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Prestack Investigation of Shallow Surface-Sourced Seismic Data in Central-Northern Louisiana

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ABSTRACT

The transgressive Carrizo Sand is a shallow reservoir sand (~1600 ft) in central-northern Louisiana that is poorly imaged in industry standard seismic data. Exploration of the sand has relied upon mapping from well-logs. To investigate this problem, a 2D high-resolution surface-sourced seismic survey was performed in LaSalle Parish by students from the University of Louisiana at Lafayette and the University of Houston. The survey consisted of a line of 144 geophones, each spaced 16.5 ft apart and a truck-mounted A 200 (nitrogen accelerated weight drop) source. The survey was designed to utilize the high frequency from the source (~60 Hz useable) and the high sampling frequency from the layout to map the shallow horizons better. In the stacked data image, the Cane River Shale/Carrizo Sand contact is a continuous high amplitude reflector. To investigate the ability of the high-resolution data to yield fluid content and lithologic information in the Carrizo, we have performed pre-stack analyses of the data. Amplitude variation with offset (AVO) analyses along the horizon indicate changes which we are investigating. If this study proves successful, high-resolution surface-sourced seismic surveys may be applied to other areas in northern Louisiana in exploration for reservoirs in the Carrizo Sand. Through pre-stack analyses and by generating AVO gathers along the horizon of interest, observations can be made that there is a change in fluid or lithology along this horizon by a large increase in amplitude with offset.

INTRODUCTION

High resolution surface-sourced seismic surveying is an acquisition practice used to image shallow reservoirs and formations. This technique, when applied to onshore targets, can be criti-

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cal to researchers and industry alike to analyze shallow reservoirs. The impetus of this study was to analyze the shallow (~1600 feet) Carrizo Sand reservoir located in northern central Louisiana to determine lithology and fluid content through pre-stack analysis and amplitude variation with offset (AVO) analysis. Very few studies have aimed to analyze the Carrizo Sand reservoir in central-northern Louisiana for the purpose of determining in situ hydrocarbons. Industry standard seismic surveys cannot accurately image shallow formations and previous studies conducted in central-northern Louisiana have relied solely on well log data. Successful results from this study can lead to further exploration of the Carrizo Sand in northern-central Louisiana and further integration of high resolution surface-sourced seismic surveys in future acquisition.

The late Eocene Carrizo formation consists of predominantly transgressive deposits of well sorted, homogeneous sands (Yancey et al., 2013) (Fig. 1). The Carrizo Sand is the uppermost unit of the Wilcox Group and sits disconformably above the Upper Wilcox (Stenzel, 1940; Harris, 1962; Breyer, 1997). The sand is very homogenous throughout the majority of the formation, consisting of close to fine- to coarse-grained micaceous quartz beds containing small percentages of clays and silts (Payne, 1975). The Carrizo Sand dips, in our research area towards east and southeast (Payne, 1975). This suggests that the formation dips basinward (Warwick, 2017). The Paleocene-Eocene Wilcox Group consists of terrigenous clastic sediments and is known for its oil and gas reservoirs (Fisher and McGowen, 1967) (Fig. 1). The Wilcox Group also contains methane-bearing coal bed intervals ranging in depth from 980 to 5500 ft, some as thick as 20 ft (6 meters) (Breland and Warwick, 2005; Warwick et al., 2006a,2006b).

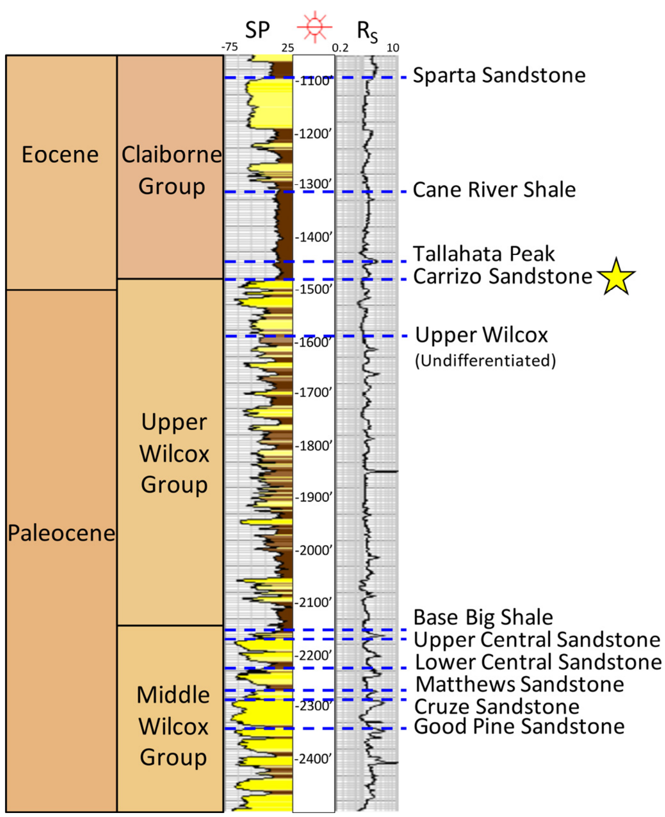

Figure 1. Geologic history with spontaneous potential and resistivity logs from WSN 69594 (modified after Quick, 2018). The red marker associated with the Cruze Sandstone represents previous gas production within this well. The target reservoir, the Carrizo Sand, is annotated with a star.

In 2015, a 2C–2D seismic survey was sourced by a collaborative project through the University of Louisiana at Lafayette and the Allied Geophysical Laboratories at the University of Houston (Kinsland et al., 2016). Previously, the Carrizo Sand was mapped at a depth of around 1600 ft and was a known producer of oil and gas products in nearby parishes of northern central Louisiana (Kinsland et al., 2016). The survey line was approximately 2519 ft long and consisted of 144 geophones, each spaced 16.4 ft apart (Kinsland et al., 2016) (Fig. 2). A truck-mounted compressed nitrogen accelerated weight drop was the primary source for this survey which was provided by United Service Alliance Inc. (Kinsland et al., 2016). At each geophone, five vertically stacked impacts were recorded (Kinsland et al., 2016).

METHODS

The raw seismic data gathered in July 2015 has been processed pre-stack in order to prepare the data for AVO. The basic pre-stack processing flow in Schlumberger VISTA software consists of trace kill, Ormsby bandpass filtering, interactive velocity analysis (IVA), and normal move out (NMO). The data are sorted by common midpoint (CMP) number and consists of 277 common midpoints. An NMO file and a velocity file are required to generate AVO gathers. A velocity file is created within an interactive velocity analysis (IVA) window. Within this window, root mean square (rms) velocity is picked every 20 CMPs. It is important to pick the correct velocity peaks or "clouds" associated with a specific reflection in order to successfully flatten an event (Fig. 3) (Yilmaz, 2001). The velocity file generated within the IVA window is then integrated into the NMO. Following these procedures, fluid content and lithology can be assessed through AVO gathers. When designing the parameters for an AVO gather, the first step is to

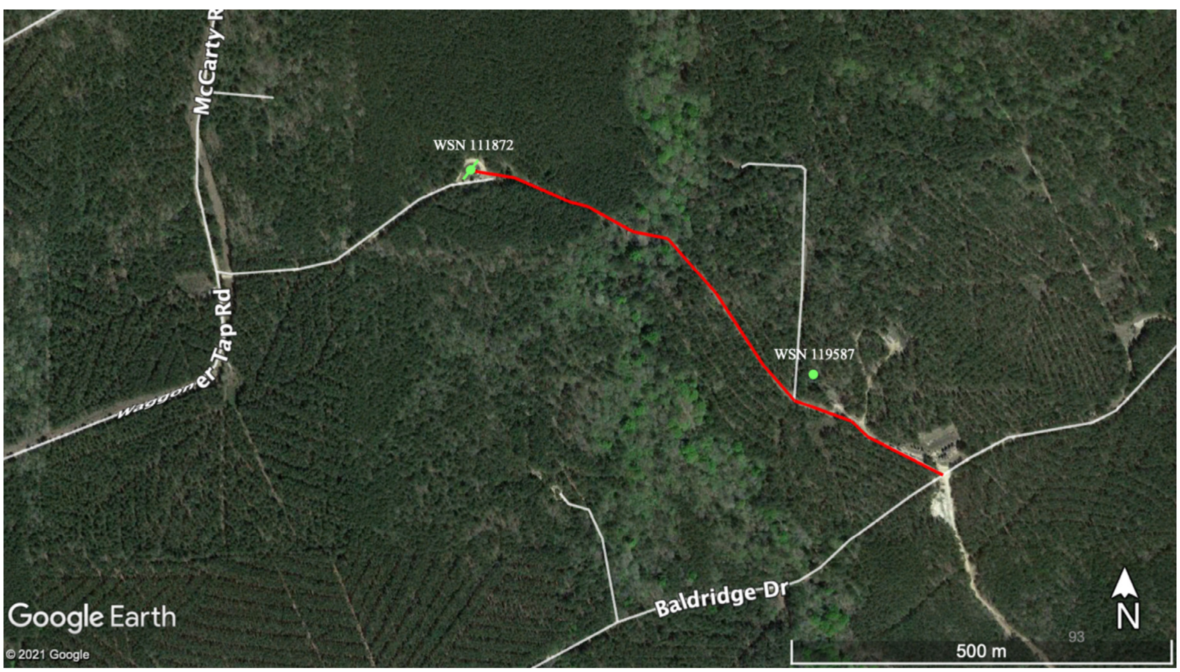

Figure 2. Depiction of the path used in the acquisition of the 2D seismic data. The seismic survey is roughly 2,519 ft (768 m) long. WSN 111872 is a plugged and abandoned oil well. WSN 119587 is an active oil well. WSN 119587 is approximately 61 meters away from the seismic line. WSN 111872 is located just outside of the seismic line and cannot be seen within the designed seismic fold.

determine the number of traces and degrees of offset. For this study, two AVO gathers were generated, one with 4 traces and the other with 8 traces with a degree of offset from 0 to 40 (Figs. 4 and 5). These parameters are determined by the fold of the data. The fold is determined by the number of receivers and the spacing for the shots and receivers.

RESULTS

Located at approximately 530 msec is the perceived target reservoir, the Carrizo Sand. Figures 4 and 5 are zoomed-in displays of the northwest side of our survey line, which depicts a large amplitude change located near the Carrizo Sand. After further investigation and analysis of this data, it has been determined that this large amplitude is actually the Tallahata peak. This came as a surprise as all previous work thus far has been modeled with the previous interpretations that this amplitude was associated with the Carrizo Sand. This new discovery came about when comparing the AVO gathers with a seismic well tie and pseudo-sonic log produced by Quick (2018) (Figs. 6 and 7). Faust was the preferred model for generating a sonic log for the most accurate seismic to well tie (Quick, 2018). The Tallahata peak is found within the Cane River Shale and displays minimal lithologic change within the spontaneous potential logs. However, in reviewing the pseudo-sonic log, a large transition in velocity occurs at the Tallahata peak and

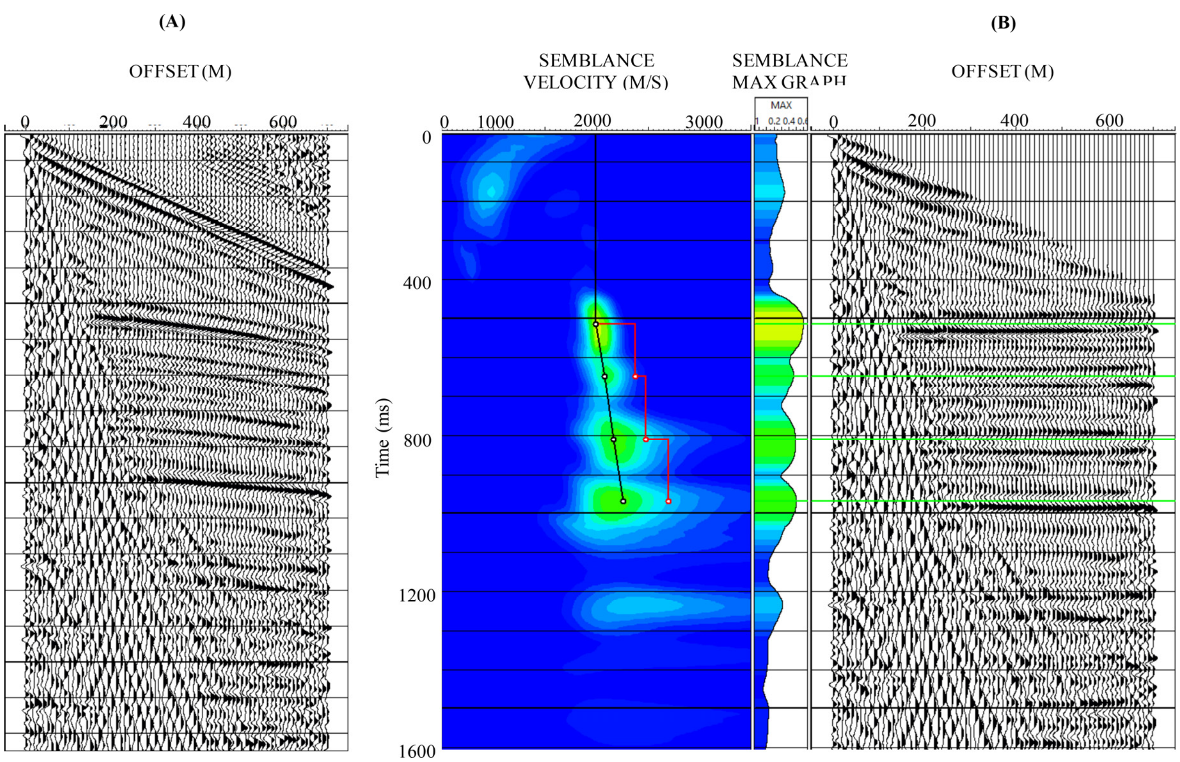

Figure 3. Interactive velocity analysis (IVA) window. Root mean square (rms) picks are chosen based on high concentrations of velocity at a given time that is associated with the corresponding formations in time. The picked velocity is depicted in black and is the root mean square (rms) velocity. The interval velocity is then auto-populated following the selection. (A) Horizons with offset prior to velocity picking. (B) Flattened horizons with offset that confirm a correct velocity pick and successful normal move out.

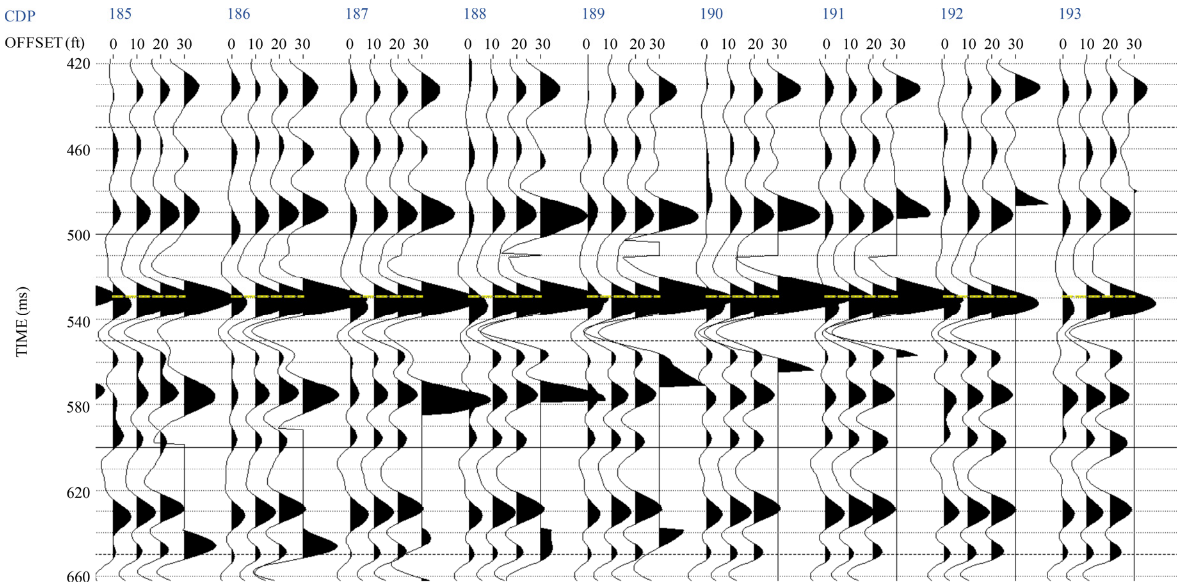

Figure 4. AVO gathers from CDP 185 to 193. The yellow line displayed is mapping a high amplitude signature located near the Carrizo Sand. The degrees in offset produced from a gather with four traces ranging from 0 to 30 ft.

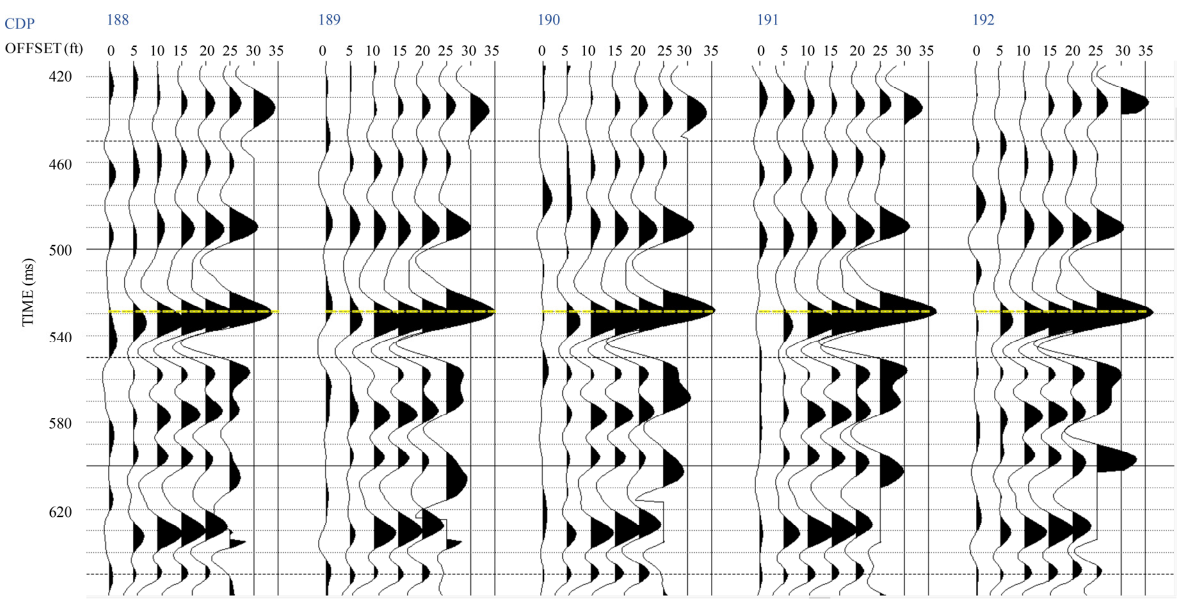

Figure 5. AVO gathers from CDP 188 to 193. The yellow line displayed is mapping a high amplitude signature located near the Carrizo Sand. The degree in offset produced from a gather with eight traces ranging from 0 to 35 ft.

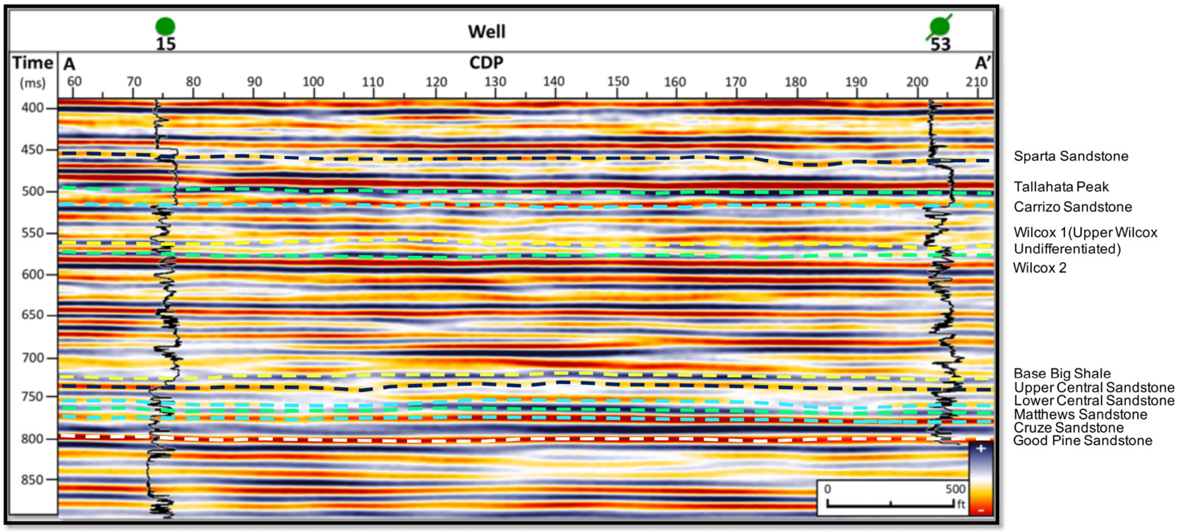

Figure 6. Seismic well tie of projected wells (modified after Quick, 2018).

it is inferred that this large change in acoustic impedance would dampen the Carrizo sand reflection. This means that future work to characterize fluid content within the Carrizo Sand cannot be analyzed as originally thought. Future work will aim to study the sonic data and the possibility of deducing the Carrizo influence in the signature surrounding the Tallahata peak and the Carrizo Sand. Additional AVO analysis may provide further insight to determine the lateral change at the Tallahata peak/Carrizo Sand contact.

SUMMARY AND CONCLUSIONS

High resolution surface-sourced seismic surveys can image shallow reservoirs and formations and can be a unique and effective technique for future exploration in northern central Louisiana. The evidence to defend this statement lies within the AVO gathers which show amplitude change with offset.

There are a few challenges that are prevalent within this dataset. Firstly, because the survey line was not shot over existing wells, there is a lack of well logs needed to conduct more advanced AVO modeling. With the use of multiple different types of well logs (the logs provided by the projected wells consist of spontaneous potential logs and resistivity logs) further analysis of lithology and fluid content can be assessed. Another problem faced is the absence of 3D data in the location of the survey. Shooting more seismic surveys is always a preferred exploration method and would provide further insight into lithologic depths and hydrocarbon potential. This could also help provide insight into the potential size of in situ hydrocarbons.

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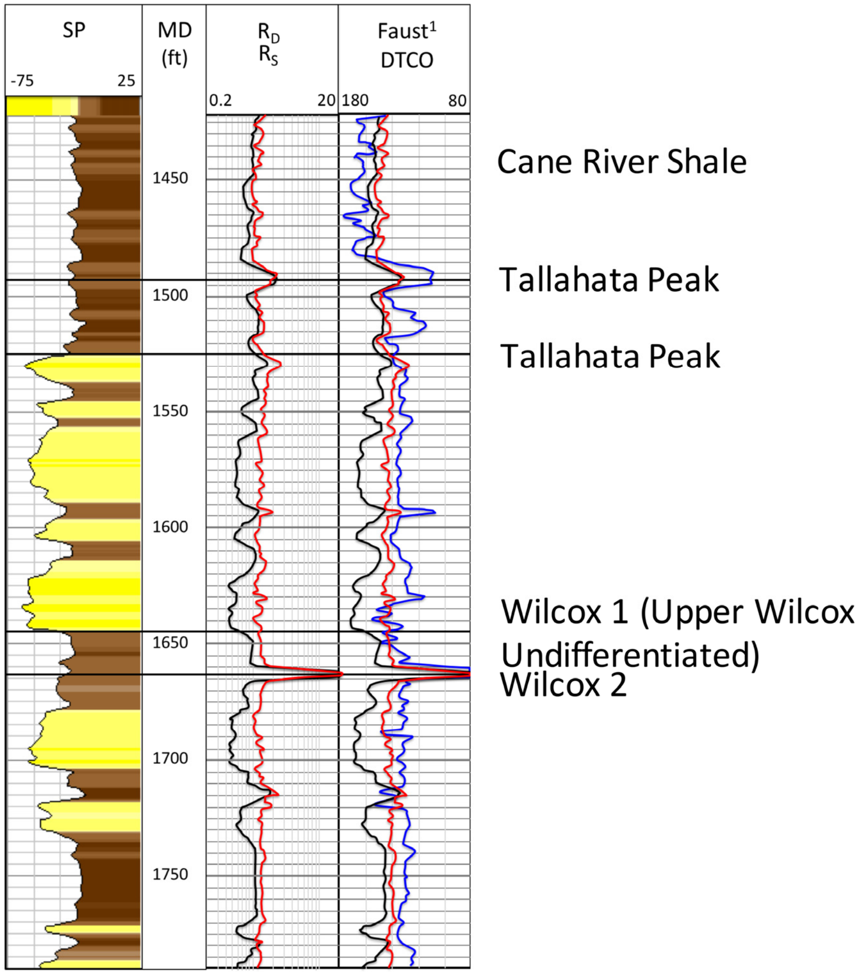

Figure 7. Faust velocity log and spontaneous potential log generated from WSN 240569 (modified after Quick, 2018). The sonic log (DTC) is displayed in blue, shallow resistivity logs (R_S) are displayed in red and deep resistivity logs (R_D) are displayed in black.

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