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Surface-Sourced Seismic Data to Find Shallow Bypassed Oil

G. L. Kinsland, D. N. Cimadoma, and R. Zhang

School of Geosciences, University of Louisiana at Lafayette, Hamilton Hall Rm. 323,
611 McKinley St., P.O. Box 43717, Lafayette Louisiana 70504–3717

ABSTRACT

We are studying how bypassed oil in old, relatively shallow fields may be found with surface-sourced seismic data (SSSD), which image to about 5000 ft. We have collected and imaged SSSD in LaSalle Parish, LA, correlated these data to old well logs using resistivity based sonic models, and have performed AVA analyses. Our results show that the high temporal and spatial resolution of the SSSD allow interpretation of the shallow fluvial deposits which were either never surveyed with industry seismic data or were not adequately resolved within such data, whose collection was designed for deeper targets. Our results illustrate the advantages and capabilities of SSSD—no shot holes, no explosive permits, less risk to subsurface infrastructure, smaller surface environmental footprint, tighter shot spacing for the cost and time, and higher frequency to horizons of interest. Examples of underdrilled old fields demonstrate where remapping of well-logs coupled with targeted 2D and/or 3D SSSD may be utilized to delineate between wells and to extend facies and structure beyond existing well control to find bypassed pay.

INTRODUCTION

Many oil fields, worldwide but particularly in the Gulf of Mexico Basin, were found and developed by drilling without the use of seismic data. For some, the reason was because they were found before the seismic method was developed. For others the reservoirs were shallower than could be adequately and/or economically imaged with the seismic techniques in use at the time. Many of these fields were around salt domes. Others were in the updip regions of the Gulf of Mexico Basin where productive strata were shallower. Others were in the shallow, younger, flu-

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vial strata near to the Gulf of Mexico. Production has continued from some of these fields; however, exploration left behind bypassed oil as the industry progressed downdip and deeper out into the waters of the Gulf of Mexico.

This bypassed oil exists in incompletely developed reservoirs as attic deposits, in fault separated deposits and in "depleted" reservoirs whose depletion cones have flattened. It also exists within fields in reservoirs never previously detected by drilling.

We propose that surface-sourced seismic data (SSSD), which image to about 5000 ft with higher spatial and temporal resolution than standard petroleum land seismic data, may be utilized to find these bypassed deposits. The high-resolution seismic data may be tied to the existing well-logs by utilizing appropriate conversions of resistivity logs to pseudo-sonic logs.

METHODS

Kinsland et al. (2016) demonstrated that SSSD may be utilized to image strata to about 5000 ft better than typical industry seismic data, which are designed and implemented to image deeper strata. They used an A–200 Nitrogen Accelerated Impact Energy Source from United Service Alliance, Inc. (Fig. 1) and a receiver system from the Allied Geophysical Laboratories at the University of Houston. Figure 2 is a single-fold field shot record from this survey in LaSalle Parish, illustrating the ability of the system to image the Carrizo Sand at about 1600 ft as well as many other strata both above and below the Carrizo.

Figure 3 illustrates that pseudo-sonic data transformed from resistivity curves using transformation equations specifically calibrated to those local wells, which have both resistivity and sonic curves, yield good ties where sonic data are not available (using the wavelet extracted from the SSSD).

Justiss Petroleum contracted for a small, 1 mi x 1.5 mi, 3D survey in Grant Parish. The survey was conducted using a surface-source similar to the one we used in LaSalle Parish. The volume was donated to our research group and interpreted by Stelly (2019) (Fig. 4).

RESULTS

We have shown that SSSD may be utilized to image strata to the range of 5000 ft with high resolution—both temporal and spatial. The technique involves an economical mobile surface source delivering repeated high frequency strikes to a base plate. Of course, the technique is not completely new. Surface sources of various sorts have been utilized in seismic data acquisition since the early days. We have shown that SSSD may be utilized in the Gulf of Mexico Basin to yield high resolution images of strata where oil was bypassed when fields were developed without seismic data. We have also shown that wells in old fields, which do not have sonic logs, may be correlated to these shallow seismic data using pseudo-sonic logs.

SUMMARY AND CONCLUSIONS

Figure 5 is an image of the well spots from Louisiana's Strategic Online Natural Resources Information System (SONRIS) (https://www.sonris.com) for the area of Cankton (just north of Lafayette) and Shuteston fields. These fields have been drilled with little to no seismic data. Many of the reservoirs are only a few thousand feet deep in the fluvial strata.

In the late 1970s, Drew Cornell and Associates drilled a well, whose location is indicated by the arrow in Figure 5, in the fluvial section and found three pay sands, all shallower than 4500 ft. They could dual complete the well and get the third sand later. However, they wanted the oil immediately, so they moved over a few tens of feet and drilled another well to drain the third sand. They found it…and a fourth sand, so they dual completed both wells.

Figure 1. A–200 nitrogen accelerated weight-drop seismic source. Photo credit: Nathan Quick.

What's our point? We believe that this fourth sand could have been imaged with the SSSD and that there are probably several other sands which contain bypassed oil, which could be imaged with the SSSD technique in Cankton and Shuteston fields.

The Gulf of Mexico Basin has hundreds of fields like Cankton and Shuteston. A survey similar in size to the Grant Parish 3D presented here could image within oil fields over several incompletely drained reservoirs with higher resolution and lower costs than standard industry seismic data. Advantages are no shot holes, no explosives, less risk to subsurface infrastructure, smaller environmental footprint. I was told that the 3D shown here from Grant Parish cost only $70,000 to shoot.

The petroleum business is not dead here. We just have to think smaller, faster, cheaper.

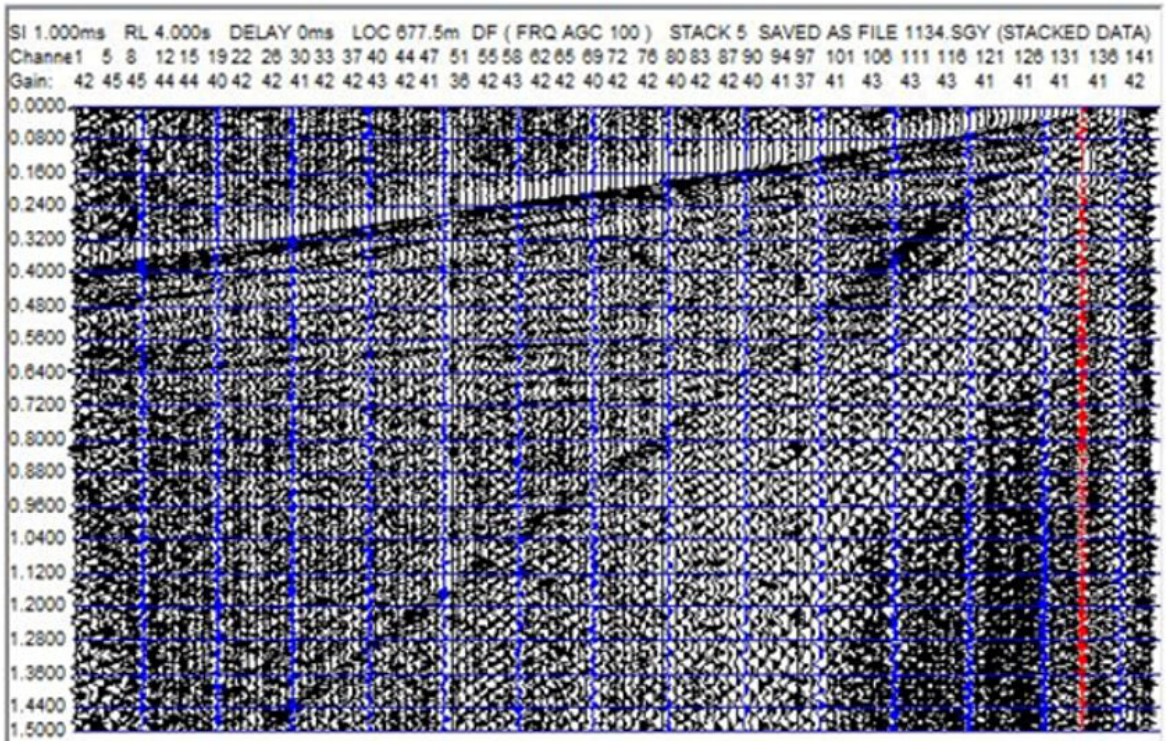

Figure 2. Screen image of a shot gather as recorded in the field. Our "minimum" target, the Carrizo Sand, is clearly imaged as a hyperbolic reflector with a far offset (left edge) time approximately 0.6400 sec. Several other reflectors are evident both above and below the Carrizo in this single fold (5 impacts stacked at one source point) record.

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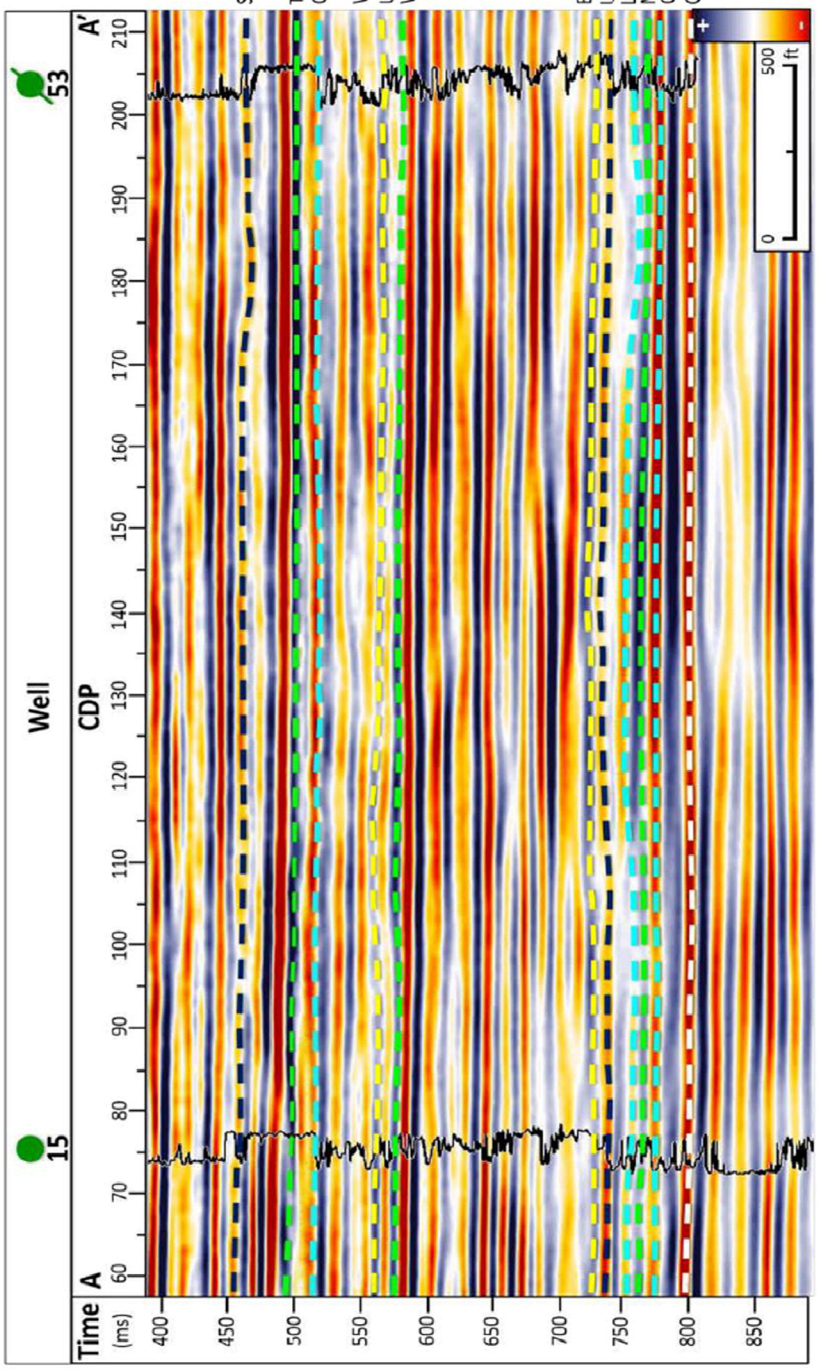

Figure 3. Close-up view of an interpreted version of the acquired seismic line, with local strata applied throughout the seismic section. Processed seismic data are courtesy of Lingfei Mao (2017). Quick (2018) was able to correlate most of the locally recognized strata within the seismic data due to the accurate seismic-to-well tie. The Wilcox 2 and Matthews sand markers are interpreted in their stratigraphic position because they are too thin to be seismically visible and register as a full event.

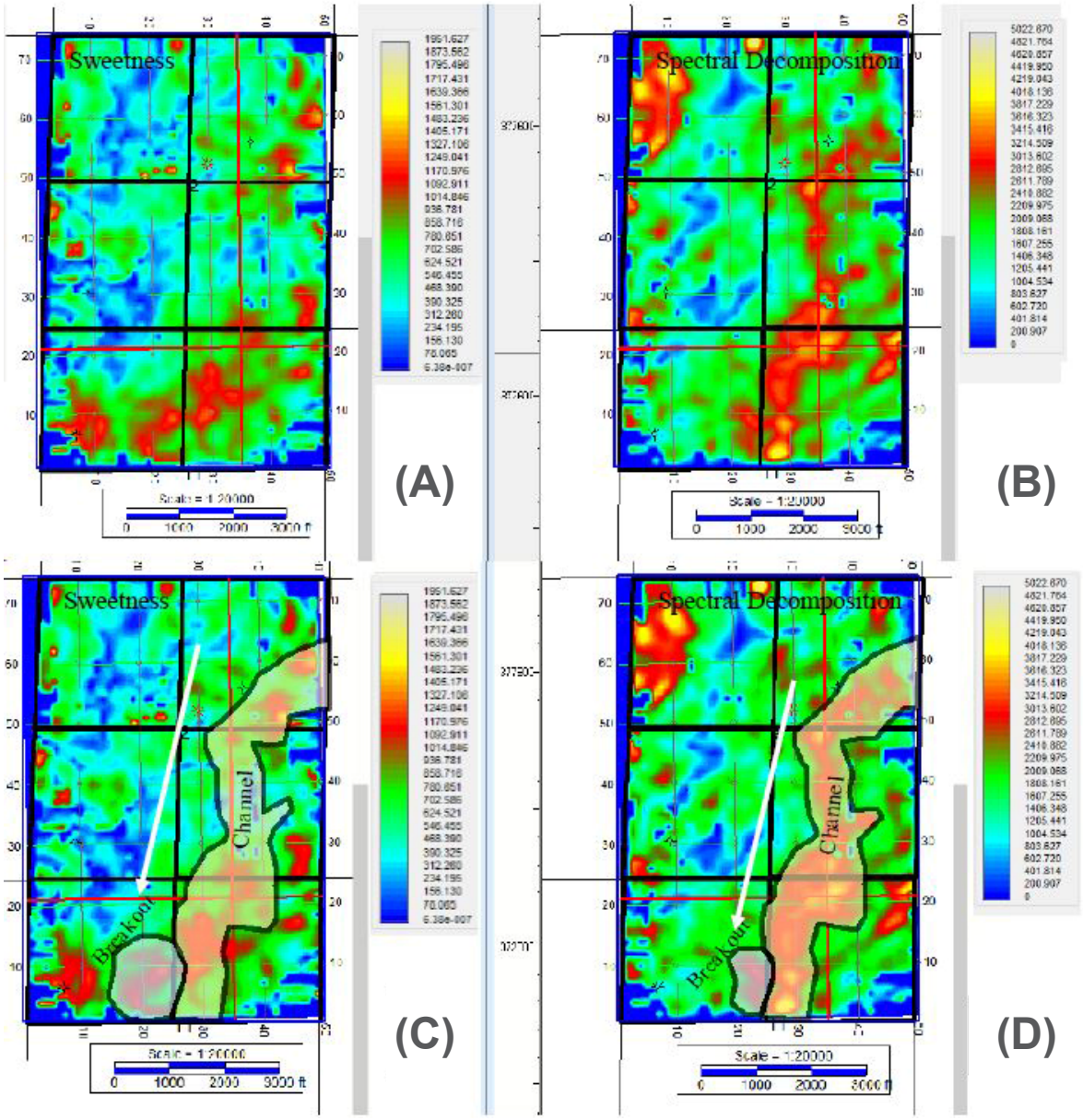

Figure 4. Small 3D from Grant Parish collected with the SSSD technique. Uninterpreted and interpreted stratal slice illustrating the ability of the data to image a small channel (modified after Stelly, 2019). Squares are ½ mile squares…not sections. The channel deposit is imaged even where it is less than a few hundred feet across. North is to top.

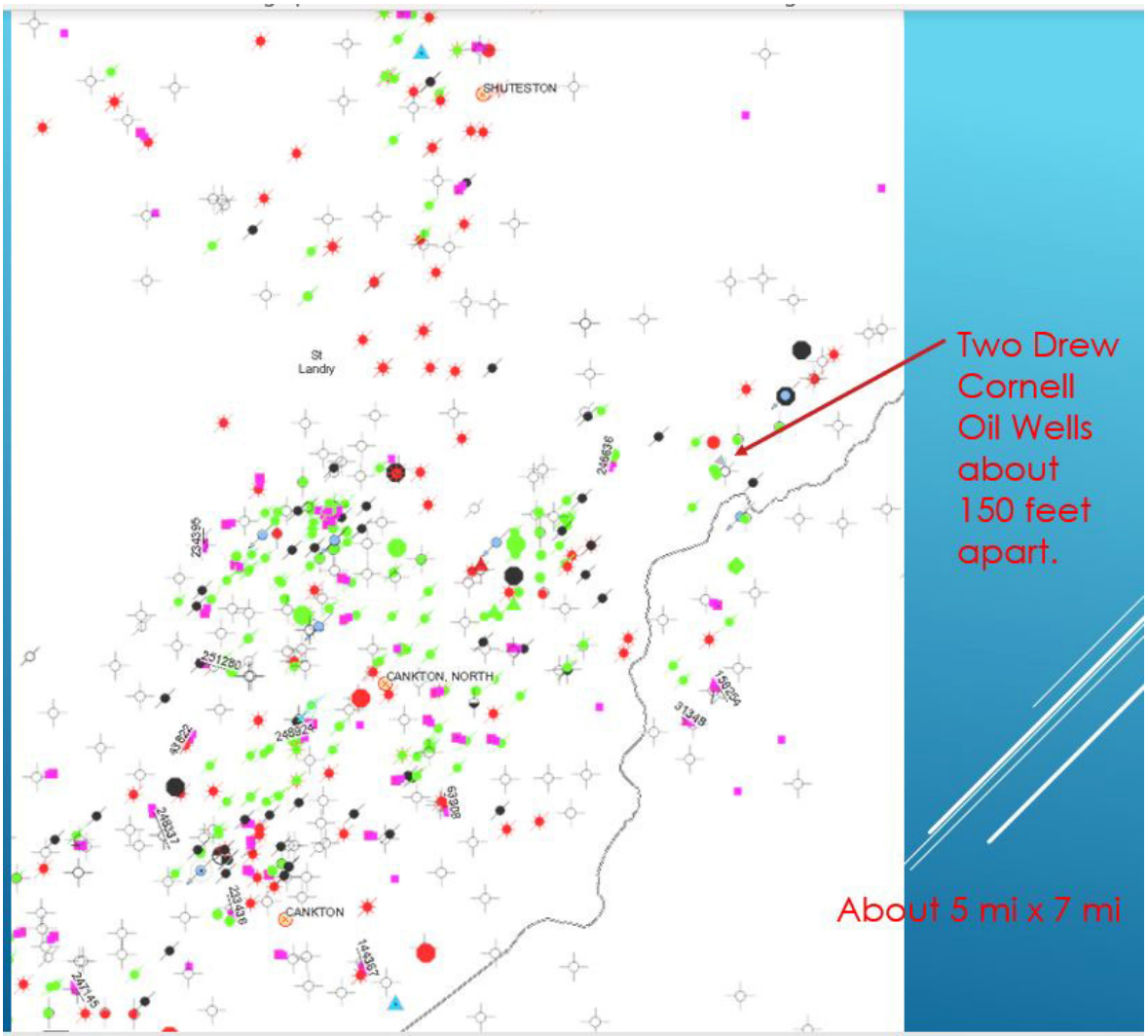

Figure 5. Well spots in the area of Cankton and Shuteston fields in southern St. Landry Parish, Louisiana. This is an example of fields which were developed with little to no seismic data...certainly no 3D data. These fields have reservoirs from a couple of thousand feet to really deep...perhaps >20,000 ft. The shallow reservoirs are certainly under-drilled. The arrow indicates the two Drew Cornell and Associates wells discussed in the text.

NOTES