# Data conditioning and seismic attribute analysis in the Eagle Ford Shale Play: Examples from Sinor Ranch, Live Oak County, Texas

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**Summary**

The Eagle Ford Shale is an emerging shale gas play in South Texas. Seismic data from the area are dominated by high amplitude reflections from carbonates and salt. The combination of land acquisition and processing challenges can produce noisy 3D seismic data volumes that are difficult to interpret. Structurally oriented noise reduction techniques remove noise while preserving signal, creating a volume that is easier to interpret. Seismic attributes calculated on the cleaner data provide a better picture of the subtle stratigraphy in this area.

**Introduction**

The Eagle Ford Shale is a marine shale located in South Texas that was deposited during the Upper Cretaecous. It is an emerging unconventional play, with fewer than 100 wells drilled so far. It has recently attracted the attention of major oil companies and is proving to be competitive with the Haynesville and Marcellus due to higher liquid content and lower well costs. Additionally, the Eagle Ford has a higher carbonate to shale percentage, making it brittle and thus more "fracable" and is not as highly pressured as the Haynesville. While it is primarily a gas play, some oil has been discovered in the southwest portion of the trend.

Geophysical support for the play will become more critical as many companies receive 3D data sets in the area in 2010. The depth, thickness, and mineralogy of the shale can vary significantly over short distances and at different scales (Liro et al., 1994). Seismic attributes can be a critical factor in identifying these changes. Sandwiched between the Austin Chalk and the Edwards, the Eagle Ford can be overwhelmed by these bright reflectors. In addition, drilling in this play is moving from vertical to horizontal wells. Therefore, accurate and interpretable seismic data is more vital than ever to well success. We can utilize seismic attributes as we move from understanding the Eagle Ford as a source rock into a reservoir context.

Live Oak County, Texas, is the site of several recent discovery wells in the Eagle Ford, with many more wells planned for 2010. We present examples of seismic data conditioning and attribute analysis on a 3D seismic volume from Sinor Ranch in Live Oak County to help increase our understanding of the geologic context of the play.

**Geologic Setting**

After the rifting that occurred during the Jurassic, the Cretaceous period was relatively quiescent in the northern Gulf of Mexico. In the early Cretaceous, shelf-edge reefs developed along the boundary between the continental shelf and Gulf of Mexico basin. In the late Cretaceous, no reefs formed; the Eagle Ford was deposited during a transgression that covered the reefs with lime mud and shale (Condon and Dyman, 2006).

The Eagle Ford consists of a lower transgressive unit of dark shales and an upper highstand of unit shales and limestones. The lower unit was deposited in a lower energy, poorly oxygenated environment and is more oil-prone. The upper unit accumulated in a higher energy, shallower water environment during a regressive highstand and is gas-prone (Dawson, 2000; Liro et al., 1994). There is a regionally recognizable unconformity at the base of the Eagle Ford, and the Austin Chalk lies unconformably on top of the Eagle Ford. The Austin/Eagle Ford contact represents the Turonian/Coniacian boundary (89 Ma) (Condon and Dyman, 2006). In Live Oak County, these strata are underlain by Jurassic salt.

The Eagle Ford Shale is at medium depth (4,000-12,000 feet) and up to 300 feet thick in places. The early Cretaceous shelf edge (Edwards trend) cuts through the middle of Live Oak County, trending southwest-northeast (Condon and Dyman, 2006). Most of the production occurs near the convergence of the Stuart City Reef Trend and the Sligo Reef Trend.

The Eagle Ford has long been known as the source rock for the overlying Austin Chalk, but it has only recently been investigated as an unconventional reservoir. Structural and stratigraphic information will be crucial to reservoir characterization, and with less than 100 wells drilled into the trend, we must rely heavily on seismic data to provide geologic constraints.

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# Seismic Attributes in the Eagle Ford Shale Play

## Data Conditioning

Seismic data acquired over the Eagle Ford Shale can be noisy, due both to acquisition and processing effects. The lithology in the area includes carbonates, shales, clastics and salt. The Eagle Ford is fairly deep, at depths of up to 12,000 ft and two-way travel times of over 3 seconds. It is important to image the Eagle Ford as accurately as possible, because small changes in the character of the reflector may imply significant changes in reservoir characteristics, such as porosity (Montgomery, 2000).

Noise reduction, or data conditioning, therefore becomes a very important processing step. Our input data consisted of a 3D post-stack seismic data volume from Seitel, which was acquired in 2007 with a Vibroseis source and processed through prestack time migration. We applied a structurally oriented mean noise filter that utilizes pre-computed dip and azimuth volumes to steer the filter. Two iterations of the filter with a small filter length produced the best result (Figures 1 and 2). The difference volume indicates that a significant amount of coherent noise was removed by this filter. Removal of this noise increases reflector continuity in the Eagle Ford section, while preserving signal and edges. The pre-computed dip and azimuth steering volumes allow the filter to recognize and preserve geological events.

Plays in the Eagle Ford can consist of subtle stratigraphic traps, so it is crucial to preserve all geologic information contained in the seismic data. The noise reduced data will allow for better performance of horizon autotrackers, fault interpretation and attribute analysis.

## Volumetric Seismic Attributes

Seismic attributes are measurements derived from seismic data and can be a valuable interpretation tool if tailored to the given geologic setting. There are hundreds of different seismic attributes, many of which can be computed in a matter of minutes on a desktop PC workstation. Attributes can now be calculated on 3D seismic data volumes, rather than horizon surfaces or time intervals. With access to this vast amount of data, it is important to understand the appropriate application of various seismic attributes in order to produce the best interpretation possible. We present an example of attributes used to enhance subtle stratigraphic features on this 3D data set from Live Oak County, Texas.

Recent industry discussions of the Eagle Ford have focused on using 3D data to help identify quality reservoirs and local faults. Production rates vary significantly over short distances; seismic techniques such as attribute analysis can help identify the best production zones, as well as faults that might provide drilling hazards. Seismic can also identify the Eagle Ford/Austin Chalk contact, which is often difficult to detect with logs.

After applying the noise filter, we calculated a number of seismic attributes in order to better characterize the Eagle Ford. We created a Bedform attribute (Figure 3) to highlight the relationship between seismic strata within the data set, including features such as pinch outs and clinoforms. This attribute is also useful for mapping through low amplitude features because it is phase-based.

The Bedform attribute was then combined with a regional instantaneous frequency attribute. Instantaneous frequency is calculated using a Hilbert transform and can be used to interpret geology. For example, high values can indicate sharp interfaces or thin beds, while larger scale low frequency areas can indicate unconsolidated sands. Merged with the Bedform attribute, instantaneous frequency can provide a detailed stratigraphic display. This combined attribute revealed pinchouts and thin beds in the vicinity of the Eagle Ford reflector (Figure 3). This multi-attribute combination was created from the conditioned data, which had already improved reflector continuity, so there was a significant improvement in interpretability.

We set the opacity of the instantaneous frequency attribute such that only the high frequencies corresponding to the thin bed attribute in Figure 3 were visible. We then created a geobody based upon these parameters in order to produce a 3D map of the thin bed (Figure 4). The geobody terminates in one direction against a fault and appears to pinch out in the other direction.

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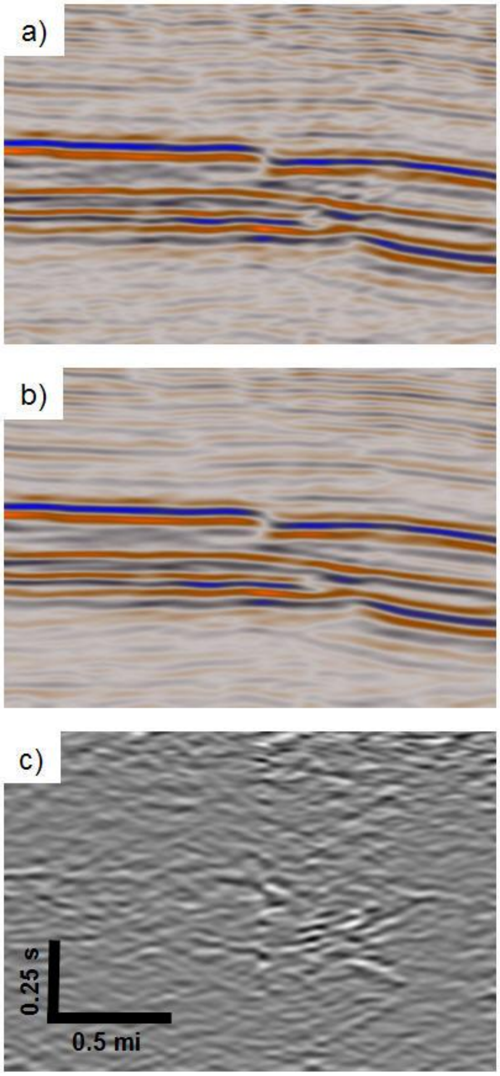


Figure 1: Seismic line over the Eagle Ford Shale in Live Oak County. The original data (a) show significant "chatter", probably due to processing artifacts. A structurally oriented noise filter was applied to the data (b) and has significantly reduced the noise, while preserving amplitude and edges. The difference between the original and the conditioned lines (c) indicates that significant dipping coherent noise was removed, which increases the continuity of reflectors.

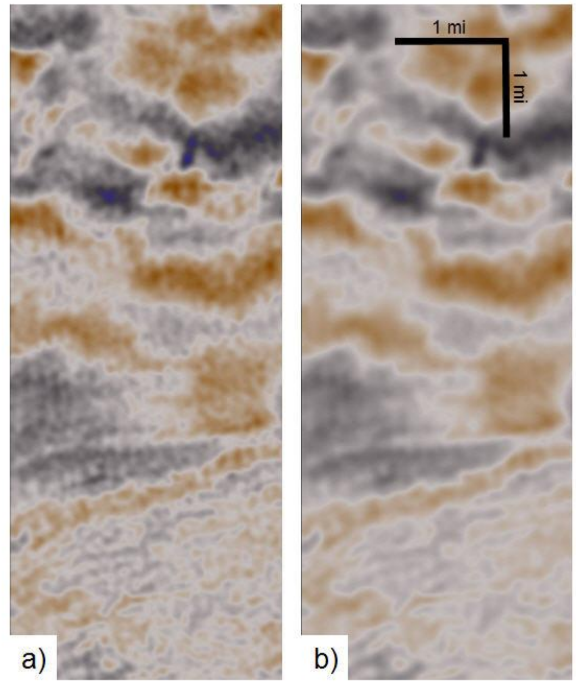


Figure 2: Time slices at 1376 ms from a) the original data and (b) the data conditioned volume. A horizon autotracker would perform much better on the conditioned data. This type of noise is visible at all time levels in the data.

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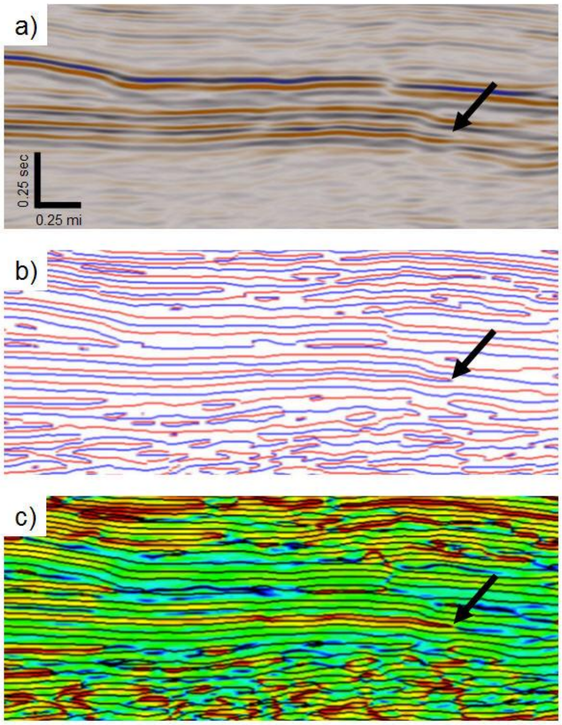


Figure 3. Seismic line over the Eagle Ford Shale in Live Oak County. a) The noise reduced data show indications of pinch outs, but it is difficult to identify exact locations. b) The Bedform attribute, clearly shows the location of the bed termination. When this attribute is combined with a smoothed instantaneous frequency attribute (c), you can identify both the pinch out and the continuation of the thin bed as indicated by the high frequencies in red.

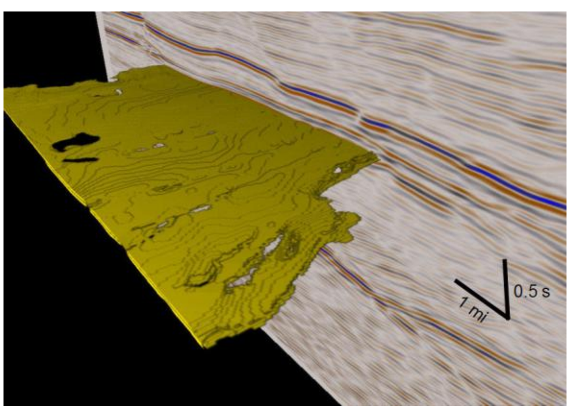


Figure 4. Geobody extracted from the instantaneous frequency attribute that represents a thin bed. This reflector terminates in one direction against a fault (background), while it appears to pinch out in the foreground (this edge corresponds to the location of the arrow in Figure 3c).

## Conclusions

Data conditioning is critical to improving the interpretability of land seismic data over the prospective Eagle Ford Shale. The structurally oriented noise reduction technique presented here increases reflector continuity while preserving edges, amplitude and frequency content.

Seismic attributes derived from conditioned data are more likely related to geology than to acquisition or processing artifacts. Bedform and smoothed instantaneous frequency attributes aid interpretation of the Eagle Ford across the 3D volume by highlighting thin beds and pinchouts.

## Acknowledgments

We would like to acknowledge Seitel as the data owner, and recognize their contribution of this seismic data.

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**EDITED REFERENCES**

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