3D Permian Basin Faulted Velocity Model

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ABSTRACT

Accurate velocity models are critical for a variety of subsurface modeling tasks, including depth-conversion of 3D seismic models and earthquake location. The 3D Permian Basin velocity model created in this study uses a unique dataset consisting of over 20,000 compressional sonic well log curves and was validated using 2,600 velocity checkshots provided by the Velocity Databank of Houston.

The stratigraphic framework contains over 50 individual formations, based on over 2.2 million surface tops for approximately 26,000 wells, modeling the Permian Basin section from surface to basement. The structural framework consists of a fully-sealed faulted framework containing over 2,000 faults, including basement-rooted faults and shallower faults. Additional 3D seismic volumes and well logs were shared by operators and vendors and licensed from data providers.

This study focuses on five tasks:

- The calculation of p-wave velocity (Vp) from well log sonic (delta T) curves.
- The creation of a sealed faulted framework using 3D fault surfaces based on published faults.
- The construction of a stratigraphic framework based on BEG and proprietary operator well top interpretations.
- The distribution of the velocity data along 100-meter-thick sublayers for each of the 50 stratigraphic framework zones.
- The validation of the 3D velocity distributions using independent velocity surveys and seismic derived velocity data.

The calculation of the velocities from well logs involved sonic-log correction, vintage-based log normalization and quality assurance. The calculated well log velocities were sampled using the vertical layer structure of the 3D model. Next, we characterized the spatial variance of the velocity data for each of the more than 50 formations. This was done by generating lateral variograms for the velocity in all zones and fault blocks. Multiple equiprobable realizations were investigated to determine scenarios with maximum predictability of velocity data away from the well and seismic velocity control.

Using the Schlumberger Petrel software, we interpreted a fault-fault connection network which was used to build a sealed faulted framework. The stratigraphic horizons were faulted using the fault-network definition and subsequently corrected and adjusted for all horizon-fault interfaces using available well log and seismic interpretations.

Finally, we used the Eliis Paleoscan software to interpret horizons in 35 available 3D seismic volumes and more than 2,000 2D seismic lines. Depth-depth correction shift values were applied to horizon interpretations for the PSDM velocity volumes. We generated synthetic seismograms for each of the 3D seismic volumes and used well-seismic tie workflows to calculate interval velocities used for additional model validation.

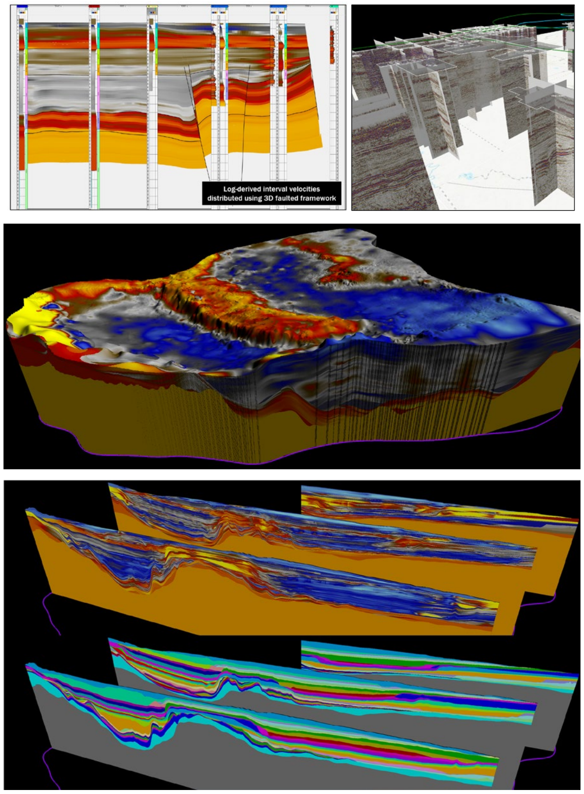

Figure 1: 2D faulted cross-section, 3D model, and fence diagrams showing velocity distributions along the zones of the 3D Permian Basin model. 3D seismic surveys used in the study are shown in the above right figure.

The result is a first-of-its-kind Permian Basin wide 3D velocity model, consisting of over 800 million cells, that can be used to more precisely depth-convert 3D seismic volumes and locate 3D earthquake hypocenters.