Title:

PROCESSING NORTH SEA 4-C SEA-FLOOR SEISMIC DATA

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Introduction
We aim to understand some unique characteristics of the wave field in sea-floor data from the North Sea (courtesy of Shell Expro), which will govern the data processing. In November 1996, Shell Expro acquired four lines of 4-component seismic data in the North Sea. The dataset comprises 3 km full fold data recorded by the Geco-Prakla drop-drag cable. Figures 1 and 2 show two typical shot and receiver gathers. The shear waves in the inline horizontal component show higher amplitude even than that of P- waves in the vertical component. The overall quality of this data set is excellent.

Characteristics of the Wavefield
Where Does P-S Conversion Take Place? – As previous literature has pointed out (Berg et al. 1994, Bertussen et al. 1997), the P-S conversion can take place either at the sea-floor or at the reflectors. The conversion point in these data is clearly at the reflector. There are two lines of evidence. First, the inline horizontal components in the common-shot gathers (Figure 1) suffer from static shifts which disappear in common-receiver gathers (Figure 2). This indicates that these shifts are due to receiver statics and one-way S-wave raypaths from the reflector. Second, non-hyperbolic effects after NMO confirm that the ray-paths are not symmetric.

The Geophone Data – There is very little P-wave energy in the inline-horizontal components while, on the contrary, there is strong converted-wave energy in the vertical components (Figure 2). The cause of this is still under investigation. However, this observation helps to separate the pure P from the converted waves in the vertical components. Using the inline horizontal data as the reference shear wave input, a designed match filter can subtract the P-S waves from the vertical component.

Water-column Reverberation – The hydrophone and geophone data may be combined to suppress water-column reverberation, using a calibration factor associated with the water-bottom reflection coefficient (Barr and Sanders 1989). The autocorrelogram of the hydrophone signals shows clearly the negative polarity peaks, representing the negative-polarity receiver ghost reflection accompanying each primary reflection (Figure 3a). However, the corresponding positive peak in the autocorrelogram of the vertical geophone signals, is hard to see in the presence of the converted waves (Figure 3b). This agrees with amplitude spectrum analysis (Figures 3c and 3d) as well. The absence of water-column reverberation in the vertical geophone data is due to high reflection coefficient of the sea-floor in this area. The combined effects from both source and receiver sides, caused by high reflectivity sea-floor, cancel some reverberation in the vertical geophone component.

Processing Results
The final vertical and inline horizontal stack sections are shown in Figures 4 and 5. The CCP (Common-Conversion-Point) number is identical with the CDP number in the survey coordinate. Analysis of velocity ratio spectra based on non-hyperbolic moveout allows accurate determination of $V_p/V_s$ and better stacking results. The overall $V_p/V_s$ ratio is about 2.8. The most striking feature in the inline horizontal component stack section is its good quality, both in terms of S/N ratio and in the continuity of the events.
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References