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# Seismic window

Michael Micenko
Associate Editor for Petroleum
*micenko@bigpond.com*

## Rock physics: past and future

In the 60s and 70s it was bright spots, then AVO in the 80s and 90s, and now it is rock physics. Let's take a look at this progression and make a prediction about where it is heading.

Bright spot technology simply involved searching for high amplitude anomalies on stacked seismic sections after it was observed that quite often gas discoveries in the Gulf of Mexico were associated with high amplitudes. Of course this was backed up with some sound mathematics, but really the only requirement was good eyesight. Success rates improved but, despite being drilled into bright events, many wells failed to find economic accumulations of hydrocarbons. Igneous rocks, coals, carbonates and low saturations of gas can all produce a brightening of the seismic amplitude. Today we can easily recognise carbonates and igneous rocks by the reflection polarity, but that was not so well understood 50 years ago.

The industry needed something better and moved on to the pre-stack method – Amplitude Variation with Offset (AVO). AVO measures the changes in reflector amplitude across a number of offsets to estimate the type of rock and its fluid fill. Again, there are pitfalls such as low gas saturation, highly porous sandstones, thin bed tuning (Figure 1), and poor processing, which create false anomalies and a dry hole results. However, a well's chance of success is often undermined by misuse of the technique by explorers that should know better – this lack of understanding (or is it?) is often displayed on the steady supply of farm-out brochures I receive.

So now we have rock physics. An AVO study is only as good as the rock physics behind it, and this is dependent on the quality and relevance of the supporting data used to create models of the expected response. For instance, a common blunder is to apply learnings observed at a shallow depth to a deeper situation. Figure 2 explains why this may be wrong. Because the relative changes of velocities with depth are different in sands and shales, there becomes a depth where the sand and shale trends cross over and the AVO response is completely different. What was successful at shallow depths will not be successful with an extra kilometre of burial.

Where is this all leading? It's a bit of a buzz word, but machine-learning is making inroads and in the future I suggest seismic data will be compared to a database of millions of prospects and outcomes. Seismic interpreters and dry holes will be a thing of the past.

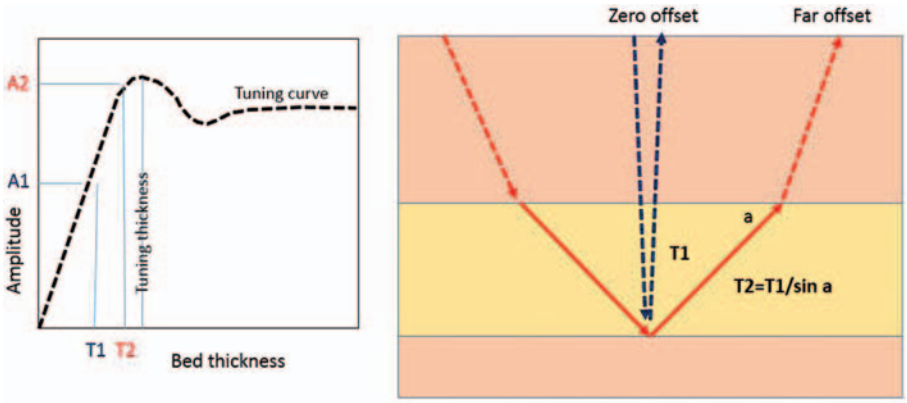


**Figure 1.** *Tuning curve (left). Thin beds can produce a false AVO response when the thickness (T1) is below tuning thickness. With long offsets the apparent thickness (T2) is larger and produces a larger seismic amplitude (right).*

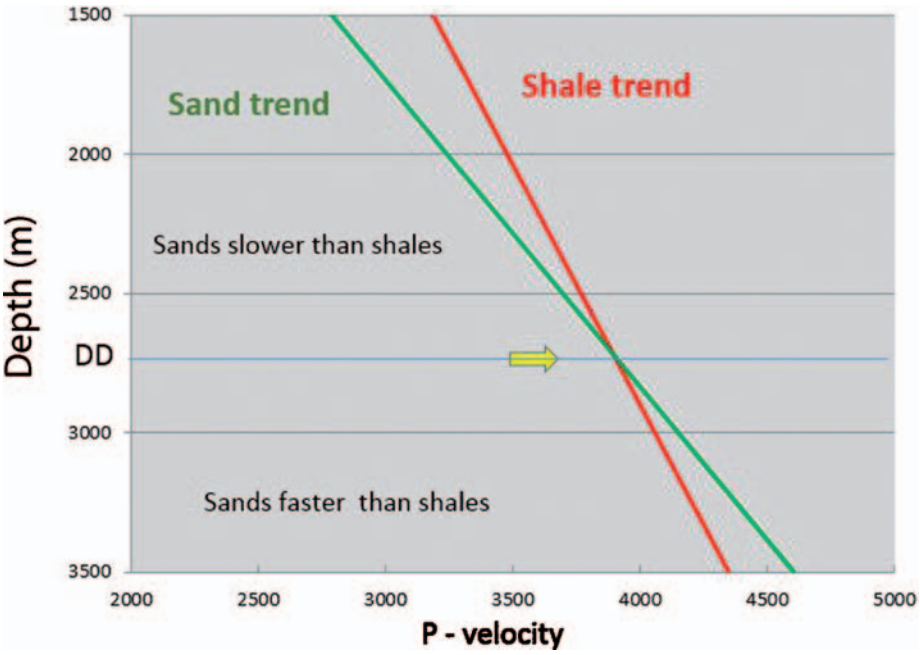


**Figure 2.** *Example P wave velocity versus depth of burial. At shallow depths (about 2000 m in this example) the sand has a slower velocity than shale, and replacing brine fill with gas will increase the difference creating a bright spot. But below a certain depth (DD) the shale becomes slower. In this case adding gas will reduce the difference between sand and shale and the reflection amplitude becomes close to zero. In the past this would be referred to as a 'dim spot'.*