Azimuthal Anisotropy from Seismic Data: The Myth and the Reality

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A lot of effort is been put into detecting fracturing within tight, mainly shale reservoirs using seismic data. Various methods have been tested such as defraction imaging, geometry attributes, shear wave splitting, AVAZ and HTI (horizontal transverse isotropy) to name a few. Wide-azimuth on-shore data are readily available, and, in this presentation, we will be investigating the possibility to use HTI to detect heterogeneous reservoir rocks and how reliable this method is.

Previous HTI studies showed mixed results and it was decided to create a fully elastic anisotropic synthetic model that mimics real geology in the Anadarko Basin. To exclude artificial anomalies, 2 different models were generated. The first model had Vertical Transverse Isotropy (VTI) in all layers. The second model was orthorhombic using all Thomson's parameters. Both synthetic datasets were depth migrated and analyzed in detail.

The investigated reservoir interval is the Woodford formation which exhibits a big drop in acoustic impedance and is buried at a depth of approximately 12,000ft. In our area of interest, the thickness of this rock unit varies from 100ft to 400ft. Our sweep frequency was taken from the actual seismic acquisition which allowed us to generate a synthetic seismic dataset with similar frequencies than found in the actual seismic. The anisotropy parameters were derived from log measurements. To investigate the effect of reservoir thickness, a flat layer was added below the base of the Woodford. In the area of investigation, the Woodford dips upwards and the addition of the flat layer creates a wedge model. After depth migration, all geological velocity effects should have been removed and the remaining azimuthal velocity variations should in theory be associated with fractured intervals.

After careful analysis, we could not detect any measurable HTI effect on the synthetic dataset. This let us to believe that at our modeled reservoir depth and reservoir properties, we are not able to detect fracture corridors, clouds using seismic velocity variations. However, various publications argue that this method can be applied and has been successful. One article that was of special interest shows a good correlation between production rates and azimuthal velocity anomalies in the Austin Chalk at a depth of approximately 6,000ft and a reservoir thickness of around 700ft. Closer inspection of the displayed pre-stack data raised many questions. The sinusoidal behavior that is indicative of an azimuthal velocity anomaly is present in the near and far offsets and furthermore, can be seen at very shallow depths. Theoretically, the near offsets should not show any sinusoidal variations as the wave needs to travel at least partially through the vertically cracked rock and the effects should only be present at higher offsets. In the near sub-surface, no high offsets are recorded and even if anisotropy is present, it cannot be measured through azimuthal velocity variations.

The results of the synthetic model and further research into work done by others indicates that many of the observed sinusoidal events are not caused by fracturing in the reservoir rocks but possibly are due to incorrect seismic azimuthal processing. At this point, it is not clear where the processing breaks down but in order to understand HTI anisotropy from seismic, this needs to be carefully scrutinized and tested.

Acknowledgements

The author likes to thank Gary Margrave, Jamie Rich, David Langton and the crew at Seismic City for their contributions.

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