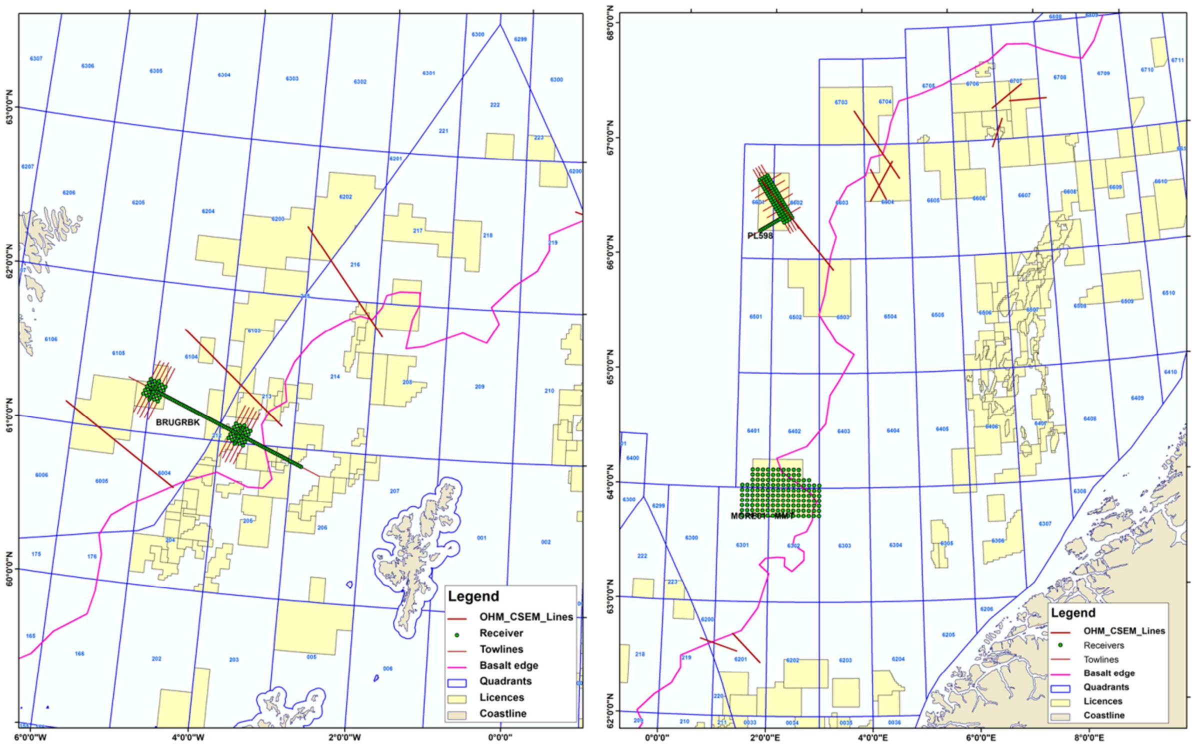
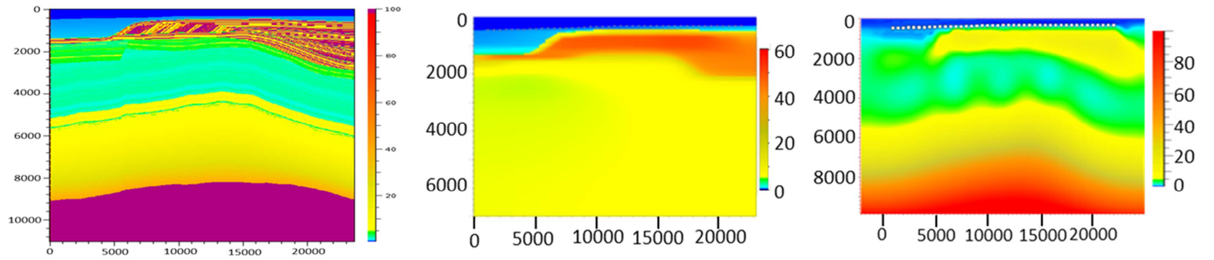


Figure 1: Overview maps showing the location of mixed MultiClient CSEM and MT surveys acquired by EMGS west of Shetlands and in the Vøring basin.

Seismic imaging can be challenging in regions where basalt is present. Strong diffraction multiples from rugose top and base basalt surfaces as well as scatterers within the basalt can make it difficult to detect the base of basalt. Complementary methods are needed to define the thickness of the basalt layer and understand the distribution of sub-basalt sediments. Electromagnetic methods such as marine CSEM or marine MT can map resistivity variations within the subsurface, and basalt has a significantly higher resistivity than sediments. Marine MT measures electromagnetic fields over a broad range of frequencies, whereas CSEM has the benefit of providing rich subsurface illumination in terms of source-receiver offset and, in the case of 3D surveys, azimuth angle. The two methods therefore complement each other in terms of resolution and depth of investigation. However, the resolution of the EM methods is inferior to the seismic resolution and small resistivity variations within the basalt layer can hardly be mapped. But large scale resistivity contrasts, i.e. due to conductive sediments below a basalt layer, can be imaged as a recent modeling and inversion study published by Herredsvela et al. (2012) demonstrates.

In this study synthetic marine MT and CSEM data were computed for a resistivity model representative of a typical basalt scenario (Figure 2a). Both datasets were then inverted to reconstruct resistivity models of the subsurface (Figure 2b, c).



(a) (b) (c)

Figure 2: 2D sections showing the original resistivity model (a), the resulting vertical resistivity model for CSEM data inversion (b) and the horizontal resistivity model for MT data inversion (c). The images were published by Herredsvela et al. (2012) at SEG.

Comparing the inversion results with the original resistivity models clearly shows the complementary nature of the two EM methods. The low resistive sediments underneath the basalt layer can be well resolved by MT inversion. Also the deep basement can be partly recovered. The CSEM method has a better resolution than MT but is only sensitive to the shallow part of the model. Nevertheless, the resistivity decrease at the base of basalt at the transition to the more conductive sediments can be resolved with an accuracy of down to 100 to 300 m.

We will show how the resistivity images provided by inversion may be used in an integrated workflow to aid geological interpretation and/or provide information for velocity model building to enhance seismic imaging.

References

Herredsvela, J., A. Colpaert, S. K. Foss, A. K. Nguyen, K. Hokstad, J.P. Morten, C. Twarz, S. Fanavoll, and F. Mrope, 2012: Feasibility of electromagnetic methods for sub-basalt exploration: 82nd Annual International Meeting, SEG, Expanded Abstracts, doi: http://dx.doi.org/10.1190/segam2012-0590.1