Paper P7

Studying Carbonate AvO Response

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AvO inversion has not been done for carbonate fields because carbonate rock does not normally display AvO effects. However, there is no hard evidence for that, so this project was setup to investigate if there are any meaningful AvO effects in Sarawak carbonates.

The project was started by studying some similar works done in the past. Some studies hinted at the existence of two types of overburden shale in Sarawak carbonate fields, i.e. hard and soft shales. There was another study that encouraged the usage of physics-based equations, instead of well data based regressions. These findings were input into this project.

Eight wells are used in this study: E6-3, E8-101, E11-106, E11 Deep-1, F14-2, F28-2, Jintan-3 and Serai-1. They are selected based on well log quality and the availability of Gassmann brine substituted logs. These wells also have measured vs logs, so that data driven rock property trends can be derived.

To model any kind of AvO response, there must be rock property trends. A set of trends were derived each for shale and carbonate. There are two kinds of overburden shale, hard and soft, so the depth (TVDss)-vp and vp-vs trends differ. The vp-ρ trend is the same for both types of shale. As for carbonate, the equations are porosity (φ)-vp, vp-vs and φ-ρ. A set of the equations were derived each for gas- and brine-filled carbonate.

With a complete set of rock property trends, the next step of the project is modeling AvO response. There are three types of interfaces modeled: top carbonate, intra carbonate and gas-water contact. Two types of modeling were employed in this project. Blocky modeling synthesizes rock property values from the derived trends, so the AvO responses are obtained from there. Monte Carlo modeling assigns an uncertainty range for each rock property and study AvO responses from many modeled interfaces.

For top carbonate, the results implied that AvO effects are bigger when shale type is soft. Also, shale type can be differentiated. For intra carbonate, the AvO effects are minimal between the two fluid types. Monte Carlo modeling showed that gas-water contacts can have different AvO response compared to intra carbonate. However, between the two types of gas-water contacts, i.e. changing porosity and constant porosity across the interface, their AvO responses are very similar.

The modeling results were tested against well synthetics to verify whether they could be observed when there were wavelet effects, i.e. tuning and interference. Well synthetics supported that AvO effects are bigger in top carbonate when the shale type is soft. However, shale type is not as easy to differentiate. Intra carbonate well synthetics were not studied because it was difficult to identify an isolated interface. Gas-water contacts synthetics did not support that the interface has different AvO response than intra carbonate, but they verified that the interface has similar AvO response even when porosity varies.

The inconsistency between modeling results and well synthetics could be because of the simplicity of the modeling used in this project. Several improvements were suggested.

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