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Geologically Complex Gas Reservoirs in Slope and Basin Facies, Canyon Sandstones, Val Verde Basin, Southwest Texas

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Abstract

Canyon sandstones, which form a prolific low-permeability gas play in the Val Verde Basin, have yielded 2.3 trillion cubic feet of gas and account for a significant part of domestic U.S. tight-gas production, reserves, and new completions. Geologic reservoir heterogeneity – small permeability compartments and internal barriers to flow – is a challenge to successful development of the Canyon resource. A dearth of published geologic description and the current high level of industry interest motivated this Gas Research Institute-sponsored study of the stratigraphy, diagenesis, and natural fractures of Ozona and Sonora Canyon sandstones centered in Crockett and Sutton Counties in southwest Texas.

The Val Verde Basin is a foreland basin, which during the Late Pennsylvanian and Early Permian was bounded on the south by the Ouachita orogenic belt and on the north and east by shelf platforms. Ozona and Sonora Canyon sandstones (Wolfcampian-Leonardian) were deposited in slope and basin systems adjacent to the Ozona Arch and Eastern Shelf in the north half of the Val Verde Basin.

The regional stratigraphic framework of the Canyon was mapped using well log correlations and lithologic interpretations. Sonora sandstones lie in a wedge-shaped interval that forms a slope apron along the southwestern margin of the Western Shelf. Total sandstone thickness reaches 1,000 ft. in the middle of the Sonora wedge. The Ozona interval is more tabular and apparently occupies a basin-floor position adjacent to the southern margins of the Ozona Arch and the Central Basin Platform. Total sandstone thickness in the Ozona reaches 640 ft. in southwest Crockett County.

Depositional facies analysis using cores and closely spaced well logs revealed that most Canyon reservoirs formed in submarine-fan channel and lobe environments and are composed of interlaminated sandstone/shale turbidites. Fan-channel sandstones are thickbedded (1 to 5 ft between shale interbeds), whereas fan-lobe sandstones are thin bedded (<1 ft between shale interbeds). Individual Canyon sandstone bodies are small, fan lobes being a few hundred feet thick and a few miles wide and fan channels less than 100 ft thick and less than 1 mi wide. Channel and lobe facies are complexly interbedded and laterally coalesced. A combination of facies-mapping techniques proved useful for delineating the most prospective reservoir sandstones.

Petrographic analysis showed that most Ozona and Sonora Canyon sandstones are fine- to medium-grained litharenites. Chert and sedimentary and low-rank metamorphic rock fragments are the predominant lithic grains. Much of the original porosity was destroyed by compaction and by cementation by quartz and carbonate minerals. In Sonora sandstones, early siderite cementation preserved some intergranular porosity by inhibiting mechanical compaction and precipitation of quartz cement. Siderite-cemented layers are developed preferentially in thick-bedded turbidites (Bouma T_a divisions).

Natural fractures in Canyon core were mapped and described to determine their attributes and orientations. Ozona and Sonora fractures are typically subvertical extension fractures that terminate at the boundaries of beds or cementation zones. Clay-filled fractures in siderite-cemented zones form the most common fracture class in Sonora sandstones but may be flow barriers. Quartz and carbonate-cemented fractures are less common in core, but fracture porosity is preserved locally along their traces. Spacing between larger, more permeable fractures could not be observed directly but is likely to be similar to the thickness of quartz-cemented intervals–several feet to tens of feet. A wide dispersion in fracture strike was observed in oriented Sonora core, but subsurface fractures trending generally northeast are most prone to be open because of in situ stress conditions.

Scott Hamlin - Biography

Scott received bachelor's and master's degrees from the University of Texas at Austin in 1975 and 1984. Except for a few years as a consultant, he has worked since 1977 at the Bureau of Economic Geology, where he is currently a research associate. His geological experience has been primarily in stratigraphy and sedimentology within the context of applied hydrogeology and petroleum geology research programs. He has published Bureau reports and journal articles on the Wilcox, Frio, and salt domes of the Texas Gulf Coast; on the Frontier Formation of the Green River Basin in Wyoming; on the Canyon sandstones of the Val Verde Basin in West Texas; and on Permian sandstone oil reservoirs of the Cooper Basin in Australia. He recently completed the research on Canyon sandstones, which will be presented in this talk, and is currently studying stratigraphically and structurally complex gas reservoirs in the Lobo Wilcox of South Texas.