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Improving Seismic Image With High Resolution Velocity Model From AWI Starting With 1D Initial Model - Case Study Barents Sea

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Summary

A feasibility study was carried out over a prospective structure in the south western Barents Sea, Norway. The need of a high fidelity velocity model to solve the complex velocity variations in the overburden was the driving mechanism for this test project. A shallow gas anomaly associated with amplitude dimming is causing distortions in imaging and leading to big uncertainty concerning fault identification within and mapping of this interval. Through a special application of FWI, the so-called adaptive waveform inversion (AWI) which allowed starting the inversion with a very simple velocity model, we solved the strong lateral velocity variations in the near surface leading to an improved image, demonstrating the superior quality provided by an AWI based velocity model.

Introduction

We present a case study in the southern Barents Sea where a form of full-waveform inversion (FWI) which has immunity to cycle skipping. The method was applied to overcome velocity-estimation challenges in the overburden that had led to a distorted seismic image. Published case studies have proven the versatility of FWI in resolving small-scale velocity features, in particular in the shallow parts of the overburden, where reflection-based velocity estimation techniques tend to struggle (Mao et al., 2016, Jones et al. 2013). For a successful application of FWI, it is commonly assumed necessary to use a reliable starting seismic velocity model, based on well data and/or on pre-stack depth-migration reflection tomography, to overcome cycle skipping (Korsmo et al., 2016). In this study, neither well data nor a depth-migration velocity field were available; instead, we used a simple 1D starting model for FWI.

Tasks and Challenges

The study area is characterized by an elongated shallow gas anomaly directly below the water bottom, which produces a strong impact on the quality of the seismic image. Large interpretation uncertainty must be considered on the presence of faults at the shallow target formations in the horst block under investigation. To overcome this problem, a target-oriented feasibility project study was initiated. The aim was to investigate possible approaches for improving the seismic image with regard to follow-up reprocessing of a larger seismic data set. The study was divided into two parts: first to produce a reliable interval-velocity field incorporating the small-scaled velocity distribution, and second to allocate an adequate imaging algorithm capable of utilizing this high-resolution velocity field.

For obtaining the imaging velocity model, standard tomographic approaches were discarded due to the shallow target depth, where minimum available offset data in combination with reduced data quality from the gas anomaly compromises reliable seismic reflection RMO based tomography. Therefore, FWI was employed to determine the velocity field. However, no wells are present in the vicinity of the area of interest as well as no previous pre-stack depth-migration velocities. Consequently, adaptive waveform inversion (AWI) was applied (Warner et al., 2013); this provides the advantages of FWI while simultaneously being able to cope with a low-quality *a priori* model (Warner & Guasch, 2016). AWI was run using 39 iterations in total, increasing the bandwidth in 13 steps from 4 to 15 Hz, using three iterations at each step.
Ray-based Kirchhoff and wave-equation RTM migration algorithms were used in the imaging part of the study to evaluate the ability of handling small-scaled velocity anomalies. For evaluation of the sensitivity of the algorithms and their ability to cope with different resolution of velocity fields, the test line migrations were carried out with the low, mid and high-resolution AWI velocity field.

Results

The resulting velocity fields show a good match to the seismic image regarding faults, location of the main horst block, and local gas-cloud anomaly. Low velocity zones correlate to the gas cloud and fault zones (figure 1).
Resolution of the seismic image improves with increasing detail in the velocity field, for ray-based methods (Kirchhoff and CRAM), this is valid only for certain detail in the velocity field (up to 8Hz model). The RTM image improves up to the velocity field with the highest resolution (15 Hz).
The results could be used to reduce the uncertainty of fault interpretation based on previous image and to guide a future reprocessing of this area.

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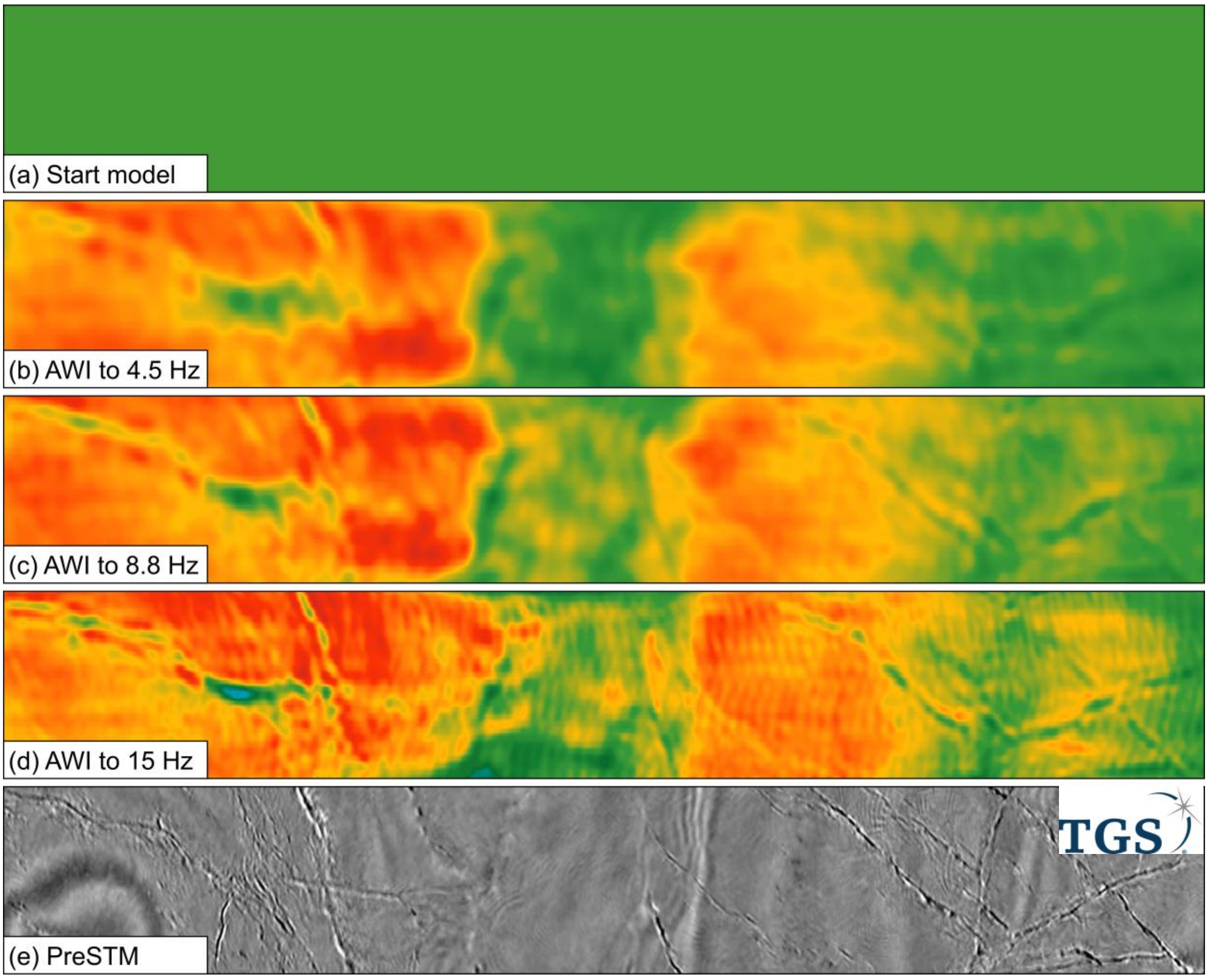

Figure 2 *Horizontal depth slice through velocity models and depth-converted PreSTM: The 1D start model (a) consists of a single velocity value only in a depth slice. With increasing frequency content of the seismic input data to AWI the resulting velocity fields (b – d) improve in resolution showing small-scale geological features confirmed by the seismic image (e).*
The central region is the horst block with the low velocity gas anomaly (green). Faults are clearly identifiable as low-velocity anomalies in the higher resolution velocity fields.

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