# Oil & Gas Company Collaborat[ion]

SUCCESS STORIES INVOLVING E&P COMPANIES

## IDENTIFYING WELL LOCATIONS IN CHANNEL SANDS

National Oil Company Exploiting One of World's Largest Onshore Reservoirs

**CHALLENGE:** Optimize well locations in complex channel sand reservoir
**SOLUTION:** Full-wave imaging and advanced geophysical analysis
**RESULTS:** First-ever characterization of complex reservoir zones

### HARD-TO-IMAGE CHANNEL SANDS IN LARGE ONSHORE RESERVOIR IN ASIA

A National Oil Company (NOC) had been the long-time operator of one of the world's largest onshore reservoirs. Production was sourced from multiple reservoir horizons that had been deposited in a braided, channel sand environment. The field has produced nearly 10 billion barrels of crude oil since its discovery fifty years ago.

Individual well production (and estimated ultimate recovery - EUR) can vary significantly across the field, even in wells that are proximate. Numerous structural and lithological factors can be identified to explain production variances, but a primary driver of well productivity is believed to be the number, size, and sand quality of the channels intersected by each individual well.

Legacy 3D seismic that had been acquired and processed over the field was insufficient to allow the NOC's geoscience team to characterize the channel deposits within the reservoir intervals and identify well locations that were likely to be the best producers.

### LAUNCHING A FULL-WAVE SEISMIC IMAGING AND RESERVOIR CHARACTERIZATION PROGRAM

In 2005, the geophysical affiliate of the NOC commissioned a full-wave acquisition pilot test using ION's digital, full-wave (3C multicomponent) VectorSeis sensors. The results were promising enough that a broader acquisition program was sanctioned the following year.

The data processing and interpretation contracts were put out to bid in 2007, with ION's GX Technology (GXT) Imaging Solutions group given the go-ahead to process and interpret both the P-wave and converted wave data, along with the remit to conduct advanced geophysical analysis on the data in order to delineate subtle structural and stratigraphic features, including lithology changes caused by channel sands cutting through the reservoir interval.

Acquisition Challenges. Acquiring new seismic data in a producing field can often prove to be challenging. Drilling rigs, pumping units, pipelines, and buried near-surface cables can make it difficult to deploy traditional recording equipment. Crews using cable-based acquisition systems must take additional time to lay cables while avoiding surface-based obstructions, while analog geophones can be adversely affected by ambient noise introduced by oil field operations. By recording the full acoustic wavefield with digital 3C sensors like VectorSeis, geophysicists can remove ambient noise to improve the quality of the recorded signal. Cableless recording systems like FireFly can play a key role in supporting acquisition operations by supporting the efficient deployment of seismic gear even in the presence of obstructions.

### WHY FULL-WAVE IMAGING?

Full-wave imaging can improve the bandwidth of recorded seismic data at both the low- and high-ends of the acoustic frequency spectrum. Improved bandwidth translates to improved resolution, which allows geoscientists to characterize thin reservoir beds or otherwise subtle changes at the reservoir level.

Full-wave data allows changes in rock types (lithology) within a reservoir to be better characterized. By directly recording shear (or converted) wave data, geophysicists can map changes in acoustic properties such as shear impedance, use that information to map similar attributes throughout the reservoir (which might correspond to the presence of a channel sand, for example) and correlate those properties to well productivity.

In reservoirs whose individual well productivity is determined by fractures, full-wave imaging techniques allow one to analyze the impact those fractures have on acoustic properties, including the effects of shear-wave splitting, which can provide insights into fracture intensity and orientation.

In this particular project, fractures did not come into play. However, the lithology analyses proved extremely useful in providing the insights needed to target future wells at the highly productive 'sweet spots' within the channel sand reservoir.

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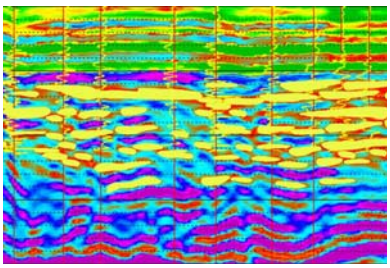
## FIRST-EVER CHARACTERIZATION OF CHANNEL SANDS IN THE RESERVOIR INTERVAL

ION's GXT Imaging Solutions group processed both the P-wave and converted wave seismic data using a combination of conventional and advanced processing techniques. The P-wave data was of high quality, with increased frequency content at both the high- and low-ends of the acoustic spectrum. This enabled ION and client geoscientists to map the reservoir interval with a higher degree of resolution.

However, the more interesting insights occurred through the analysis of the measured shear impedance data. Because the client had used a full-wave (3C) sensor to record the seismic data, they could measure shear impedance directly rather than computing it indirectly as is the convention when only P-wave data is available from standard analog geophones. Based on the analysis of this directly measured shear impedance information, ION's team was able to describe the sedimentary facies changes throughout the reservoir interval with much greater precision, helping to identify the boundaries among pro-delta facies, interbedded sand and shale sequences, and the channelized delta plain (the actual reservoir target).

Moreover, ION's Reservoir Solutions group was able to explain the large production variances among a series of wells in the study area that had produced vastly different quantities of oil (less the 1 million BOE at the low end to 5+ million BOE on the high end) despite their extremely proximate surface locations. By using the directly measured shear impedance information, ION and the client were able to discriminate individual channels within the reservoir interval and better understand the connectivity of the reservoirs. The higher EUR wells had clearly intersected a larger number of high quality, laterally extensive channel sequences compared to the lower EUR wells.

This level of channel detection was possible only because 3C data had been recorded and shear impedance directly measured; when shear impedance computations were attempted with only the P-wave data, the channel sands could not be detected or characterized.



## THE SCOPE OF ION'S INVOLVEMENT

In many of the projects it undertakes with oil & gas companies, ION is often asked to assume an end-to-end role across the entire seismic workflow. In these cases, ION provides an 'Integrated Seismic Solution' that will cover all aspects of a project, including survey design, data processing, reservoir services and the provision of hardware and software technologies that will be used by the acquisition contractor selected by either ION or our client.

In this China reservoir characterization project, ION was involved with:

- Conceptual and scoping studies
- Designing pilot tests and field trials
- Advising on the acquisition program
- Technology provision:
  - VectorSeis sensors
  - Land recording system
- P-wave processing
- C-wave processing
- Advanced geophysical analysis
- Integrated reservoir interpretation
- Jointly identifying new drill-well locations within the reservoir

→ What the Client Has to Say

"The combination of multicomponent data measurements and the advanced geophysical analysis conducted by ION's Reservoir Solutions group has helped us to better understand this strategically important reservoir. As a result of ION's technologies and services, we will be better able to develop and manage the reservoir and optimize the future investments we make in drilling."

- Asset Team Geophysicist, National Oil Company

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