Seismic and Structural Analysis of a Trenton-Black River Hydrothermal Dolomite Reservoir

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ABSTRACT

Trenton-Black River reservoirs in the Appalachian Basin are typically associated with fault-related hydrothermal dolomites that are sealed by unaltered host rocks, however the details of how faulting and fluid flow have interacted remain poorly documented. Integration of 3-D seismic, wireline and production data from Saybrook Field in northeastern Ohio has shown that the productive trend is controlled by a 5 km long, NW-SE oriented basement fault that was probably reactivated during the Taconic Orogeny in the Mid- to Late Ordovician. The far-field stresses of this compressional activity caused strike-slip movement of the pre-existing fault to create complex flower structures that branch 1350ft upward into the Trenton-Black River interval. Circular collapse structures within splays of the flower structure are the primary drilling targets. Faults were mapped using amplitude and coherency versions of the seismic data. Curvature analysis of horizons mapped in the seismic data allowed us to further constrain the location and orientation of subtle structures. Fault morphology provides insights into the path of the dolomitizing fluids, whereas the distribution of porosity, and thus the location of the reservoir, has been mapped in 3-D using a seismic attribute study. We integrated wireline log-based measurements of porosity with seismic attributes to predict the distribution of porosity throughout the 3-D volume. Advanced visualization technologies allowed us to integrate faults and porosity predictions, thereby gaining fundamental insights into the relationships between faulting, fluid flow and reservoir development. Our results, and the methodology that we employ, have application in analog settings elsewhere.

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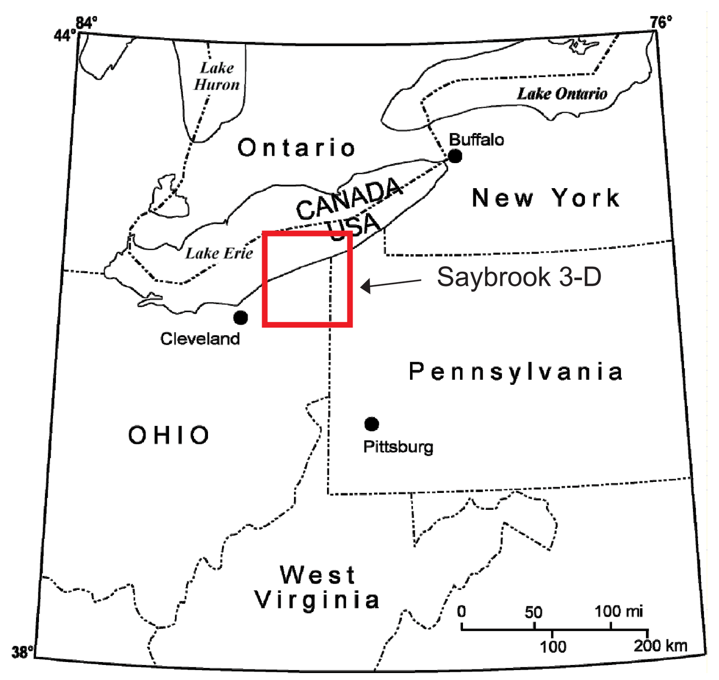

Figure 1: Location of the Saybrook 3-D in Ashtabula County in the northeast corner of Ohio.

2

System	Series	Northeastern Ohio
Silurian	Alexandrian	Clinton Sandstone
Ordovician (438mya)	Cincinnatian	Queenston Shale (Utica)
	Mohawkian	Trenton-Black River Limestone
	Whiterockian	Wells Creek Formation
	Ibexian	Knox Unconformity
Cambrian (505mya)	St. Croixian	Trempealeau / Knox Dolomite

Figure 2: A simplified stratigraphic column for northeastern Ohio from the Late Cambrian to the Early Silurian (adapted from Larsen, 2000). The Trenton-Black River was deposited primarily as supratidal to subtidal bioclastic carbonates (Middleton et al., 1993).

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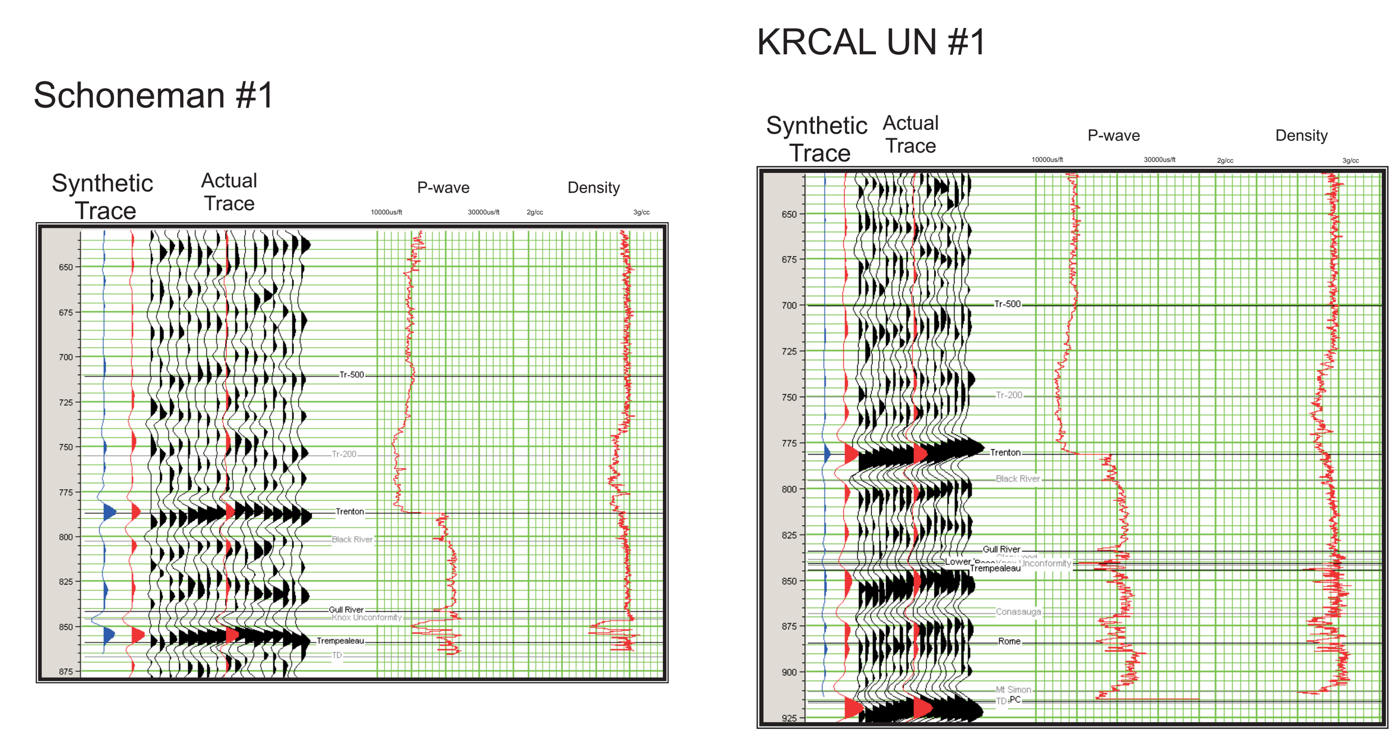

Figure 3: The synthetic traces and well ties for the two wells with sonic logs, Schoneman and KRCAL. The synthetic correlated well with correlation coefficients of 0.82 and 0.87 respectively.

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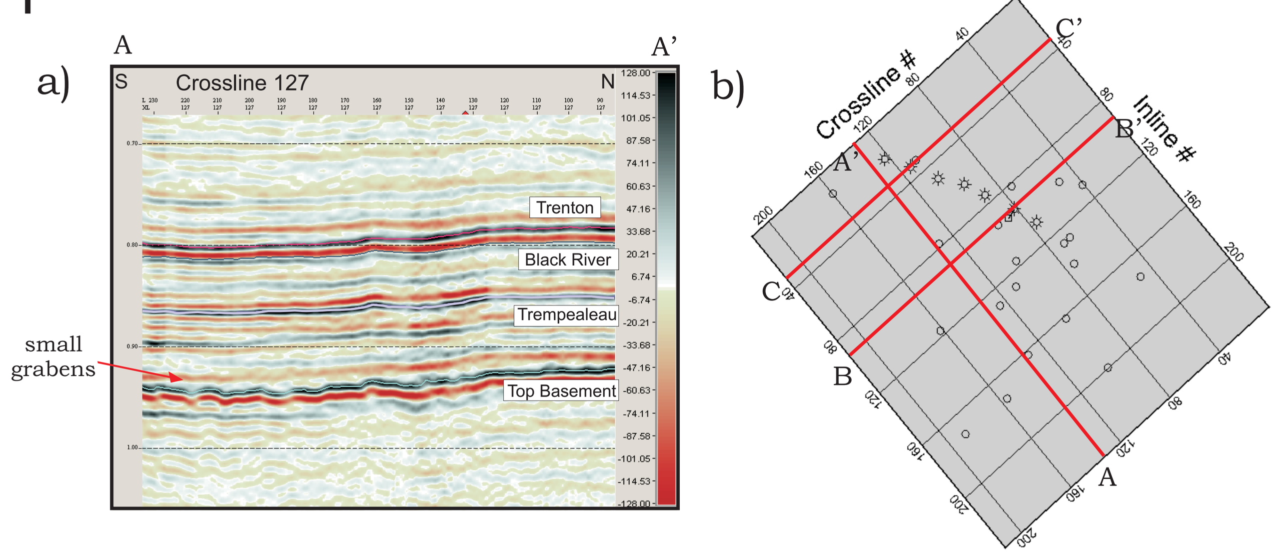

Figure 4: a) Sample seismic line with horizon picks shown. Note the small grabens in the basement in the south of the survey, and the higher structure to the north. b) Base map for Saybrook, with the cross sections for Figures 7 and 17 shown.

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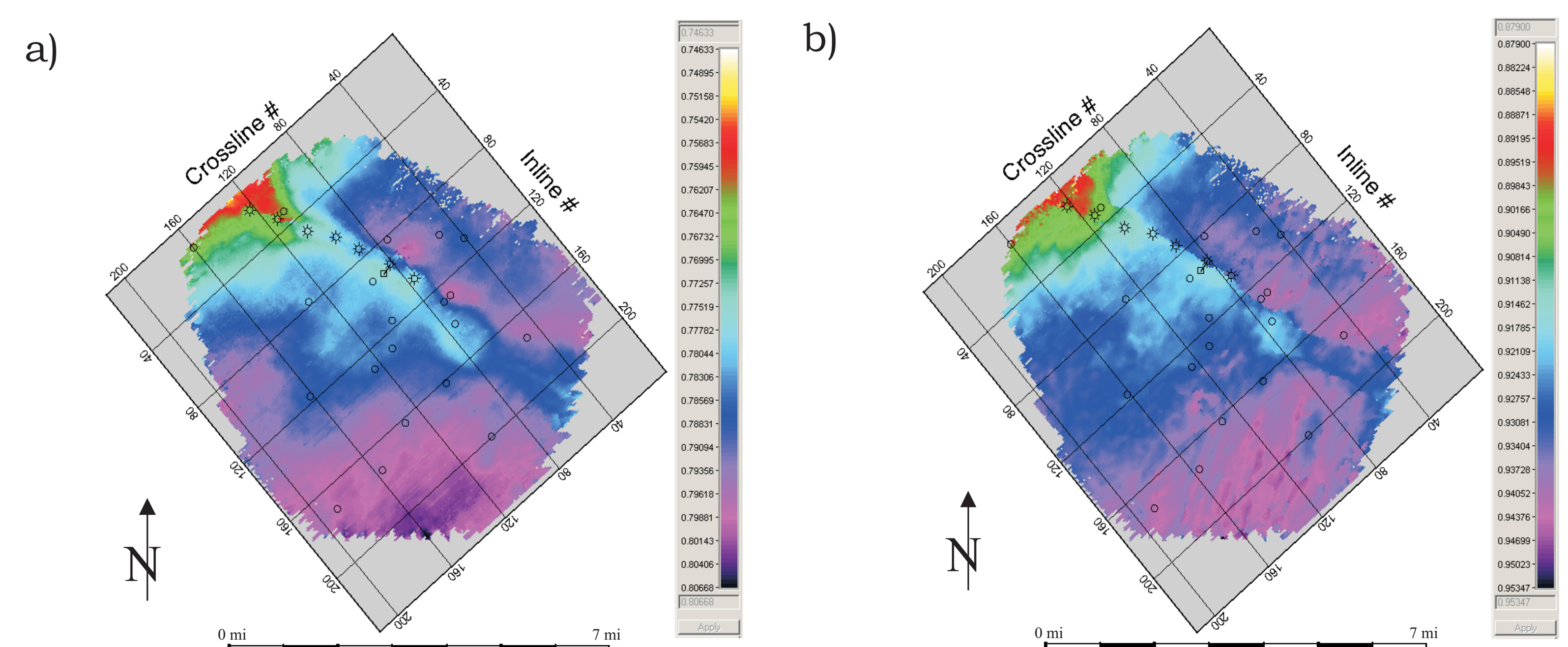

Figure 5: Time structure maps for top of the Trenton (a) and Top of the Basement. Both structure maps show a ridge associated with the faulting and productive trend. The Top Basement map shows some NE-SW trending structures that appear to be small grabens in cross section (see Figure 4). However, these structures are not apparent at the Trenton level.

6

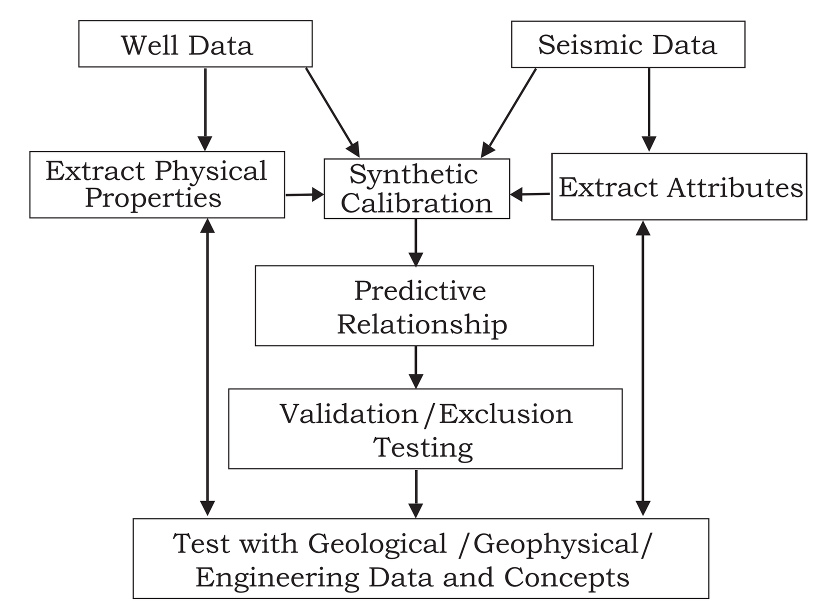

Figure 6: A schematic diagram of the workflow followed during this study (adapted from Pearson and Hart, 2004)

METHODOLOGY

The following steps were taken in the completion of this study:

First the horizons were picked in the well logs, then synthetic seismograms were created to tie the wells to the seismic data. The horizons were then picked in the seismic data, and faults were mapped using a combination of coherency and conventional amplitude seismic displays and the resulting structural features were analyzed. We sought to create a porosity volume for the Trenton-Black River interval using the total average porosity (PHIA), which was generated from the average of the density porosity and neutron porosity logs. We used the methodology of Hampson et al. (2001) to identify the best combination of attributes for predicting PHIA. We then trained a neural network to convert the seismic amplitude data to a porosity volume. The porosity volume was combined with the fault mapping in order to examine relationships between porosity and structural features.