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

Journal of Conference Abstracts
Volume 7(2), 166

On cable feathering and its impact on sub-basalt imaging algorithms

CLEMENT KOSTOV (Clement.Kostov@WesternGeco.com)

WesternGeco, 10001 Richmond av, Houston, Tx 77042 , USA

Introduction

In the Faeroe-Shetland basin, the success of imaging beneath basalts (Ogilvie et al., 2000, Barzhagi et al., 2001, Fliedner and White, 2001) depends to a large extent on being able to attenuate multiples effectively, which in turn depends on the cable feathering caused by the strong marine currents, typical for this area.

According to published processing results, multiple attenuation methods such as SRME (Surface Related Multiple Elimination, Verschuur et al., 1992) have not been widely applied so far to data from the Faeroe-Shetland basin. This is surprising, considering that such methods model a wide range of multiple events, have been very successful in many cases (e.g. Gulf of Mexico sub-salt exploration) and have demonstrated a good record of preserving primaries (P or PSP modes, pre- and post-critical reflections, refracted waves).

In fact, the performance of SRME multiple attenuation was reported to be only marginally better than conventional multiple attenuation in tests on WesternGeco's GFA-99 dataset, acquired in the Faeroe-Shetland basin with a single boat towing an 11.4 km long streamer (Kostov et al., 2000, Bagaini et al., 2000). Strong cable feathering was pointed out as the main cause of sub-optimal SRME performance.

This paper follows up on the analysis of the GFA-99 data with a two-parts discussion. In the first part, we examine SRME's modelling errors due to feathering by applying SRME to synthetic data generated using the navigation information from the field survey.

We note also that new streamer acquisition technology is expected only to decrease feathering. Canter et al. (2000) indicate possible reduction in feathering angles of up to 3 degrees, while in the Faeroe-Shetland area feathering of up to 10 degrees is common.

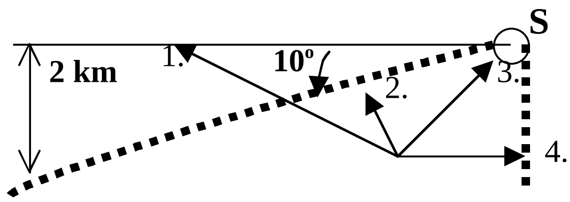
This observation motivates us to look, in the second part of this paper, for velocity analysis and imaging methods, which are robust with respect to residual multiples and feathering.

Sword (1987) describes a method for tomographic interval velocity estimation where estimates of ray parameters and ray tracing in a velocity model are used to identify and reject multiple events. Wang et al. (1999) and Sheng et al. (2001) discuss imaging methods, which also use estimated ray parameters to separate primaries from multiples. Following the above references we discuss the estimation of ray parameters from synthetic and field data in the context of sub-basalt imaging in the Faeroe-Shetland area. In particular, we consider the sensitivity of criteria for separating primaries and multiples to errors in the velocity model and to cable feathering.

SRME performance in presence of cable feathering

The SRME modelling method requires pairs of traces such that the receiver position for one trace coincides with the source position for the other trace. Cable feathering introduces large differences between nominal and actual receiver positions, and leads to the combination of traces in SRME where shot and receiver positions differ by up to 2 km, as illustrated in figure 1.

Map view of nominal and actual receiver positions



Receiver positions:
1. nominal, in Common Shot gather (CSG); 2. actual, in CSG; 3. nominal, in Common Receiver gather (CRG); 4. actual, in CRG.

Figure 1: For a feathering angle of about 10 degrees and an 11.4 km long streamer, *nominal* and *actual* receiver positions differ by up to 2 km. Nominal and actual source positions (S) are practically coincident.

We observe that the SRME model of multiples doesn't break down completely as a consequence of feathering. However, its performance is severely degraded as time and space variant modelling errors due to feathering need to be compensated by matching filters.

Other uses of the synthetic data include evaluation of acquisition or processing options, such as cable steering, 3-D acquisition, or matching filter estimation in Common Offset sections versus Common Shot Gathers.

Journal of Conference Abstracts
Volume 7(2), 167

Velocity analysis and imaging algorithms, which are robust with respect to multiples and cable feathering

Figure 2 illustrates schematically that ray parameter information can be used to distinguish primary and multiple events with common source and receiver positions, as well as traveltimes. In addition, the ray parameters can provide initial angles for tracing rays in a velocity models, assuming a ray history, most often one for a primary event. When using actual source and receiver positions (accounting for feathering) the ray tracing should be done in a 3D velocity model.

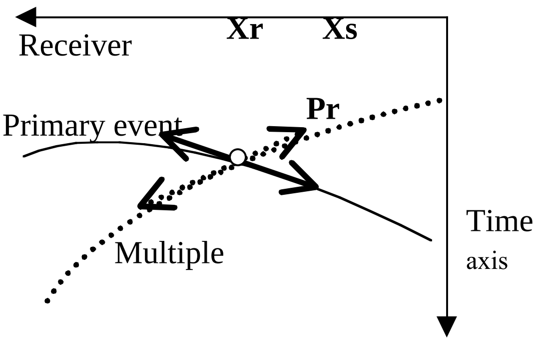


Figure 2: A primary and an interfering multiple events have common shot and receiver positions (Xs, Xr) as well as traveltime. Generally, such events will have different ray parameters along the receiver axis (Pr) and along the source axis (Ps).

Consistency requirements between estimated and computed traveltimes, ray parameters, or location of image points, are then expressed in different ways and used to separate primaries from multiples. Using synthetic and field data from the GFA-99 survey, we discuss the applicability of these approaches to sub-basalt imaging, and in particular to data from the Faeroe-Shetland basin.

Conclusions

Due to strong feathering, the performance of multiple attenuation methods on streamer data acquired in the Faeroe-Shetland area is likely to remain sub-optimal.

The velocity analysis and imaging methods discussed in this paper are robust with respect to multiples and feathering, and therefore appear promising for sub-basalt imaging applications.

References

Bagaini, C., Hoare, R., Hansen, J. O., Kostov, C., Ronen, S., 2000. Contributions of wide-angle P and PSP data to sub-basalt imaging, presented at the *PETEX bi-annual conference, London, UK.*

Barzaghi, L., Calcagni, D., Passolunghi, M. and Sandroni, S., 2001. Faeroe Sub-Basalt Seismic Imaging - a New Iterative Time Processing Approach, *63rd Mtg.: EAEG,* O-20.

Canter, P., Hodnebo, O., Austad, P. and Olafsen, W., 2000. Marine seismic cable steering and computerized control systems, *70th Ann. Internat. Mtg: Soc. of Expl. Geophys*., 61-63.

Fliedner, M. M. and White, R. S., 2001. Sub-basalt imaging in the Faeroe-Shetland Basin with large-offset data: *First Break,* **19,** no. 05, 247-252.

Kostov, C., Hoare, R., Jasund, S. and Larssen, B., 2000. Advances in sub-basalt P-wave imaging with long offset streamer data, *62nd Mtg.: Eur. Assn. Geosci. Eng.*, Session:X0018.

Ogilvie, J. S., Crompton, R., Hardy, N., 2001. Characterization of volcanic units using detailed velocity analysis in the Atlantic Margin, West of Shetlands, United Kingdom, *The Leading Edge*, vol **20**, no 1.

Sheng, J., Sun, H., Wang, Y. and Schuster, G.T., 2001.
Imaging Conditions for Primary Reflections and for Multiple Reflections, *63rd Mtg., EAEG, IM-7* .

Sword, C. H., Jr, 1987, Tomographic determination of interval velocities, PhD thesis, Stanford University, also SEP report **vol . 55**.

Verschuur, D. J., Berkhout, A. J. and Wapenaar, C. P. A., 1992. Adaptive surface-related multiple elimination: *Geophysics, Soc. of Expl. Geophys*., **57**, 1166-1177.

Wang, Y., Sun, H. and Schuster, G., 1999. Migration imaging condition for primary reflections, *69th Ann. Internat. Mtg: Soc. of Expl. Geophys*., 1126-1129.