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"Karst and Paleocave Geology: 3-D Seismic Response Study"

Abstract

The 3-D seismic volume over the Pettijohn Ranch reveals a spatially complex system of paleocaves and other karst features in the Mississippian Osage natural gas reservoir. First and second derivative (slope and curvature) maps detail over ten miles of a major cave system with caves of various shapes, sizes and lengths.

The 3-D seismic Osage amplitude map reveals two intriguing patterns. The west pattern is shaped as a dragon. At the heart of this Draco the Dragon is two caves with over 30 percent porosity. Both of these caves are located near the apex of a large structural anticline. The northwest third of the ranch lies on the southeast flank of this large anticline. Both of these caves are connected to an extensive patchwork of natural-gas-filled paleocaves covering all of the Pettijohn Ranch and perhaps much of the surrounding ranches. Each of the two caves would be an excellent location for the next drilling site.

At the heart, near the middle of the northeast pattern (shaped as a scorpion) is a one acre, 35 foot tall open cave filled with natural gas. The larger scorpion complex covers over 40 acres of high porosity (50%-100%) limy dolomite caverns.

A synthetic seismogram study developed numeric relationships between the seismic amplitudes and the rock porosities, natural gas saturations and rock compositions within the Mississippian Osage Reservoir under the ranch. These numeric relationships "prove" that the cave at the center of the scorpion complex contains natural gas. This one acre open cave is located near the lowest structural position on the ranch. Because of this, natural gas exists in the Osage reservoir over the entire ranch and much of the surrounding ranches.

The mathematical equations developed from the synthetic seismogram study allow a 3-D "seismic porosity" map to be generated over the ranch. Three geologic facies are recognized from this seismic porosity map. First, the limestone facies was the original deposition of low porosity (less than five percent) limestone and is seen in limited areas in the southern portion of the ranch. Second, the dolomite facies (porosities between five and fifteen percent) was a later diagenetic transformation of the original limestone into dolomite which covered most of the rest of the ranch. Third, the "karst and paleocave" facies (with porosities greater than fifteen percent) was a dissolution karsting event during the last half of the Mississippian period. This facies covered, to some extent, much of rest of the ranch but is most prominently seen in the two ends of the ranch as the "dragon and scorpion" amplitude patterns. This karsting event is expected to be observed over a wide regional area surrounding the Pettijohn Ranch.

The Pettijohn 3-D seismic porosity Osage map, along with an Osage Isopach thickness map was used to compute both an Osage natural gas reserves map and an Osage natural gas economic

map. The seismic porosity map and the thickness map of the Osage were also used to compute the natural gas volumetric recoverable hydrocarbons. Nearly five billion cubic feet of natural gas (5 BCF) is producible from the Osage reservoir alone on the ranch. Log analysis of the Pettijohn #1 well indicates gas resources throughout the Mississippian Formation and into the top one hundred feet of the Arbuckle Formation. The total recoverable natural gas resources, from both the Mississippian and Arbuckle Formations, from only the Pettijohn Ranch could exceed twenty billion cubic feet of natural gas and helium.

Our Presenter

Tom W. Stander

Tom Stander received his BS in Earth Science from the University of Northern Colorado in 1974. After working for Amoco Production Company as a petroleum geophysicist for two years, he returned to graduate school and earned a MS in Geophysics and Geology from the University of Kansas in 1980. During graduate school, he worked at the Kansas Geological Survey as a geophysicist in the earthquake laboratory and on shallow seismic reflection projects. His MS thesis "Structural nature of the Humboldt fault zone in northeast Nemaha County, Kansas" was the first research study at the survey to use modern seismic reflection technology.

In 1981, he formed and managed a geological and geophysical consulting firm - Orion Inc.. Orion, Inc. provided a variety of geological and geophysical services to local Kansas oil and gas operators. During 1981 through 1986, Orion, Inc participated in the discovery and development of numerous natural gas and oil fields discovered within the Pennsylvanian

Cherokee and Mississippian Formations in eastern Kansas. During this period, Stander managed and operated two natural gas and oil fields.

Since 1986, Stander has provided a wide range of geophysical and geological consulting services. Services included: an earthquake assessment study for a low-level Radwaste site in Ward Valley, CA.; supervision of the installation of dozens of environmental wells at an environment site in Joplin, MO.; the design and invention of an agricultural irrigation water moisture probe ; and geologic consulting on the exploration and development of a 50 well natural gas field in Kansas.

In 2014, Stander started Trifecta Energy, LLC. Trifecta Energy is a production company exploring and developing natural gas, helium and oil fields in Kansas. In 2015, Stander and his partners discovered a new natural gas field found in a paleocave reservoir of the Mississippian Osage formation.

Stander's professional interest includes: exploration geophysics, petroleum geology of Kansas, computer programming projects in geology and geophysics, and mathematical analysis of geological and geophysical systems. Stander has served as chapter chairman and treasurer of the Denver SIPES chapter between 2009 to 2015.