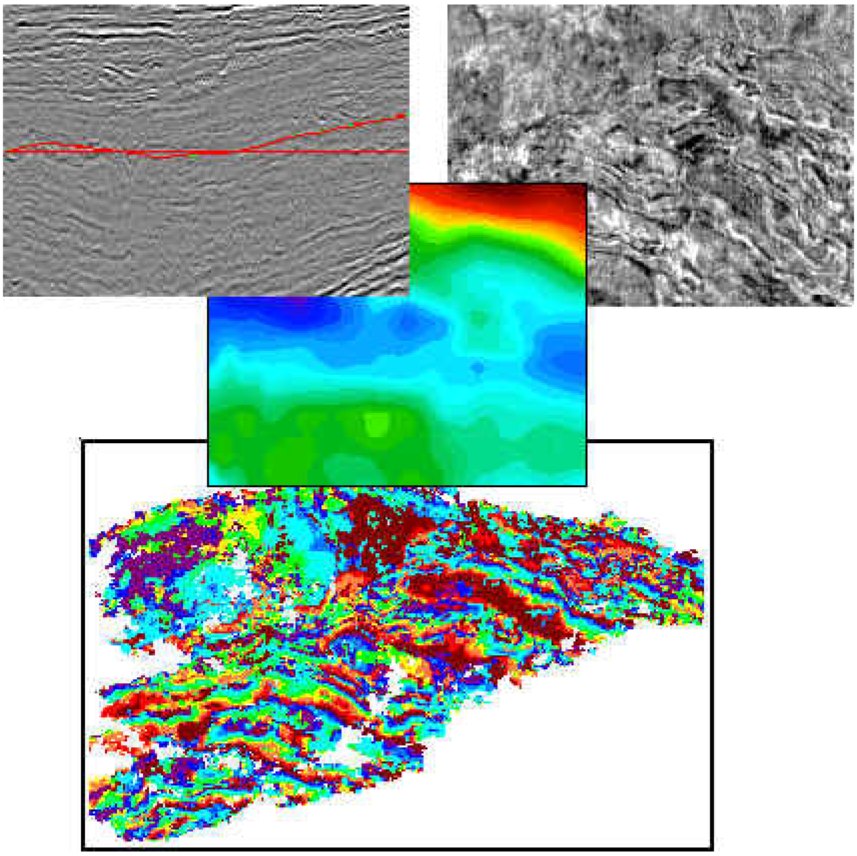
Data Mining in Low Signal to Noise Overpressured Zones

A Case Study from Offshore Louisiana, Gulf of Mexico



Introduction

The reduction of reflection coefficients due to dropping shale velocities in overpressured zones is well documented in the literature (Burns 1985; Ringstad and Fjær 1997). The difficulty in seismic interpretation caused by overpressured zones is often complicated by faulting and convoluted horizons. This paper provides an approach that will offer the seismic interpreter a tool to extract information from 3D seismic in the presence of these complications.

The methodology presented here allows the interpreter to "look" into these overpressured zones and consists of two major steps.

1. Reconnaissance with a conforming cut surface to quickly find and focus on an area of interest within the zone.
2. An analysis of the seismic facies within the zone to determine prospective areas for further study or drilling.

The first objective is to quickly locate areas that show geologically related geometry. In areas with good seismic reflections, this can be achieved by flattening the seismic cube on an interpreted horizon then time slicing the results. With the Horizon Slice tool available in Stratimagic™ the slicing could be done from a reference horizon on the original volume without flattening. However, in both cases a time structure surface must have been interpreted over the entire area of interest. In an overpressured zone the interpretation of such a surface is, at best, extremely difficult and time consuming, and at worst impossible. The use of a conforming cut surface can greatly aid in the reconnaissance phase.

The Conforming Cut Surface

Historically time slices have been used in an effort to identify a prospective zone. However by definition a time slice can not present data out of a flat plane and therefore features that are inclined or convoluted can not be represented completely with a time slice. Figures 1 through 3 illustrate this problem. The time slice does not show the entire feature while the horizon slice, done with a conforming cut surface, yields a much more complete picture of the feature.

The horizon slicing was utilized by digitizing a surface on 11 inlines and 8 crosslines that maintained conformity with the orientation of the surrounding layers but ignored the faulting. The interpretations were interpolated and smoothed to create the cut surface shown in Figure 5. Figure 4 illustrates the difference between a conforming cut surface and a true seismic surface. The interpretation takes very little time because this surface need not, and indeed should not, coincide with an actual seismic event. When used in conjunction with Stratimagic™'s Horizon Slice tool, the surface allows the interpreter to slice features that are not flat in time.

Caution should be exercised when using a conforming cut surface to avoid interpreting 'fault shadow' (i.e. bends in the cut surface due to faults) as stratigraphic features.

Figure 1: The relative positions of the slices shown in Figures 2 and 3.

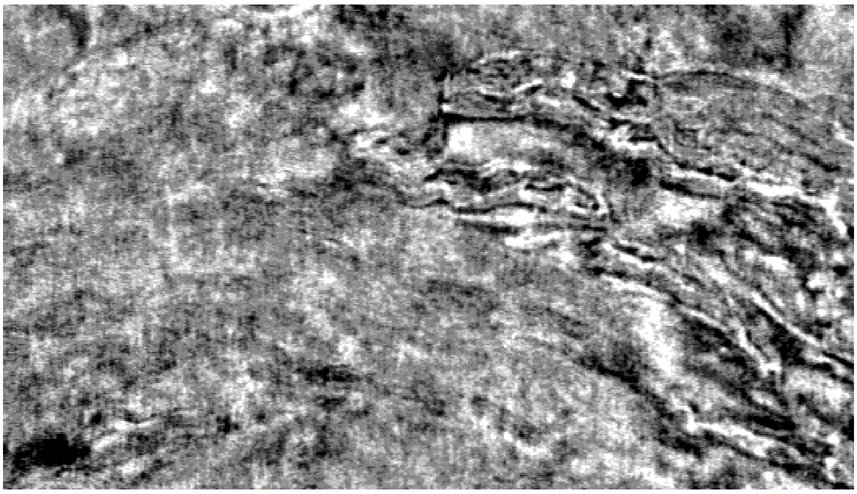


Figure 2: Time slice showing missing southwest portion of feature

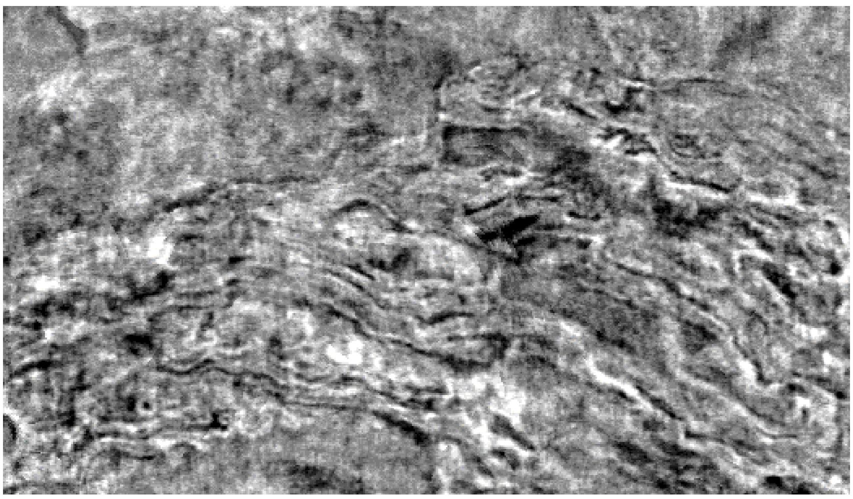


Figure 3: Horizon slice showing complete feature

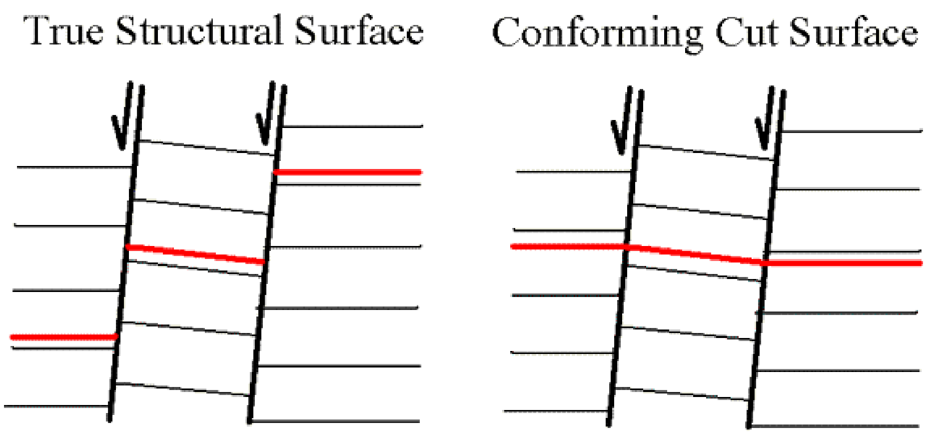


Figure 4: The difference between a true surface and a cut surface

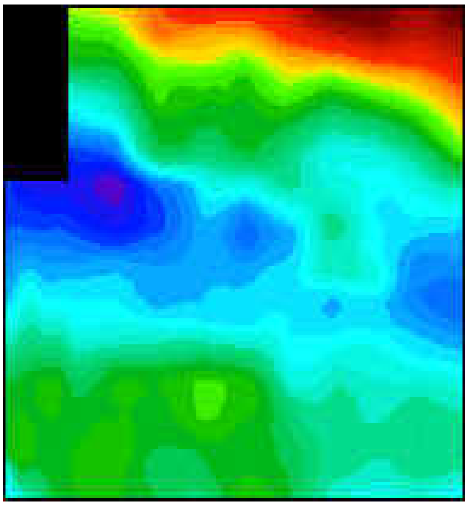


Figure 5: The Conforming Cut Surface

True Seismic Surface and Facies Analysis

The horizon slice reconnaissance revealed an interesting feature, which is shown in Figure 3. The next step in the methodology is to run a facies analysis of the feature to better delineate internal structure and attempt to offer insight into possible interpretations of the nature of the feature.

To use the trace shape comparison capabilities of Stratimagic™'s Neural Network Facies Analysis, a constant interval must be created. In order to compare appropriate portions of the traces, the upper and lower boundaries of the interval should be parallel and created from a reference horizon that is a true seismic surface. The reference seismic surface need only be interpreted over the area that includes the feature of interest, which can be a great time saver in an overpressured environment such as this example.

A local horizon was interpreted using Stratimagic™'s Wave Shape Auto-Propagation tool (Figures 6 & 7). No interpolation or extrapolation was used after the initial interpretation to illustrate the difficulties of obtaining an interpreted horizon in this area. Using this horizon also shows the ability of Stratimagic™ to produce good results in low signal-to-noise areas. This horizon was used to create a constant interval of 120 msec on which a facies analysis was done. Figure 8 shows the resulting classification map. The facies classifications are also shown on a seismic section (Figure 9).

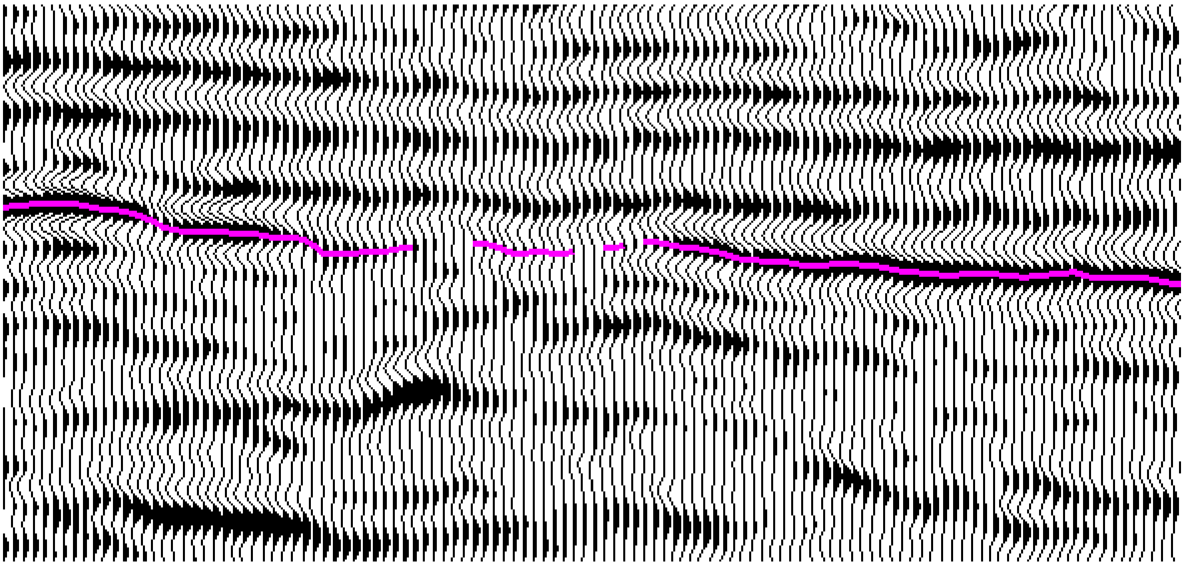


Figure 6: The true horizon used to create a constant interval shown on seismic illustrating poor data quality area.

Figure 7: Time map of the true horizon used to create a constant interval. Uninterpreted areas are shown in white and location of Figure 6 is shown in blue.

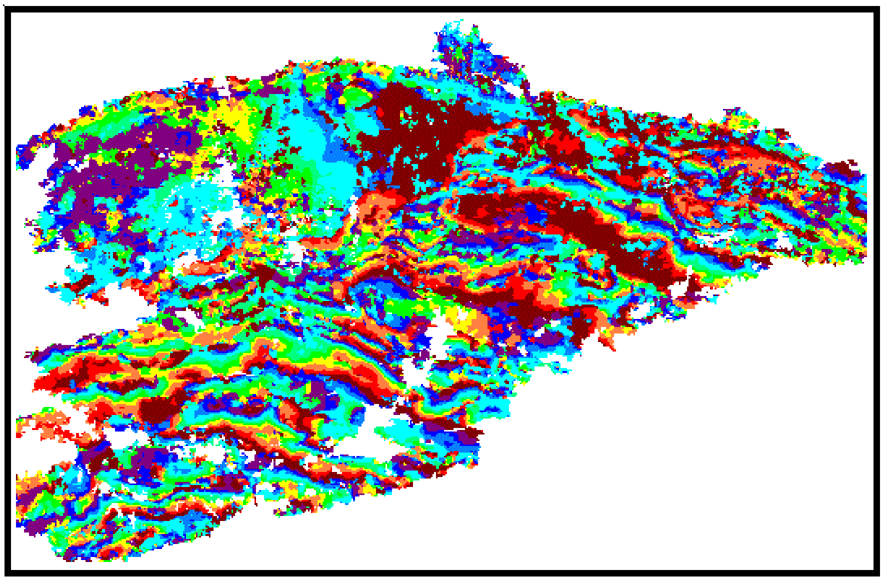


Figure 8: The seismic facies map over the 120 ms interval referenced to the horizon shown in Figure 7.

Facies Interpretation

There are areas interpreted as paleo-highs, such as the ones shown on a section in Figure 9. These paleo-high areas were removed from the original horizon and another facies analysis was run using the new edited horizon. The results of this analysis are shown in Figure 10. The paleo-high areas can also be seen on a map, which shows a horizon slice, and the new facies classification map. These maps were combined with Stratimagic™'s Mixed Image utility, which allows overlaying of two or more maps (Figure 11).

Figure 9: The edited facies analysis displayed on a seismic section.

Figure 10: The seismic facies map after paleo-highs were removed from the interval. The location of Figure 9 is in red.

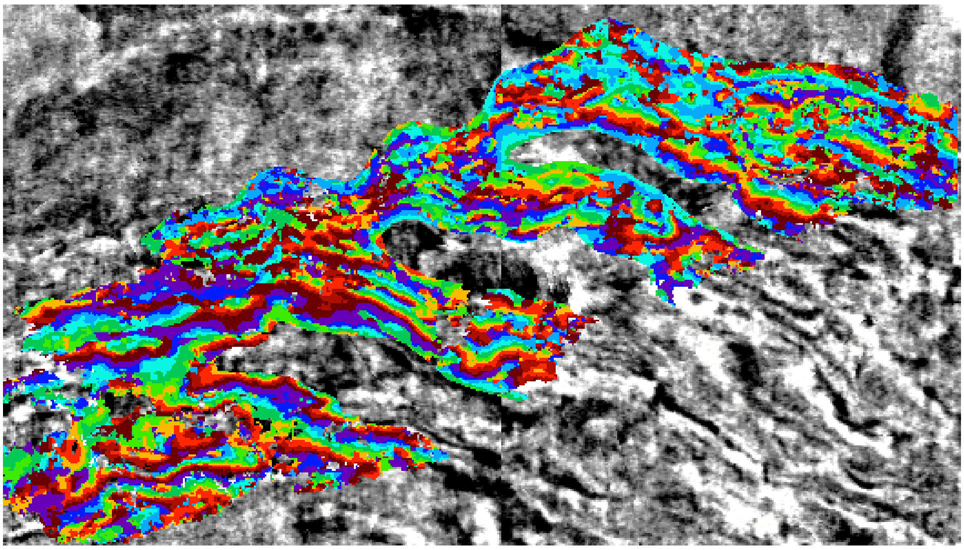


Figure 11: Mixed Map showing facies classification map and a horizon slice

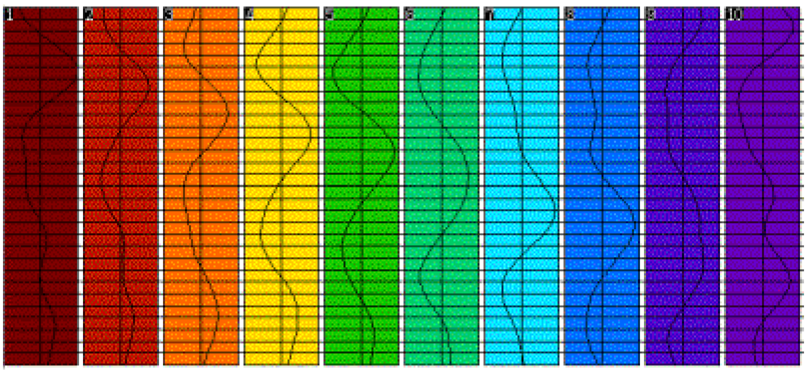


Figure 12: The facies model classes corresponding to the seismic facies map shown in Figures 10 and 11.

With the facies analysis, it is now possible to answer questions about the internal structure apparent on the horizon slices. Primarily, 'What are the possible geologic relationships between these structures?' and 'What sedimentary environments might these relationships suggest?'

The classification of the trace shapes can be used in conjunction with Stratimagic™'s Palette Tool to isolate a particular set of 'similar' seismic trace shapes. This ability allows the interpreter to focus on one or several classes independently. This method was used to highlight classes 2, 3, and 4 (Figure 13 & 14) revealing a set of sub-parallel features that are suggestive of meanders in a delta system.

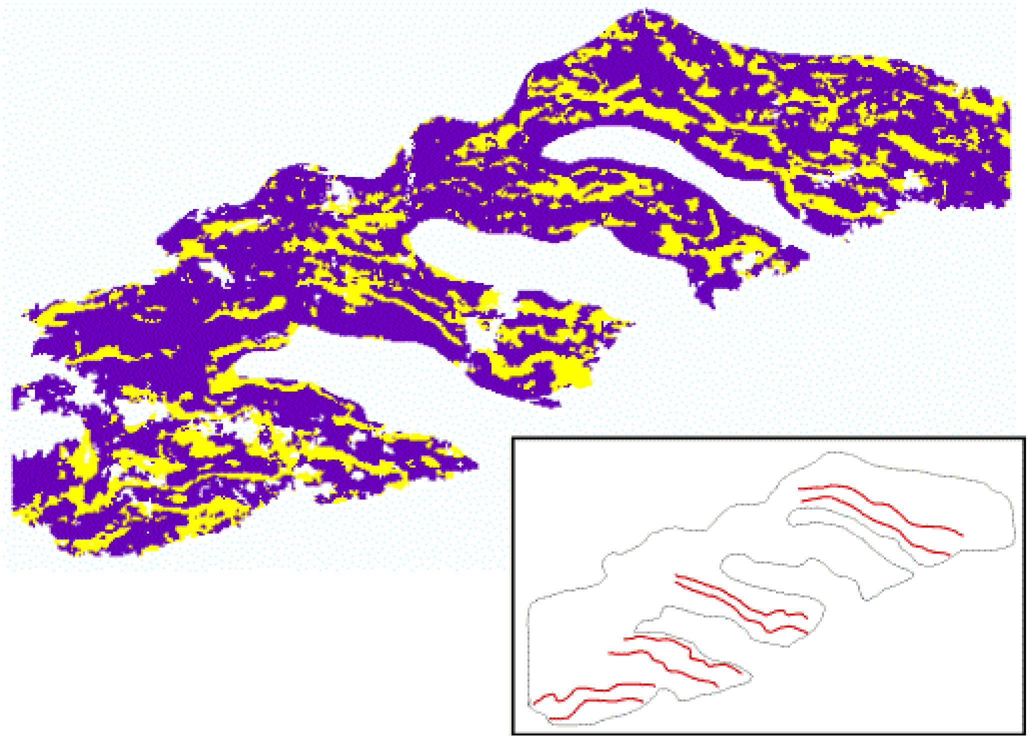


Figure 13: The seismic facies map shown in Figure 10 with edited color palette highlighting model traces 2, 3, 4 (Figure 14). The location of the sub-parallel features are shown with red lines.

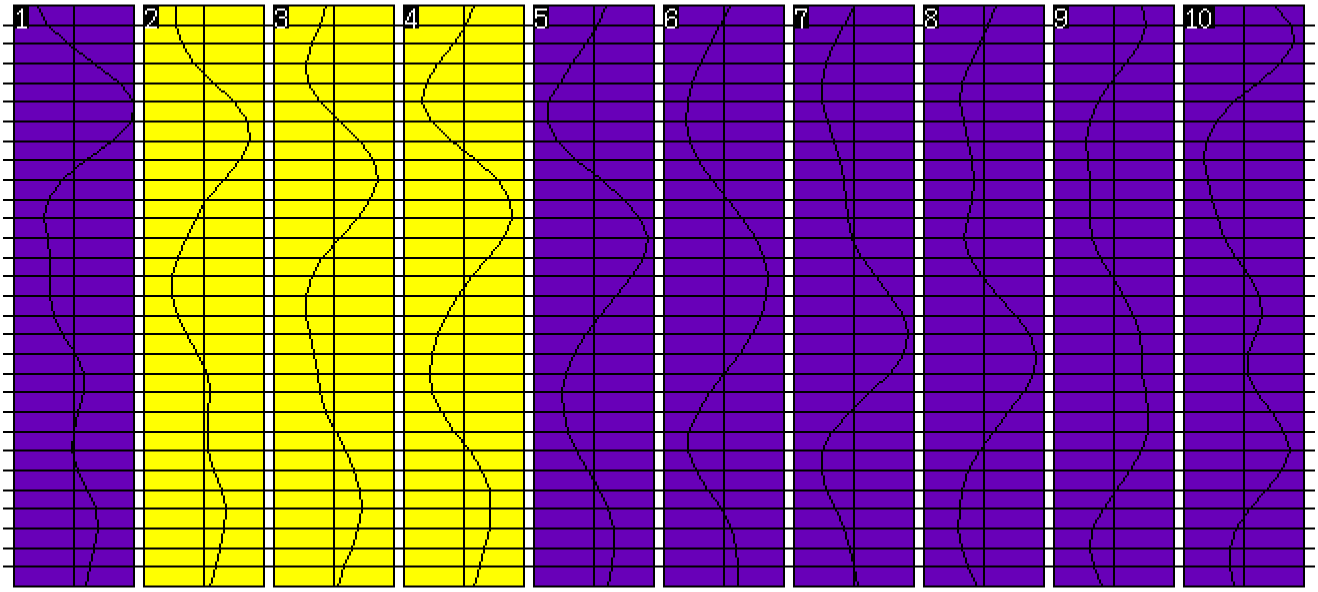


Figure 14: Color edited facies model classes

Conclusions

The reduction of seismic amplitudes characteristic of overpressured zones in the Gulf Of Mexico has impeded efforts to quickly identify and analyze possible productive zones. Methodologies presented in this paper have illustrated Stratimagic™ in a reconnaissance role as a tool to more deeply investigate previously identified targets. With the insensitivity to changes in amplitudes, Stratimagic™ is well suited to find, enhance, and analyze data within zones of low signal-to-noise ratio in seismic 3D volumes.

Data Preparation and Setup

The 3D seismic block was loaded from a SEG-Y tape (32 bit data provided by Seismic Exchange Inc., 1776 Yorktown Suite 500, Houston TX 77056). The input 3D survey consisted of 526 inlines and 641 crosslines with 82 by 82 feet bin spacing. The sampling interval was 4 ms and the record length was 4 seconds.

References:

Burns, C.S., 1986, Relating Gulf Coast Sand/Shale Statistics to Petrophysical Properties as Seen by Seismic: 61st Annual Technical Conferences of the Society of Petroleum Engineers, Special Paper SPE15527 – New Orleans, Louisiana, USA.

Ringstad, C., Fjær, E., The Effect of Pore Pressure on Acoustic Velocities: EAGE 59th Conference – Geneva, Switzerland