Interpretation of 3D Seismic and Subsurface data from the Buffalo Valley Field, Chavez county, New Mexico
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Abstract
Structure and isopach maps derived from formation top picks reveal the presence of differential subsidence across the Buffalo Valley field during the Pennsylvanian and Permian periods. The Buffalo Valley field is located along the Northwest Shelf of the Delaware Basin. 3D seismic data reveal that the field is bounded by two normal faults, both of which drop to the southeast. The fault bounded block rotates slightly to the southeast during deposition of the reservoir intervals. Production from the Morrow Formation is concentrated within this fault block. The Morrow production trend in this area is roughly north-south at an angle to the northeast trending Northwest Shelf in this area.

3D seismic data volumes consisting of P-wave and PS-wave data are interpreted and compared in this study. VSP data (zero offset an some 3D VSP coverage) are incorporated into the seismic interpretation. The tie between surface seismic and well-log derived synthetics is generally poor due to Fresnel zone effects in these heterogeneous intervals. Correlation of formation top depths to arrival times in the zero-offset corridor stack are used to identify reflection events in the surface seismic data. In this study we examine the relationship of reflection amplitude and other seismic attributes associated with reflections from the Atoka-Morrow interval to 5-year cumulative production data from the field.

Synthetic Tie
The tie between reflection events and formation tops was established at the Read and Stevens, Inc., Lula #3 well (API No. 30-005-60481). Data available for the Lula #3 include a near offset VSP and near offset corridor stack (Figure 3). Arrival times of reflection events in the surface seismic data were approximately 44 milliseconds early relative to those in the VSP corridor stack. Weathering corrections and surface consistent static corrections are the likely cause of this difference. Surface seismic data in the vicinity of the Lula #3 well (Figure 3) along with the near offset corridor stack and bandpass filtered synthetic seismic traces compiled from the Lula #3 sonic illustrate the seismic tie used to interpret reflection events. The east well inline 1034 is split at the Lula #3 well. The corridor stack along with a series of bandpass filtered synthetics have been inserted into the gap at the well location for comparison to surrounding seismic data. Formation top correlations to reflection events are illustrated. The section is quite heterogeneous at local scales, and Fresnel zone effects likely prevent a good match of synthetic to corridor stack and VSP corridor stack to surface seismic. Some of this heterogeneity can be observed in the 3D VSP data around the Lula #3 well (Right). The Fresnel zone radius at lower Pennsylvanian Morrow depths is approximately 1500 feet using an RMS velocity of 16400 feet per second derived from the well velocity survey, and dominant frequency of approximately 62.5 Hz. Given the 3D VSP response, it is not surprising to see disagreement in the details of the seismic response observed between the various data sets and the synthetic seismogram. Based on the above comparisons we place the base of the Morrow (top of the Chester) at 1.074 sec in the surface seismic. The reflection from the top of the Atoka arrives at approximately 1.041 sec.

Background
The study area is located within the Buffalo Valley field in the southern part of the Chavez County, New Mexico (Figure 1). The area lies on the Northwest Shelf of the Delaware Basin. Production in the Buffalo Valley field is largely from a channel sand at the base of the Morrow Formation. Reservoir depth in the field is approximately 9000 feet subsurface. The Morrow Formation consists mostly of interbedded sand, shale and thin limestone deposits. The reservoir quality sandstone lies in the lower part of the Morrow formation and is interpreted to be an inter-distributary channel fill deposit. The base of the Morrow coincides with the Mississippian unconformity. Channels at the base of the Morrow scour into the Mississippian Barnett shale, which overlies the Chester Formation. The top of the Morrow is overlain by Atoka Formation which is comprised mostly of sand shale and carbonate.

Seismic time structure
Time structure on the Chester and Atoka reflection events (figures 6 and 7, respectively) reveals that the field is bounded along its western and eastern margins by two faults across which the strata drop to the east. Seismic profiles from the 3D survey (Figure 8) reveal that these faults are nearly vertical. The isochore map for the Atoka to Chester reflection events (Figure 9) suggests some movement along these faults occurred during deposition of this lower Pennsylvanian interval.
Structure & Isopach Maps

Structure on the top of the Chester and Atoka formations is shown in Figures 10 and 11. In general the structure follows the northeast trend of the Northwestern Shelf; however, north trending structural indentations interrupt the regional trend within the field. Comparison of the time and structure maps suggests that the north trending faults observed in the 3D seismic data are probably associated with the structural indentation portrayed in the well derived structure maps.

The isochore map of the Atoka to Chester top (Atoka through Morrow) reflection times (Figure 9) shows thickening along the westernmost fault as well as across the southern extent of the fault block in the survey area. The southern part of the block appears to have rotated south-southwest during deposition, and at the same time there appears to have been local subsidence across the western fault that diminished to the north along its length. Reduced travel time differences observed in the Atoka-Morrow isochore to the north, along the trend of the western fault, show some similarity to the decreased thickness of the interval observed in the isopach map (Figure 12).

The Atoka-Morrow isopach map (Figure 12) reveals that in the northern part of the 3D survey area the Atoka-Morrow interval is over 100 feet thick, and increases to over 200 feet thick in the south. The well derived maps provide a much coarser view of the subsurface, with well spacing of about 2000 feet on average. However a pronounced trend of thickened Atoka-Morrow is clearly revealed along the trend of the seismic interpreted fault block. Future efforts will include conversion from timer to depth based on available sonic and well control from the field.

Production Data

Five year cumulative production data from the Buffalo Valley field are shown in figures 13 and 14. Production data from two wells were included. The average 5 year cumulative production obtained from 57 wells in the field is 4842.07 Bbl

Seismic Attributes

The 3D seismic data set also includes a converted P to S wave volume. Side-by-side examples of the P-wave and PS-wave data are shown below (figures 17 and 18 respectively). A pronounced zone of reduced amplitude is observed in the PS-wave data volume that is not observed in the P-wave section. This zone of low amplitude and reflection coherence may be associated with a narrow fracture zone (potentially gas filled).

References

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Acknowledgements

This research was funded through DOE/NETL contract DE-FC26-03NT41629. Our thanks to WesternGeco for providing the 3D seismic data from the area. The comments of Dave Oldham were greatly appreciated. Much of the well data were obtained from the New Mexico Energy, Minerals, and Natural Resources Department Oil Conservation Division at http://localhost/oemnd/state.nmsu.edu/. Production data used in the study were obtained from the New Mexico Tech “Go-Tech” site at http://octane.nmt.edu/data/engan/.