[EA]Thailand's First 4D Seismic Project - Bualuang Field Case Study*

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Abstract

In mid-2015, Ophir Energy acquired the first ever Ocean Bottom Node (OBN) seismic survey in Thailand. The survey was acquired on the producing Bualuang Field, situated offshore of the Western Gulf of Thailand, seven years after first oil production. One of the OBN survey's secondary objectives was to be able to perform 4D studies, as the original Bualuang streamer survey was acquired in the beginning of the life of the field (2009). For this reason, the survey, which is wide azimuth by design, was acquired with a very large fold, several times higher than the original streamer survey. This would allow optimal matching of monitor survey (OBN) and baseline survey (streamer) traces during the 4D binning processing stage.

After the baseline and monitor survey were put through a specifically designed 4D processing sequence, the surveys ended with an NRMS value <0.2 (Figure 1). This value measures the repeatability of the surveys and by global industry standards it is considered to be a very good result. In this context, very careful seismic processing played a key role. However, due to the different nature and orientation of the baseline and monitor surveys, some additional processing scalars had to be used at the target level. This resulted in a 4D signal of lower quality than in other specifically designed 4D projects.

The Bualuang oil is very low gas oil ratio (GOR) and the oil is being produced through aquifer support resulting in no gas coming out of solution and very minimal pressure changes. Forward modelling of the simulator results indicated that the replacement of oil by water as a result of production would induce a small but detectable change in the elastic parameters. Therefore, a pre-stack simultaneous inversion of the 4D data to elastic parameters was performed (Figure 2).

Because saturation (Sw) and pore pressure (Pp) changes within the reservoir affect the elastic parameters differently, in theory the 4D differences in acoustic (AI) and shear impedance (SI) should allow for the discrimination and quantification of ΔSw and ΔPp. With the help of a 3D rock physics model, the ΔAI and ΔSI between the baseline and monitor surveys have been converted to production induced ΔSw and ΔPp.

However, 4D inversion projects often produce results not suitable to a fully quantitative interpretation and a more qualitative approach has been adopted in Bualuang.

At the shallow reservoir levels, the Bualuang Field is a simple north-south trending faulted anticline comprising of multiple stacked fluvial reservoirs of Late Miocene age. The main producing reservoir sand is well resolved in the seismic data and this study confirms it contains meaningful 4D signal that matches the simulator results reasonably well (Figure 3).

This reservoir is being developed with horizontal producers and well infill spacing is key to avoid either over-drilling or leaving bypassed oil in between wells. Traditionally, these decisions were made with the results of the history matched dynamic model alone. However, it is now possible to bring in another independent discipline (geophysics) to qualitatively validate the simulator results. In Bualuang, this is quickly becoming a crucial tool for the management and planning of optimal reservoir development.

In conclusion, this paper will show recently drilled examples and discuss how integrating the G&G and RE disciplines can maximize hydrocarbon development and reduce drilling risk in a mature field.

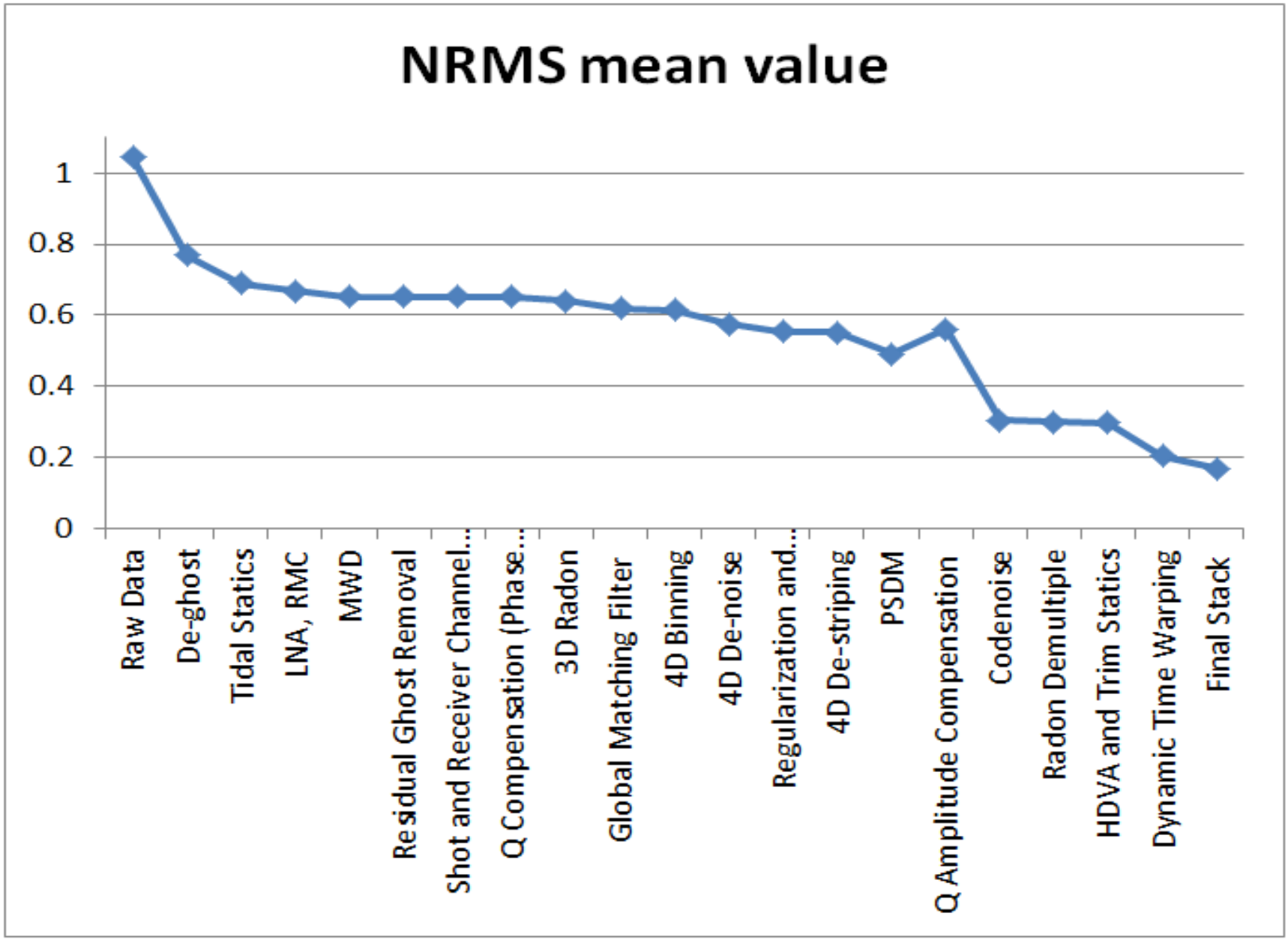

Figure 1. NRMS value progression throughout the 4D processing project.

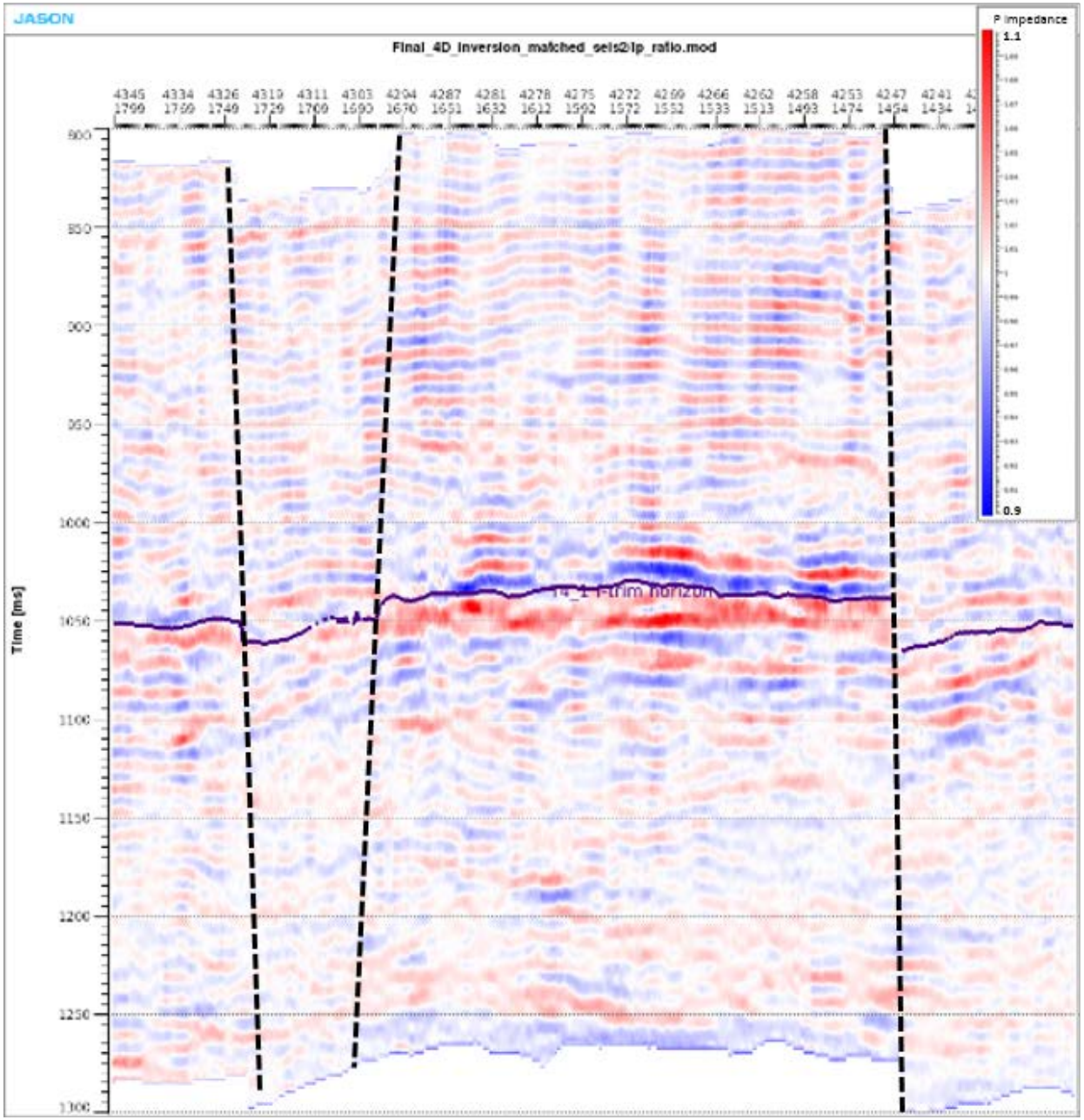

Figure 2. Ratio of the Monitor survey AI over the Baseline survey AI.

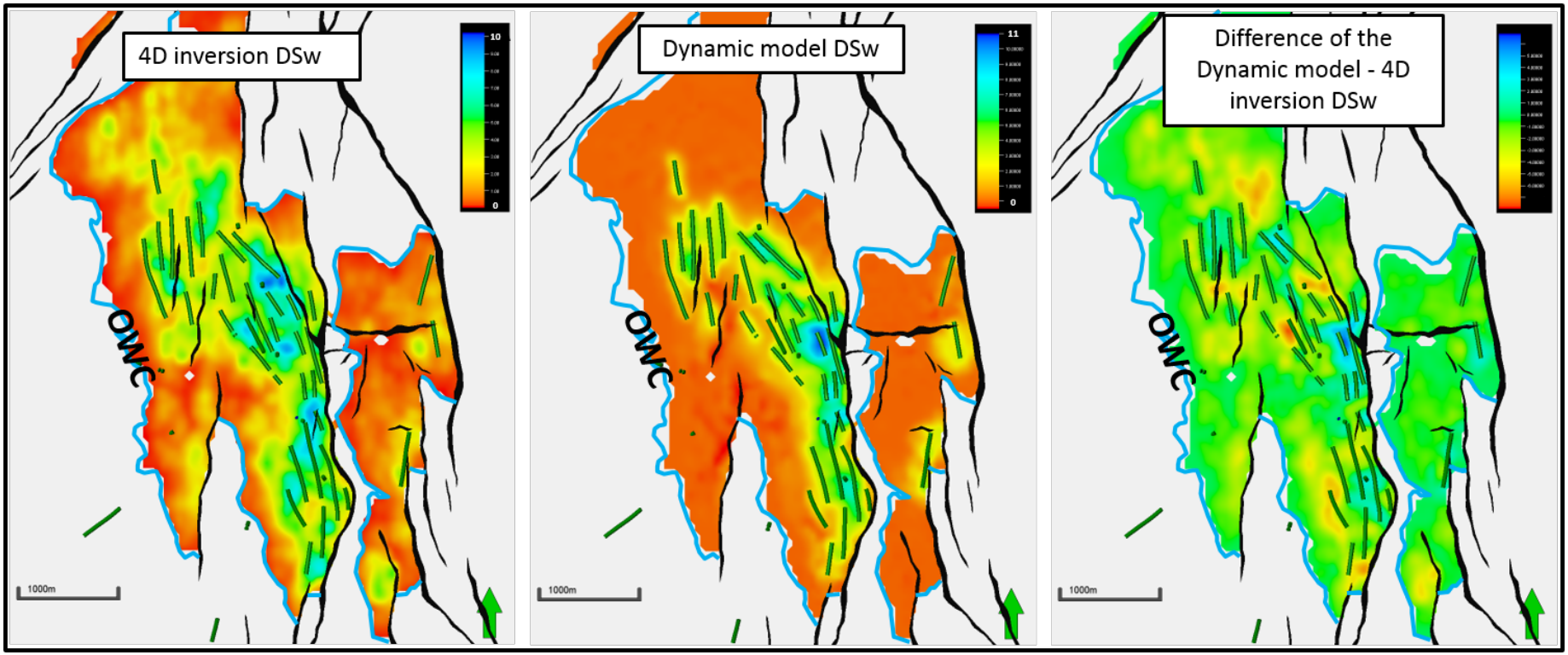

Figure 3. Comparison between 4D inversion Sw, Dynamic model Sw, and difference. Horizontal producers in green.