Mapping Lower Austin Chalk Primary and Secondary Porosity Using Modern 3-D Seismic and Well Log Methods in Zavala County, Texas*

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Abstract

Establishing fracture distribution and porosity trends is key to successful well design. The Austin Chalk has historically been referred to as an unpredictable producer due to high fracture concentration and lateral variation in stratigraphy, however recent drilling activity targeting the lower Austin Chalk has been very successful. The Upper Cretaceous Austin Chalk (AC) and Eagle Ford (EF) units are considered by many to act as a single hydrocarbon system so both units are investigated. Communication between these two units is largely through expulsion or dewatering fractures, extensional faults or along the AC/EF unconformity. Total porosity for the Eagle Ford is composed of a primary matrix component and secondary fracture porosity. For the Austin Chalk, the secondary porosity includes both dissolution and fracture components which complicate wireline and seismic interpretation.

The current study interprets 40 square miles of modern 3D seismic data for horizons and faults using amplitude, coherence and ant tracking seismic attributes. Post stack acoustic impedance (AI) inversion is applied to the time migrated seismic volume with control from two wells; this input data is similar to that available to independent operators active in the area. Wireline acoustic impedance plotted against density-porosity reveal strong correlations that allow calibration of seismic AI into primary, secondary and total porosity from which time slices and surface maps are created. Relationships are identified between porosity and geological features of interest, such as faulted and brittle zones, that may prove useful in guiding future well development in the lower Austin Chalk.
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Abstract
Establishing fracture distribution and porosity trends is key to successful well design. The Austin Chalk (AC) has historically been referred to as an unpredictable producer due to local fracture density and lateral variation in stratigraphy. Total porosity for the AC is comprised of a primary matrix component and a secondary component including fracture and dissolution porosity which complicate reservoir and seismic interpretation.

A post-stack acoustic impedance inversion (AI) was applied to the time migrated seismic volume with control from two wells. Fractures not confined to the Lower AC are typically leaky or unpredictable producer due to local fracture density and lateral variation in stratigraphy. Total porosity for the AC is comprised of a primary matrix component and a secondary component including fracture and dissolution porosity which complicate reservoir and seismic interpretation.

Seismic Inversion
AI is the product of density and P wave velocity. Resolution is increased and wavelet side lobes are removed, reducing the risk of false geological structures.

A synthetic seismogram was performed on the Holdsworth Nelson (92%) and Holdsworth Nelson (95%) wells using a wavelet extracted from a 3x3 radius around the well, over a time window of 600 ms centered on the Lower AC. The amplitude volume shows faulting in the younger units but no offset within the AC. Higher AI is associated with brittle rocks and lower AI with ductile units. Good correlation between wireline AI and the surrounding AI volume in seen from both wells. Values close to 46000 ft/s*g/cm³ make up most of the Lower AC in the Holdsworth Nelson, however from the FMI, this is known to be relatively fracture-free.

Seismic Interpretation
Fractures not confined to the Lower AC are typically leaky or unpredictable producer due to local fracture density and lateral variation in stratigraphy. Total porosity for the AC is comprised of a primary matrix component and a secondary component including fracture and dissolution porosity which complicate reservoir and seismic interpretation.

Fractures confined to the Lower AC are typically likely to be water bearing. Greater production is correlated with the increasing numbers of fractures intersected.

The AC is divided into 3 lithological units. The Lower AC is an interbedded marl and chalk unit and is the focus of this study. It is a laminated wackestone, deposited during a regressive cycle in water depths up to 3000 ft.

Model based Inversion Workflow
A model based inversion workflow was created using a time slice approach in wireline acoustic impedance (AI) and sonic logs. Total porosity was calculated from sonic logs and neutron-density logs using a proprietary AI vs. sonic and AIm vs. ND correlation.

Results
The amplitude volume shows faulting in the younger units but no offset within the AC. Higher AI is associated with brittle rocks and lower AI with ductile units. Good correlation between wireline AI and the surrounding AI volume is seen from both wells. Values close to 46000 ft/s*g/cm³ make up most of the Lower AC in the Holdsworth Nelson, however from the FMI, this is known to be relatively fracture-free.

Conclusions
A model based inversion produced the most accurate AI volume.

Selected References