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The Alba Field OBC Seismic Survey

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ABSTRACT
In early 1998, Chevron acquired one of the world's first full-field four-component ocean bottom cable surveys at the Alba field in the central UK North Sea. The primary objective of the survey was to use converted shear waves to image the top of the reservoir and internal shales within the reservoir interval. The secondary objective was to map water movement in the reservoir after four years of production and water injection by comparing the P-wave OBC data with the original 1989 streamer data. Our initial interpretation shows that both objectives were achieved with dramatic results – the converted shear wave images provide the clearest image of the Alba reservoir sands ever seen and production effects are obvious on the new P-wave OBC data.

INTRODUCTION

The Alba field is located in the central North Sea at an average subsea depth of 2000 meters. The reservoir is a poorly consolidated Eocene turbidite sand channel and can be up to 100 meters thick. The main channel is roughly 9 kilometers long and 1.5 kilometers wide. The channel contains intra-reservoir shales that can cause significant drilling and production problems. Oil production is from horizontal wells drilled from a platform at the northern end of the field. Development drilling is ongoing and several long-reach and re-drill wells are planned.

It is vital that the horizontal wells be placed as close to the top of the reservoir as possible. Therefore we need accurate maps of the top of the oil-filled sandstone and the location of the intra-reservoir shales. This mapping is extremely difficult because there is a weak, inconsistent seismic event at the top of the reservoir and the intra-reservoir shales are often seismically invisible on the existing 1989 streamer data. Furthermore, as we drill more wells close to existing production and injection, an understanding of water movement becomes critical.

In this paper we first provide an overview of the methods used to help justify acquiring a 3D OBC survey. Then we describe 2D field trial results that supported using the OBC method to achieve the objectives of the survey. Finally, we present some results from the survey.

Methods

Using P waves to image shale-oil sand interfaces in the Alba reservoir is extremely difficult because the oil sands and shales have, on average, the same acoustic impedance. However, a dipole sonic log from Alba shows a significant contrast in shear wave impedance at the top and bottom of the reservoir (Fig. 1). Not surprisingly, synthetic seismic models show that this shear wave impedance contrast gives rise to a strong converted shear (P converted to S) seismic event at the top reservoir (Fig. 2). Additionally, P-wave AVO models show a more clearly defined top reservoir event on the far-offset section when compared to the full stack. Finally, seismic models confirm that movement in the oil-water contact due to production could be seen on a new seismic survey.

The modeling results suggest several approaches to achieve a better image of the shale-oil sand interfaces and image fluid movement: 1) record converted shear wave data, 2) generate far-offset sections from the 1989 streamer data, and 3) record a second streamer survey. A decision was made to try to accomplish both objectives using ocean bottom cable seismic (OBC) technology.

Prior to acquiring the 3D OBC survey, Chevron acquired a 2D OBC test line with two different contractors. While we found significant differences in recording fidelity between different recording systems, both systems produced sections with very high quality converted shear wave energy. The P-wave OBC data was found to be most comparable to the 1989 streamer data when using Geco-Prakla's Nessie4C* Multiwave Array seabed system.

Based on these encouraging results, Chevron commissioned Geco-Prakla to acquire a 67 sq. km. 3D multi-component survey. The survey was recorded in 14 swaths parallel to the 1989 streamer survey. Acquisition took 8 weeks in rough weather during a period of intense field activity.

Converted wave and 4D data processing

The 3D converted wave processing was steered by information obtained from the 2D test line and from initial analysis of the 3D recorded data. One fortunate surprise was that we did not observe significant azimuthal shear wave anisotropy which obviated the need to correct for shear wave birefringence effects. The converted wave processing addressed the

challenges associated with large shear wave statics, higher order normal moveout and asymmetric wave modes. A further consideration was that the converted wave processing had to be completed within four months so the data could be used to assist the drilling program.
The 1989 streamer data and the P-wave OBC data were processed in tandem using identical flows and parameters where practical.

Results and conclusions

In almost every part of the field, the converted wave data show an improved image of the Alba reservoir compared with the P wave seismic data (Fig. 3). This has enabled a more confident interpretation of the top sand and helped identify some of the larger intra-reservoir shales. The interpretation of the converted shear wave cube is now a critical component in our understanding of the geometry of the Alba reservoir.
The 4D results show large changes in the strength of the oil-water contact near producer and injector wells (Fig. 4). These results will impact placement of future wells and aid our understanding of fluid flow. Future work will focus on making accurate depth predictions from the converted wave data and building a new reservoir model that is consistent with the new information provided by our analysis of the converted shear wave and 4D data.

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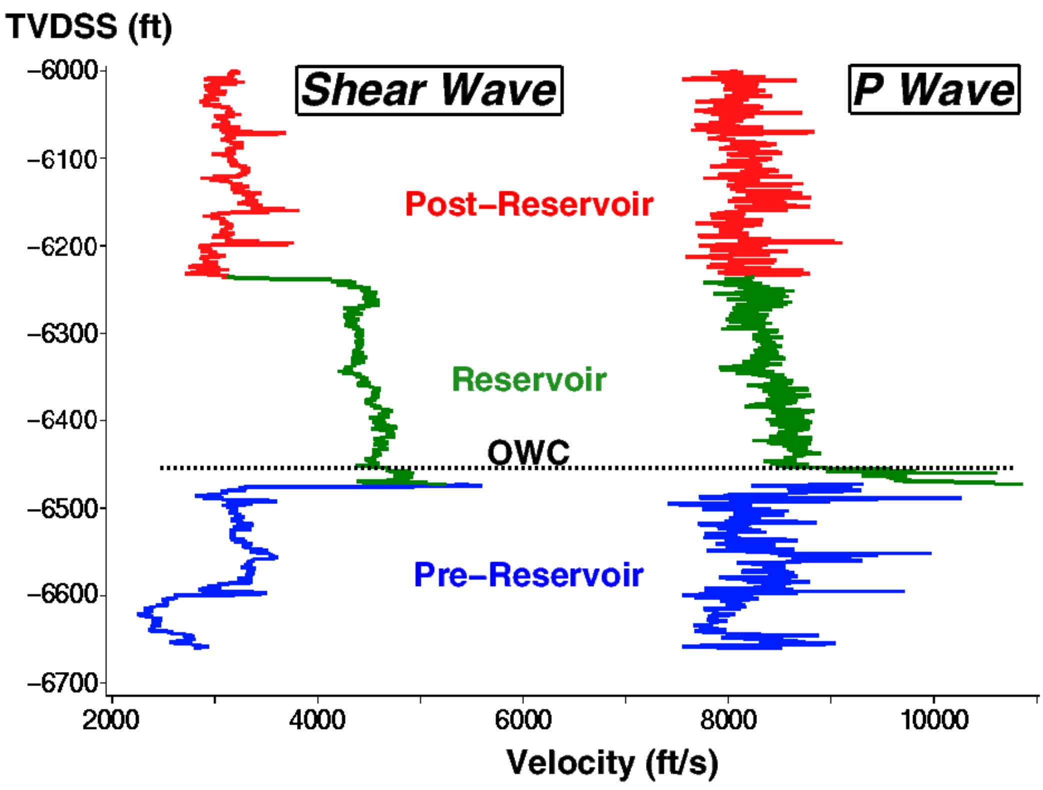

Figure 1. Dipole sonic log through the Alba reservoir sand showing a large contrast in shear wave velocity and a small contrast in P wave velocity with the surrounding shales.

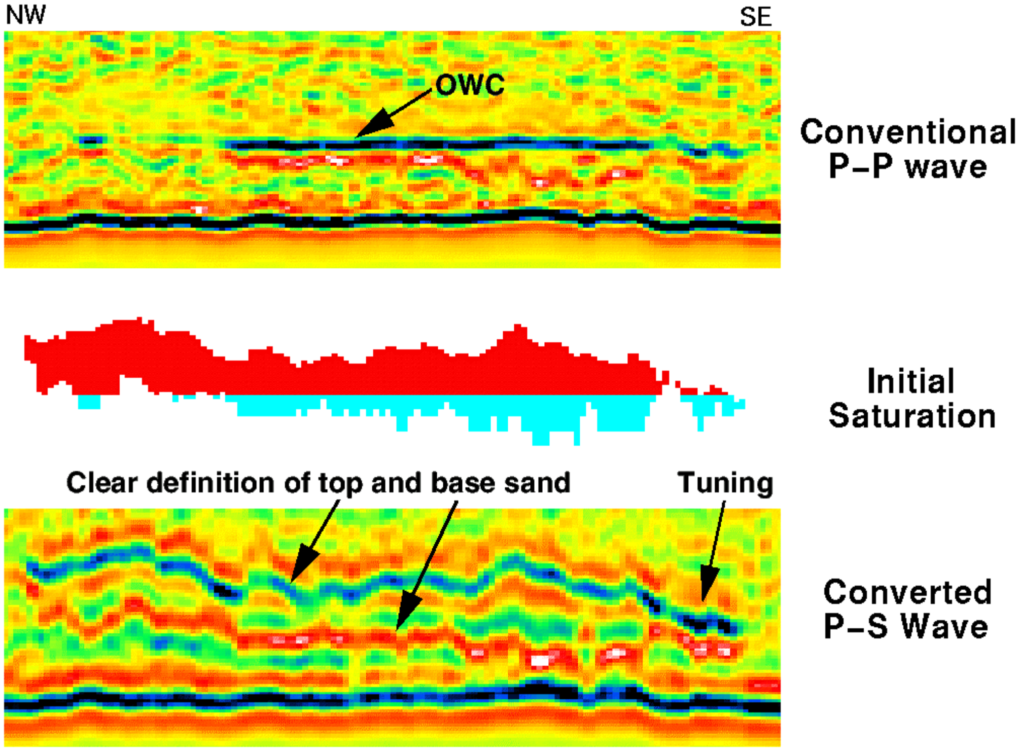

Figure 2. P wave and converted wave synthetic seismic model of the Alba reservoir. The P wave results show a strong event at the OWC. The converted wave model shows strong events at the top and base of the producing sand but no reflection at the oil-water contact.

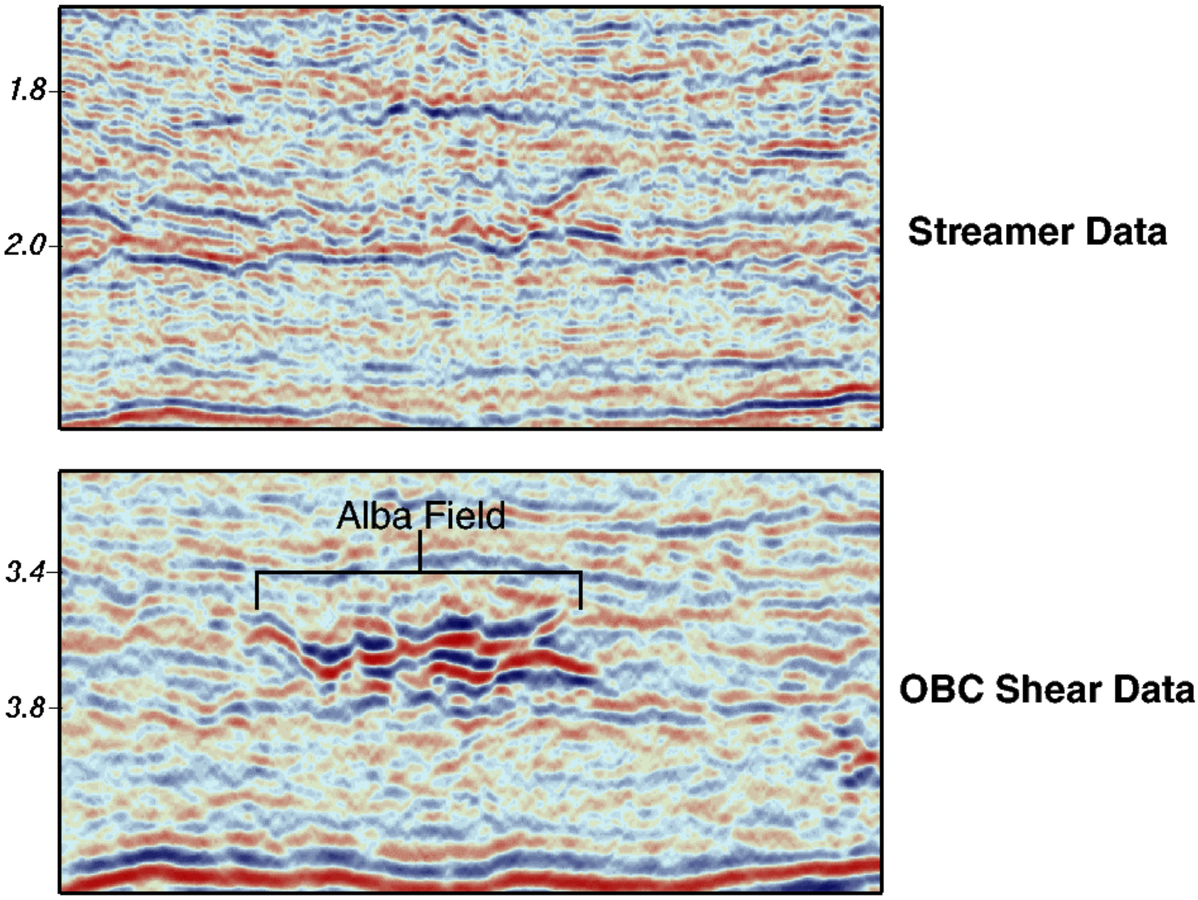

Figure 3. Comparison of 1989 streamer data and converted shear wave OBC data. The shear wave data provide a much clearer image of the reservoir interval.

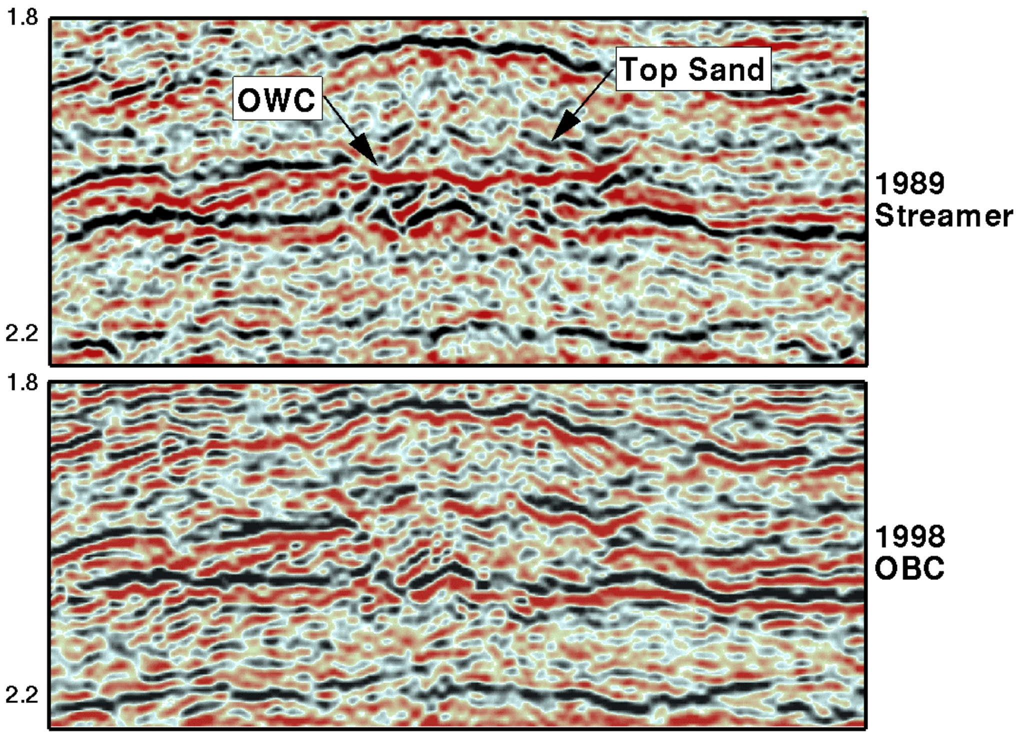

Figure 4. Comparison of 1989 streamer data and P-wave OBC data. The large change in the strength of the oil-water-contact is a result of water injection.