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Reservoir-Scale Carbonate Sequence Stratigraphy, McKittrick Canyon, and 3-D Subsurface Examples

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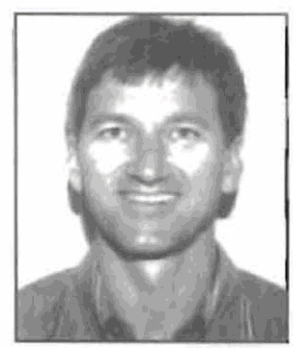
A principal goal of reservoir characterization is to derive a spatial understanding of interwell heterogeneity. Traditionally, geological attempts to characterize interwell heterogeneity have used hand-drawn or computer-generated 2-D maps and cross sections. Results can improve dramatically using 3-D interpretation and analysis techniques. The goal of three-dimensional geologic modeling is to construct an accurate, digital depiction of a three-dimensional body of rock. The hypothesis of this paper is that the stratigraphic framework exerts a primary control on the accuracy of a 3-D reservoir model and that a sequence-stratigraphic interpretation results in the most accurate stratigraphic framework.

In order to test the hypothesis, an experiment had to be designed in which a "known" sequence-stratigraphic framework interpretation could be compared to an alternative lithostratigraphic framework interpretation. The continuous, well-exposed, shelf-to-basin outcrops of the carbonate-dominated Permian Seven Rivers, Yates, and Capitan Formations along the north wall of North McKittrick Canyon, New Mexico and Texas, provide the ideal laboratory in which a sequence-stratigraphic interpretation can be made with a high degree of confidence. The data collected from McKittrick Canyon were used to create two 3-D reservoir models, one with a sequence-stratigraphic framework and one with a lithostratigraphic framework. Model results, including lithofacies distribution, volumetric calculations, and synthetic seismic were compared against the "known" interpretation in order to test the hypothesis. Unfortunately, in contrast to the outcrop, subsurface data are always limited. Interpreting the sequence-stratigraphic framework is the most difficult and creative part of the 3-D modeling process and involves integrating all available core, wireline log, seismic, and production data in order to arrive at a reasonable stratigraphic interpretation.

This paper will be presented in three sections. The first section will discuss the mechanics of 3-D reservoir modeling and illustrate the conceptual importance of a correct stratigraphic framework. The second section will introduce the detailed sequence-stratigraphic interpretation of the carbonate-dominated outcrop exposures in McKittrick Canyon. Results from the 3-D reservoir models in McKittrick Canyon will be presented that: 1) quantify the importance of a correct stratigraphic framework; 2) illustrate the differences in reservoir compartment distribution as a function of stratigraphic framework and well spacing; and 3) confirm the hypothesis that the stratigraphic framework exerts a primary control on the accuracy of a 3-D reservoir model. Finally, highlights from several 3-D reservoir models will be presented to illustate the importance of a sequence-stratigraphic interpretation and the positive impact that an accurate 3-D model has on reservoir management.

Biographical Sketch



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