

3-D Seismic Sweeps Through Time*

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Search and Discovery Article #40115 (2004)

*Adapted for online presentation from the Geophysical Corner column in AAPG Explorer, February 2003, entitled "3-D Seismic Maps Tell Tales," and prepared by the author. Appreciation is expressed to him and to Larry Nation, AAPG Communications Director, for their support of this online version.

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Introduction

Three-dimensional seismic has become the tool of preference for petroleum exploration and development. Over the last 20 years, advancing technology in seismic recording systems has allowed the acquisition of large areas of 3-D seismic data, and high drilling success rates have fueled the use of 3-D seismic in basins around the world, in both onshore and offshore arenas.

As 3-D seismic has swept across the U.S. onshore, it leaves evidence of past activities where explorers saw potential in various basins. Early surveys were targeted for evaluating infill drilling around existing fields. Over time, surveys spread along productive trends looking for new fields. The current pattern of 3-D seismic coverage is a good indicator of exploration maturity.

Patterns of Exploration

Location information about where 3-D seismic surveys have been shot is available from various sources. The maps shown here were compiled from public records in counties where survey locations must be reported as part of the acquisition procedure and from the many companies who place their proprietary surveys with seismic brokers for sale or trade. Although these maps may not contain all of the surveys shot, they do represent the general density of coverage in various areas -- and they reveal an interesting and thought-provoking view of seismic activity and thus exploration activity since the early 1980s, when 3-D seismic became widely available.

Looking at 3-D seismic coverage maps in Texas and Oklahoma (Figure 1) and over the Rocky Mountain basins (Figure 2), one sees a pattern of decreasing seismic coverage as you move from offshore to onshore areas. Although one might think this pattern shows the overall cost increase of acquisition, it primarily reflects the economic success of 3-D seismic in finding hydrocarbon entrapments.

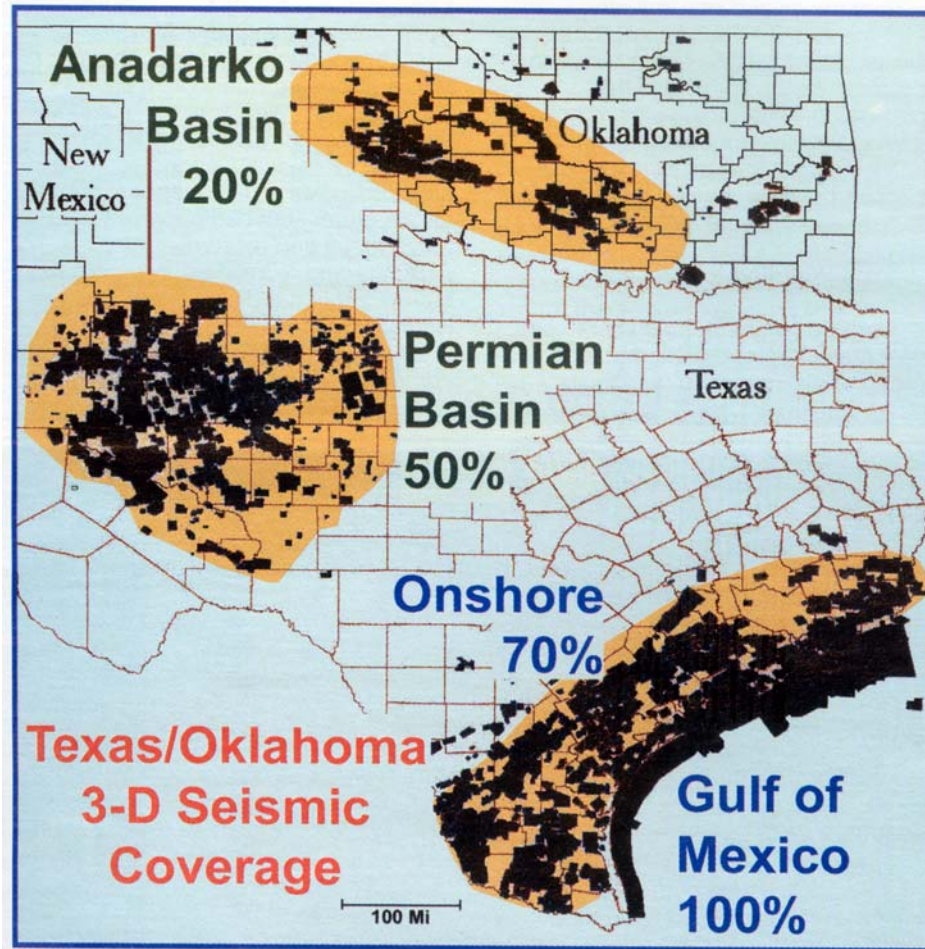


Figure 1. Texas and Oklahoma 3-D seismic coverage: A general pattern of decreasing area coverage is shown as you move from offshore (100 percent) to more difficult shooting onshore (70, to 50, to 20 percent). Graphics and data, based on a combination of public domain information and exclusive data, provided by Tricia Dark, Terra Ventures Inc. (www.terrasearch.net).

The exploration of Gulf of Mexico offshore areas is mostly dependent on seismic (no outcrops to map!), so the coverage is usually 100 percent of the area. In fact, many offshore areas have more than 100 percent coverage since there may be multiple surveys acquired by different companies over the same area.

Moving onshore in Texas, the coverage stays high at 60 to 70 percent. Early surveys were acquired over fields and then spread along coastline parallel faults looking for new traps.

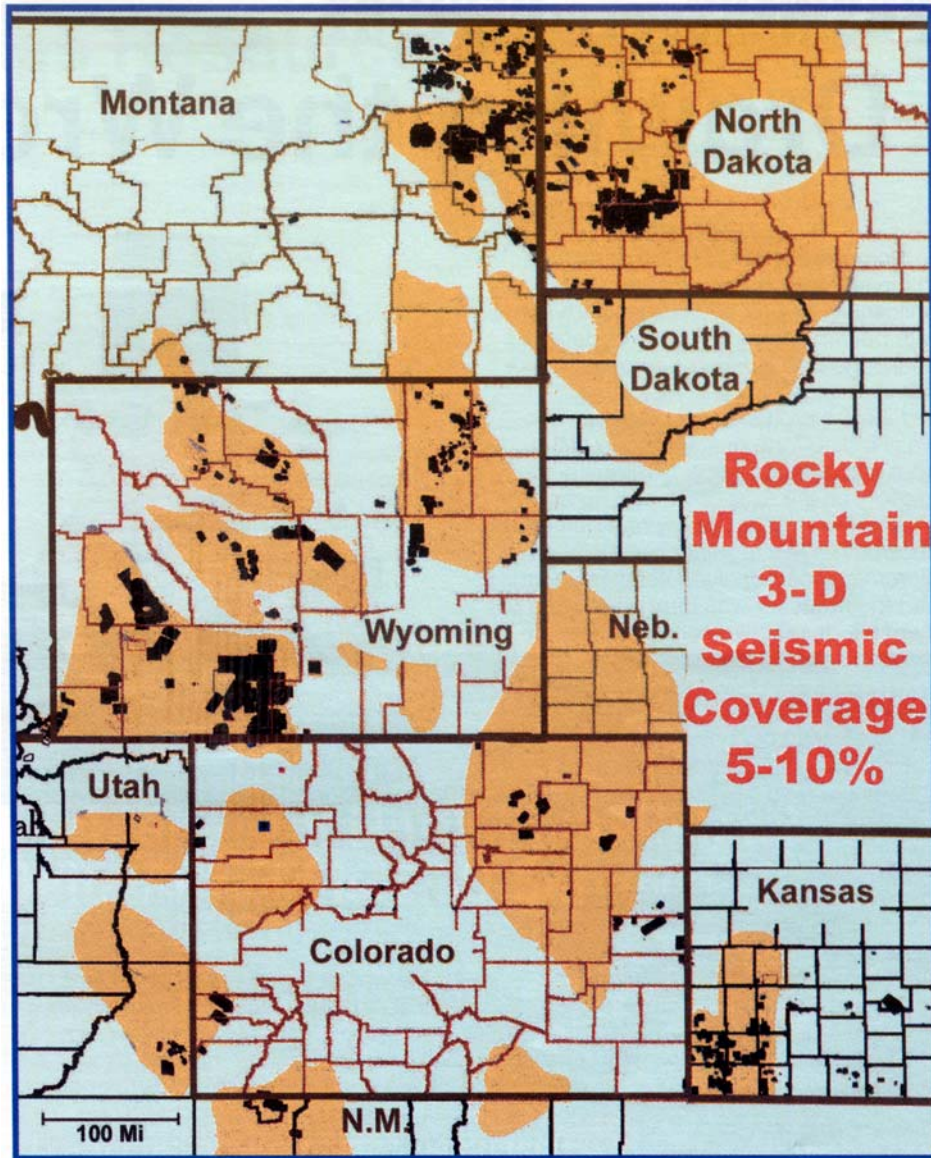


Figure 2. Rocky Mountain 3-D seismic coverage: Overall coverage is only 5 to 10 percent of the known basin areas. Localized plays within basins show coverage of 30 to 60 percent. Graphics and data, based on a combination of public domain information and exclusive data, provided by Tricia Dark, Terra Ventures Inc. (www.terraresearch.net).

"Bright Spots" and Light Spots

One reason why seismic is so widespread in the Gulf Coast is because of the enhanced capability of seismic in "soft rock" settings. In Tertiary-and Cretaceous-age clastic rocks, seismic contrasts often allow the direct detection of hydrocarbons, or "bright spot" prospecting. New AVO techniques have extended that capability by allowing more detailed analysis of amplitude anomalies in pre-stack gathers.

In the Permian Basin, seismic coverage spreads over about 50 percent of the basin. Easy land access and large ranches encouraged widespread surveys. In the early 1990s we heard stories about the Permian of "shoot the 3-D and the prospects will come," because of the multi-pay potential in stacked carbonate reservoirs. Older, harder rocks meant geophysicists could not rely on bright spots, and there was a push for higher frequency data to resolve thin porosity zones in high velocity carbonate rocks.

In the deep Anadarko Basin, seismic coverage continues to drop to about 20 percent. And in the Rockies there is a noticeable lack of 3-D seismic, with overall coverage down to only 5 to 10 percent of the basin areas. Why? Seismic acquisition is more difficult in rough terrain, and federal lands restrict access to a narrow time window of July 15 to November 15 in many areas. These onshore areas also are dominated by independent operators who have limited seismic budgets, and many proposed large surveys were not shot due to lack of underwriting.

Under-Utilized 3-D Seismic in Rockies

Based on area coverage, 3-D seismic has been under-utilized in the Rocky Mountain basins. New "Basin Centered Gas" plays, where widespread, low-permeability, gas-saturated sandstones and shales hold large gas reserves, are new targets for seismic evaluation.

Seismic techniques for mapping reservoir-enhancing characteristics, like fractures and over-pressured compartments, are developing rapidly. These "sweetspot" properties can be derived by analyzing vertical and horizontal velocity variations in 3-D data volumes.

The promise of new discoveries will fuel the continued expansion of 3-D surveys in the Rockies and other areas