G&G Research

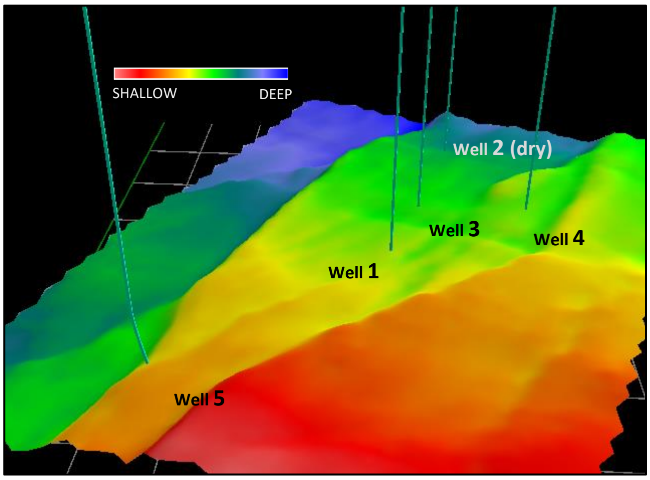
new wave ENERGY

Dispersivity Analysis Can Reduce Costs and Increase Oil Recovery

An Illustration from the Exmouth Plateau, Western Australia

Low-frequency seismic dispersion has been known-about for a long time, but only recently has it been well-enough understood to be a contributor to seismic reservoir studies. G&G Research has developed tools for the measurement of Acoustic Dispersivity, a rock-property associated with low-frequency dispersion, as an indicator of movable hydrocarbons in the subsurface.

This extract from a case-study illustrates how dispersivity analysis, providing an additional view of a reservoir, can reduce hydrocarbon risk and help avoid wasted wells. In the case of the field studied, if these tools had been available at the time it was developed, many millions of dollars could have been saved and significantly more oil produced.

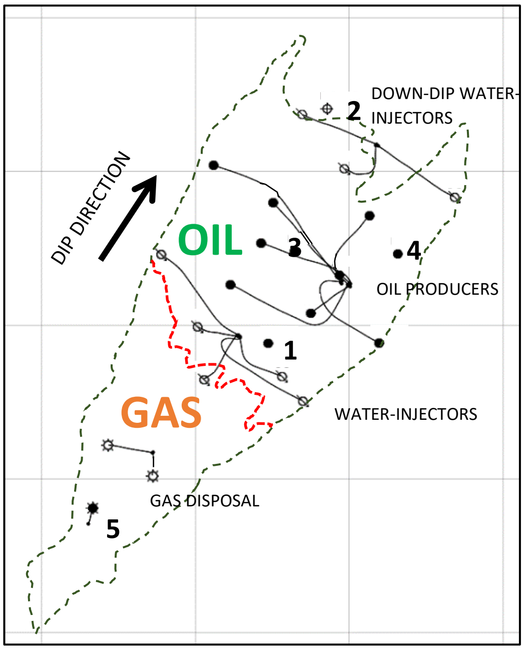


The subject is an oil-field which is no longer in production. Data used is open-access seismic and well data and reports provided by the Australian Government.

The field was discovered in 1999 with well 1; four appraisal wells were then drilled, and a 3D seismic survey was acquired, before field development. Oil and gas were present in a late-Jurassic sandstone reservoir, in a structural, fault-terrace trap.

At the up-dip, south-west end of the field, appraisal well 5 found gas over oil. Pressure analysis, and strong seismic reflection amplitudes at top-reservoir in the southwestern, shallower half of the structure, led to an interpretation of an oil accumulation with a large gas-cap.

A development scheme was designed accordingly.



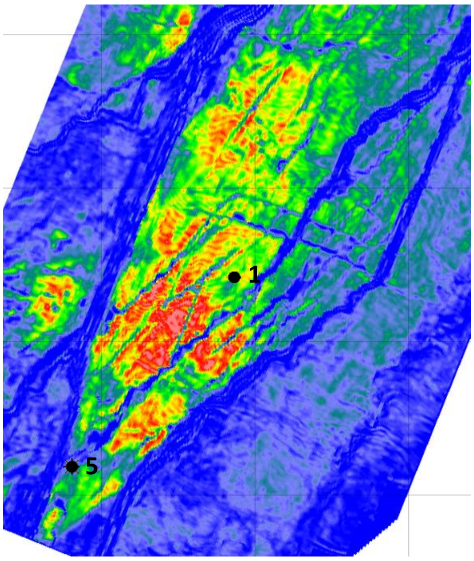
Development Scheme

There were eight mainly horizontal producers in the oil leg;

+ three water-injectors down-dip for pressure support;

+ two gas-disposal wells up-dip;

and water-injectors near the gas-oil contact, to keep the gas-cap from expanding towards the producer wells, and for pressure support.



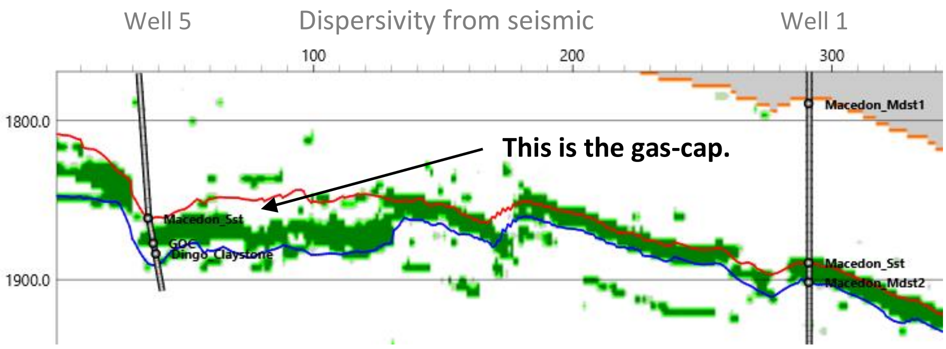
Top-reservoir Stack Amplitude

The Gas-cap is less extensive than it seemed.

The extent of the gas-cap was originally deduced from pressure gradients in the discovery and appraisal wells, supported by quantitative interpretation of the reservoir reflection amplitudes: a strongly negative top-reservoir reflection in the up-dip part of the field.

However, on this top-reservoir amplitude map, notice that the high-amplitude anomaly (red) does not extend to the area of well 5, the only gas-bearing appraisal well.

This new dispersivity study has shown that the gas-cap was much less extensive and the high amplitudes were a consequence of strong Acoustic Dispersivity (see yellow box below) in the oil-bearing high-permeability sand.



The well-seismic tie at well 5 is poor because imaging was locally disturbed by a significant sea-bed feature (the well was deviated to avoid it).

On this well cross-section, **red** and **blue** horizons represent top and base of the reservoir; the property in **GREEN represents oil-bearing sand** detected by dispersivity analysis.

The gas-cap (within the reservoir interval, but white) appears to be local to a fault-block. In other words, there is not a continuous GOC across the field, but different fault-blocks have different GOCs (or none). Pressure differences found in wells drilled during production life show that this is not a single interconnected fluid accumulation.

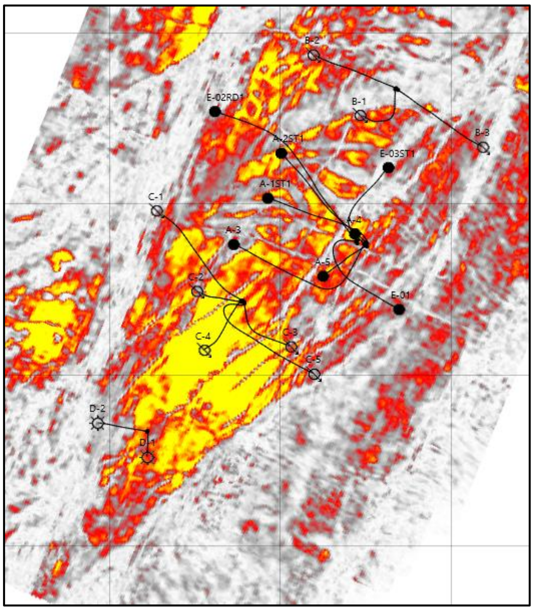
Dispersivity Analysis

Acoustic Dispersivity (AD) is the rock property that causes low-frequency dispersion and frequency-dependence of reflection coefficients. Physically, AD is a reduction in bulk modulus at low seismic frequencies, compared with what would be deduced from sonic logs or core measurements. It is caused by the nature and movability of pore fluids and is usefully strong in oil-bearing sandstones.

Measurement: AD can be measured by analysing reflection coefficients over a range of frequencies (approx. 5 to 50 Hz) and at different angles of incidence. Alternatively, a form of machine learning can be applied to seismic data, trained by well results.

Bright-spots can indicate oil: in a very permeable sand, as here, the AD anomaly due to oil can mimic the reflection amplitude effect of gas by making the rock acoustically soft at normal seismic frequencies.

Reservoir connectivity



Relative Acoustic Dispersivity in the reservoir interval

Dispersivity analysis allows us to make maps showing where reservoir quality and geometry combine to favour local accumulation of movable oil.

This map shows the strength of the relative AD anomaly in the reservoir interval, yellow colour representing the best-quality oil-bearing sands.

This was the picture before production began.

The map shows how cross-faults and depositional features make the reservoir very discontinuous.

(It also shows oil in the up-dip area that was supposed to be the gas-cap.)

Un-swept oil and stranded reserves

This heterogeneity suggests that the development scheme was not likely to provide an even sweep of oil towards the production wells (solid symbols, in the centre).

Perhaps more importantly, the central water-injectors, which were meant to hold back the gas-cap, probably served to isolate an up-dip oil-filled region from the production wells.

If Acoustic Dispersivity analysis had been available:

A different model of the field might have been made and hence a different development scheme.

At least the cost of the redundant water-injectors in the centre of the field might have been saved, along with the cost of their pipework.

Cost of the central water-injectors: the three initial injectors C1 to C3 at the supposed edge of the gas-cap had a drilling cost of A$43 million. Injection well C4, deviated up-dip, cost A$66 million to drill, and C5, drilled later, a further A$53 million.