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Hongliu Zeng[1], Bruno Courme[2], Charles Kerans[3] (1) The University of Texas at Austin, Austin, TX (2) Total-Fina-Elf, (3) Bureau of Economic Geology, The University of Texas at Austin, Austin, TX

Realistic Reservoir Model from Seismic Data—Lessons from Seismic Modeling and Inversion of Prograding Carbonate-Ramp Sequences

Previous geologic and seismic modeling studies of prograding carbonate-ramp outcrops (Permian Abo Formation, Apache Canyon) present excellent analogs for subsurface reservoirs of similar architecture in the Permian Basin and elsewhere. Velocity data were measured on outcrops at 10-ft trace intervals for lithofacies boundaries with significant impedance contrasts and were then sampled at 1-ms in time. The model is characterized by sigmoid to oblique clinoforms within the reservoir architecture in layered geometry in the host formation. Seismically thick and thin beds, as well as multiple lithofacies with wide-ranging rock properties, make for a strong heterogeneity. To clearly understand the reservoir models interpreted from seismic data, we first constructed synthetic seismic models of the outcrop and then conducted neural net inversion for best recoverable impedance section. We analyzed the quality of the interpreted reservoir model by comparing inversion results with the original outcrop model. Parameters tested included (1) seismic data density (trace interval), (2) seismic data frequency, (3) noise level of seismic data, (4) neural-net-training data size, (5) accuracy of training data sampling, and (6) impedance distribution of modeled lithofacies. The study shows the necessity of acquiring higher frequency (>100 Hz) seismic data for high-resolution (<5 m) reservoir models in general, as well as increasing the trace interval and reducing the time sample rate for better recovery of reservoir information based on available seismic technology. Precautions should be taken in seismic inversion and interpretation to avoid inadequate sampling, location error, and overestimation of seismic resolution.