

RESERVOIR CHARACTERISATION OF A REMOBILISED SAND-RICH TURBIDITE RESERVOIR — THE ALBA FIELD

DAVIDE DURANTI¹, ANDREW HURST¹, REX HANSON²,
CHRIS BELL² and MARK MCLEOD²

¹ Aberdeen University, Department of Geology & Petroleum Geology,
King's College, Aberdeen AB24 3UE, UK

² Chevron UK

The Alba Field (Late Eocene, North Sea) is a sand-rich, turbidite fairway-fill. Earlier interpretations of the Alba Field infer sand distribution and the overall reservoir geometry to be related to deposition in a low sinuosity submarine slope channel (Newton and Flanagan, 1993). Re-examination of the borehole data and interpretation of the converted wave dataset acquired through a recent OBC seismic survey (Hanson *et al.*, 1999) changed this interpretation, providing evidence of extensive post-depositional fluidisation and remobilisation of sandstones with injection in the surrounding shales. Fluidised/remobilised (FR) sands are commercially important as, above the oil-water contact, they are oil-saturated and are believed to hold substantial reserves.

Sedimentology

Several facies referred to FR sandstones can be recognised in cores from the Alba Field. The most common are, in inferred increasing degree of fluidisation and remobilisation

- sandstones with deformed and upturned laminae,
- “giant pillars”,
- homogenised sandstones
- injection breccias.

These four main facies are generally associated and occur most frequently at boundaries between sandstone and shale units. Sand-shale contacts are not depositional but sharp, often cross-cutting bedding, and similar in appearance to intrusive igneous contacts. The shale units may be within the reservoir (intra-reservoir) or post-date it

Wireline data

Units of FR sandstone have characteristic wireline log signatures. Density (RHOB) and acoustic (DT) logs display higher bulk density and acoustic velocity in FR intervals with respect the non-fluidised sandstone (Figure 1). The gamma log (GR) has no response to this facies variation. Petrographic data and petrophysical core analysis confirm that the differences detected by the wireline logs are caused by slightly lower porosity and tighter grain packing in the FR sandstone relative to the undeformed units. Petrophysical properties of this kind of sands do not display the typical compactional trend observed in earlier studies for the sandstones as a whole (MacLeod *et al.*, 1999)

Seismic data

Interpretation of PS wave seismic data reveal substantial modifications by fluidisation and remobilisation of the original depositional geometry of the reservoir. Large geometric features, such as: mounds, lateral wings, ridges and partly detached sand bodies, cross-cutting biostratigraphic relationships, can be recognised (Figure 2). The “wing” features seen in these seismic data are often quite high amplitude or “bright”. This could be related to higher impedance contrast, confirming the well logs and core observations, but others factors (thickness, tuning and overburden effects) may be effective. The identification of the increased impedance and of its cause solely from seismic data is an area for further study.

Reservoir geometry

Integration of core, wireline and seismic data allows the interpretation and reconstruction of the reservoir geometry. RHOB and DT values reveal the occurrence of FR sandstones even in absence of preserved cores. Following detailed analysis of the borehole data and in particular recognition of the RHOB and DT characteristics, several intra-reservoir shales are now interpreted as shale units originally overlying the main sandbody and enclosed by remobilised and injected sandstones (Figure 3). Confidence in picking of injected sand features allows better interpretation of intra-reservoir shales.

Many of the injection features are related to faults displacing the base of the Oligocene. Few oil-bearing sands are present at and even above the Base Oligocene level. These observations point to an interpretation of large scale “injections” (+/-100 m of vertical sand injection) that are the result of buoyant or squeezed fluidized sands moving along zones of weakness in the surrounding rocks.

Sand remobilisation and injection

Many of the sedimentary structures in Alba are typical of fluidisation and are associated with major sand injection features (Figure 2). The scale of sand remobilisation (Figure 2), inferred from cores and seismic, shows that fluidisation was not simply a local bed-scale event that produced characteristic dish structures and consolidation laminae but a later event that occurred on a large scale throughout a large volume of the Alba reservoir.

The mechanism and physical control of remobilisation is unclear and several processes may have interacted. The density contrast between the reservoir sandstones and the surrounding denser shales favored the remobilisation and injection of sands in the overlying shales. The density contrast between the sand and mudstone during injection requires the generation of substantial overpressure that is unlikely to be created by compaction alone and may involve the input of an extraneous gas charge, for example, methane. A reduced present day gas-cap in the reservoir may be evidence for escape of gas during sand injection. Reverse faults and injection below the main reservoir are identified from which it may be inferred that compression and squeezing of the reservoir occurred during remobilisation (Figure 4). Small reverse faults may develop during loading but the features resolved on seismic are likely to have formed later once the sand was enclosed below a mud seal.

Sand body geometry such as revealed on Alba (Figures 3, 4 and 5) demonstrates the importance of identifying the characteristics of injected and remobilised sand units both from borehole and seismic data so that an integrated reservoir model can be developed. Unfortunately, the factors controlling fluidisation, remobilisation and injection of sand remain poorly understood. Improvement of methods for characterizing large-scale fluidised and injected units are the targets of on-going research and may contribute to a better understanding and optimise development of Alba-type reservoirs.

References

Hanson R. A., MacLeod M. K., Bell C. R., Thompson C. J. and Somod, J. 1999. Multi-component Seismic Interpretation: Data Integration Issues, Alba Field, North Sea, paper 6-27 presented at the 1999 EAGE Annual Technical Conference, June 7-11.

MacLeod M. K., Hanson R. A., Bell C. R. and McHugo S. 1999. The Alba Field Ocean Bottom Cable Seismic Survey: Impact on Development. Paper SPE 56977 presented at the 1999 Offshore Europe Conference. Aberdeen, Scotland, 7–9 September 1999.

Newton, S.K. and Flanagan, K.P. 1993. The Alba Field: evolution of the depositional model.

In: Petroleum Geology of Northwest Europe, Proceedings of the 4th Conference (ed. J.R. Parker), Geological Society of London, p.161-171.

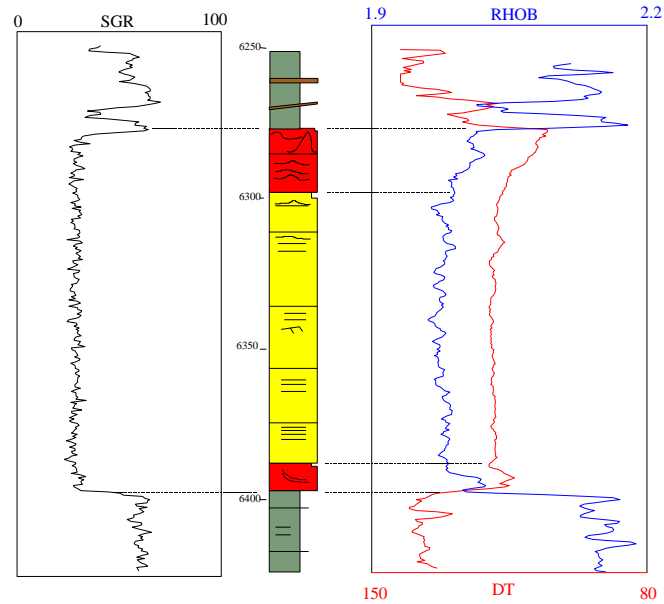


Figure 1. Typical wireline log data from the Alba field showing higher bulk density and acoustic velocity in fluidised/remobilised sand intervals. RHOB = formation density log, DT = acoustic velocity log, GR = natural gamma-radiation

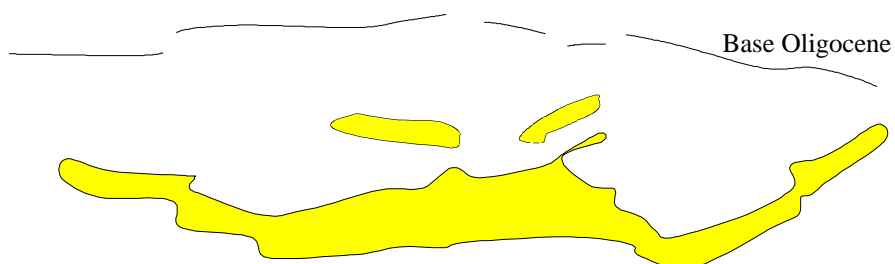
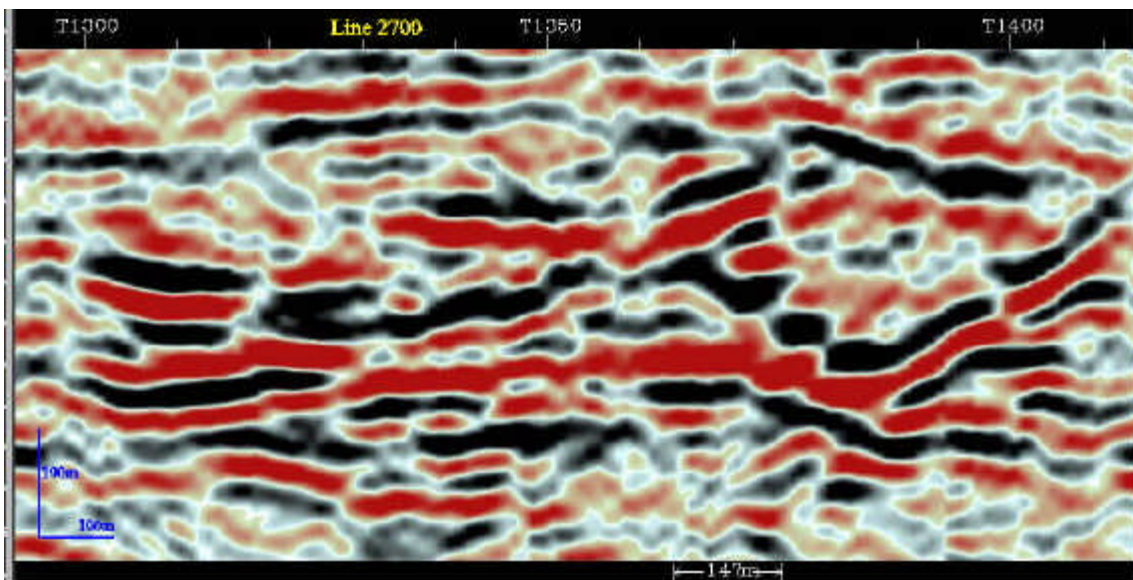


Figure 2. Examples of injected and remobilised sand geometries imaged on 3-D seismic data.

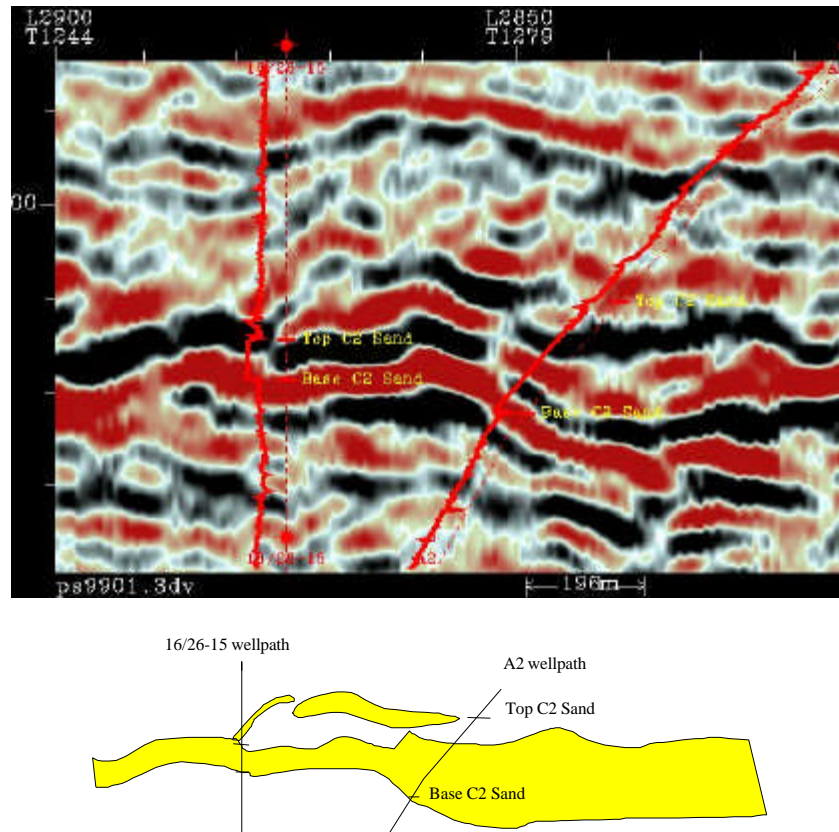


Figure 3. An intra-reservoir shale interpreted as shale enclosed by remobilised sandstones

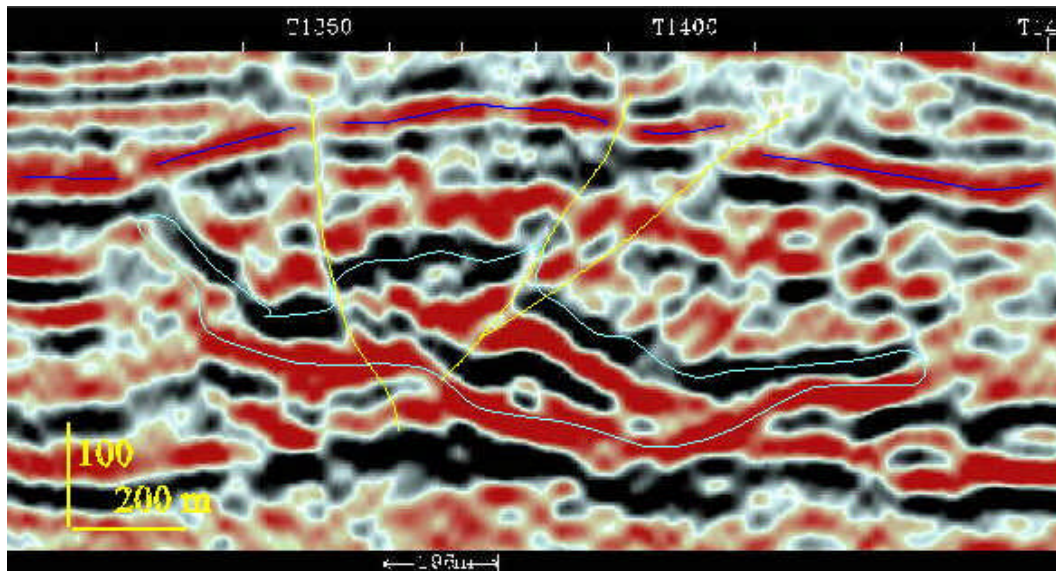


Figure 4. Reverse faults displacing the base of the Oligocene and giving rise to a sort of pop-up structure in the central part of the Alba Field. They seem also associated to large injection features.