Seismic Attenuation for Reservoir Characterization

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Abstract

In this report we will show results of seismic and well log derived attenuation attributes from a deep water Gulf of Mexico data set. This data was contributed by Burlington Resources and Seitel Inc. The data consists of ten square kilometers of 3D seismic data and three well penetrations. We have computed anomalous seismic absorption attributes on the seismic data and have computed Q from the well log curves. The results show a good correlation between the anomalous absorption (attenuation) attributes and the presence of gas as indicated by well logs.

Contents

Experimental

No experimental work is reported. Data shown are from commercial well log and seismic data contractors.

Results and Discussion

Seismic and Well Log Derived Attenuation in Gulf of Mexico

Figure 1 shows the seafloor and two interpreted horizons, the "Trim B" unconformity and the Miocene unconformity. This data focuses on a major gas discovery that has been proven by three well penetrations. We will examine one of these wells (Well #1) in detail for the purpose of computing seismic attenuation and comparing the log-derived attenuation to seismic data derived anomalous absorption.

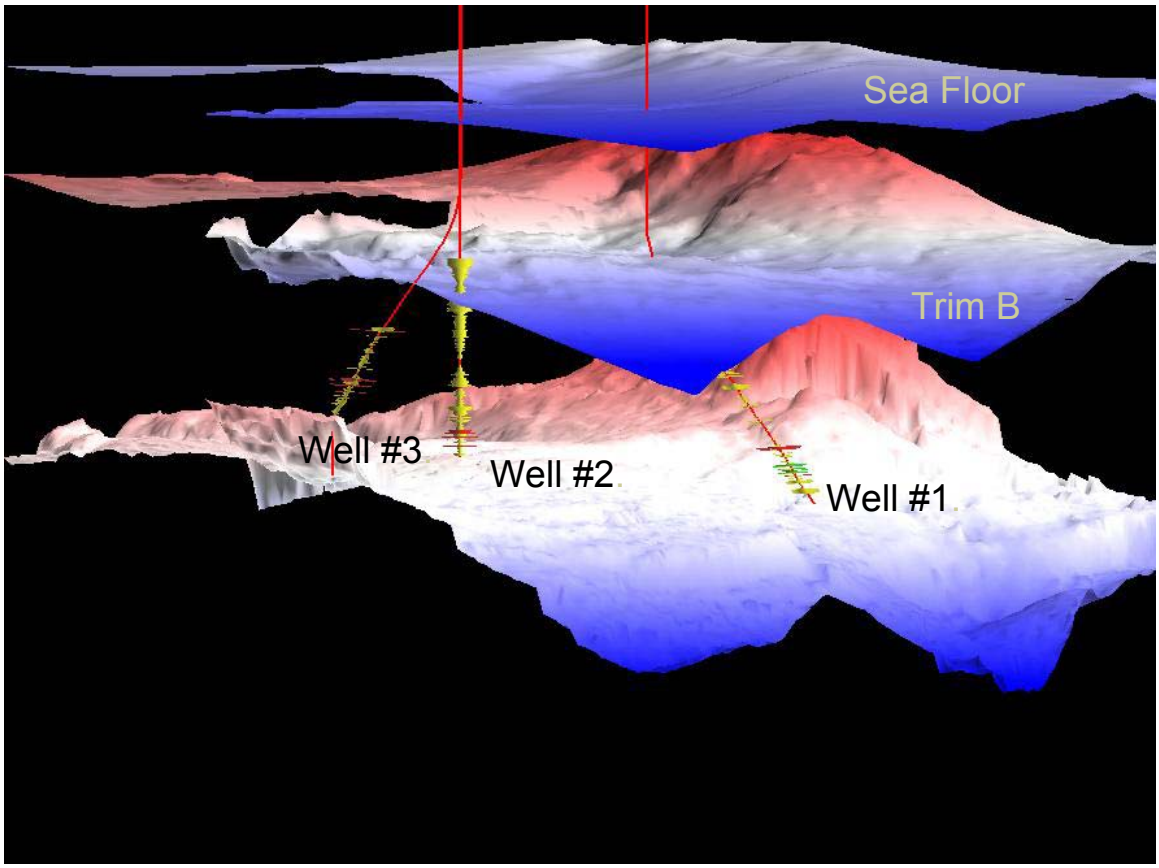

Figure 1: Deep water (~3000 ft) Gulf of Mexico study area, including three gas wells.

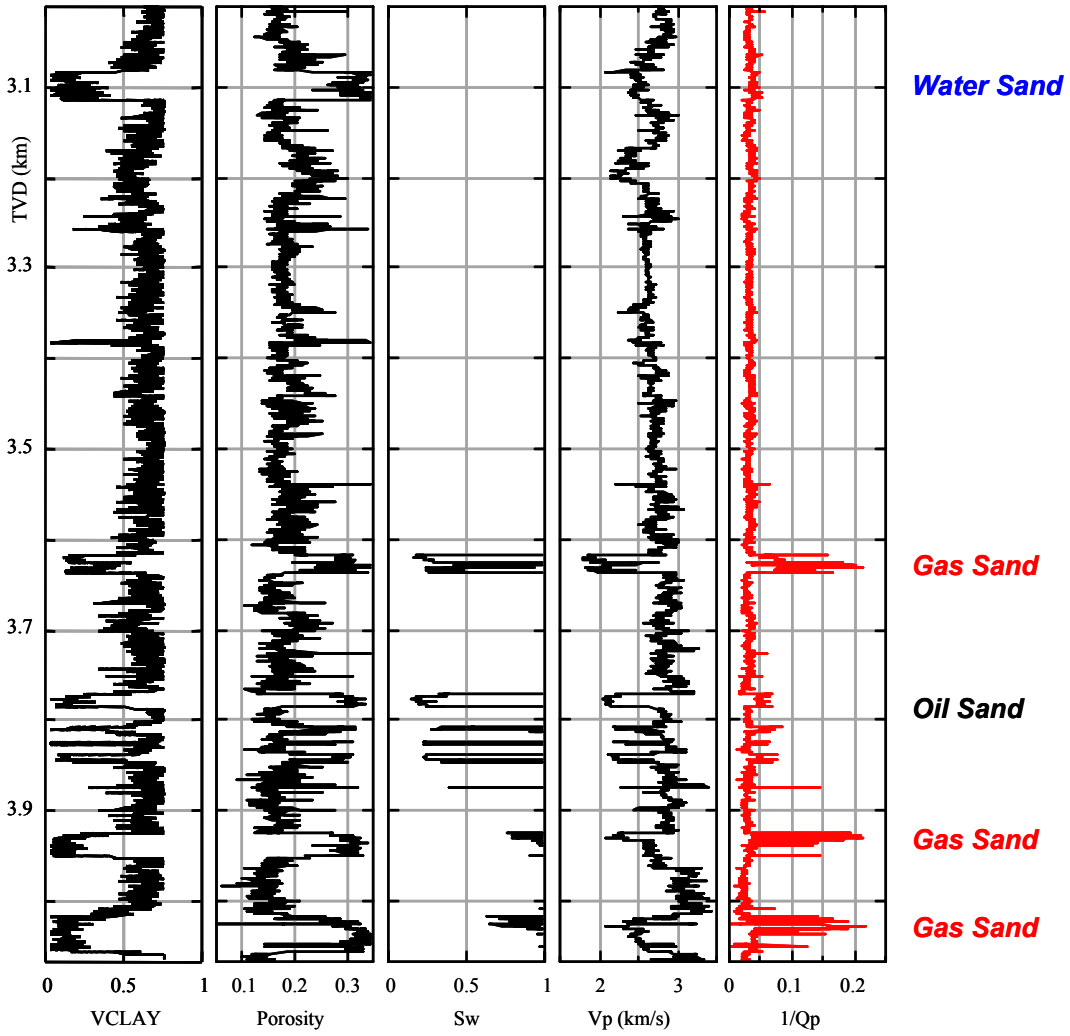

Figure 2: Log data for Well #1. Curve in red is computed attenuation (1/Qp).

In this well, we were provided all necessary log curves to allow for computation of porosity, Vclay, and water saturation. From these curves, we computed seismic scale attenuation (1/Qp) using the patchy saturation model of Dvorkin, et al. This method was described in a previous report (Q2 Report, April 2002). These results show that zones of partial gas saturation, for example just below 3.6km depth, exhibit a high value of attenuation. An oil saturated zone just above 3.8 km depth also shows an attenuation anomaly, but not as strong as that associated with gas. High attenuation zones below 3.9 km were caused by a low computed gas saturation condition (<50% gas saturation). This low gas saturation was later found to be erroneous. It was caused by a misinterpretation of the resistivity log. The zones should have been computed at 100% Sw, which would have eliminated the Q anomalies.

Using a seismic data visualization system, we have displayed the seismic amplitude data for the zones of interest (Figure 3).

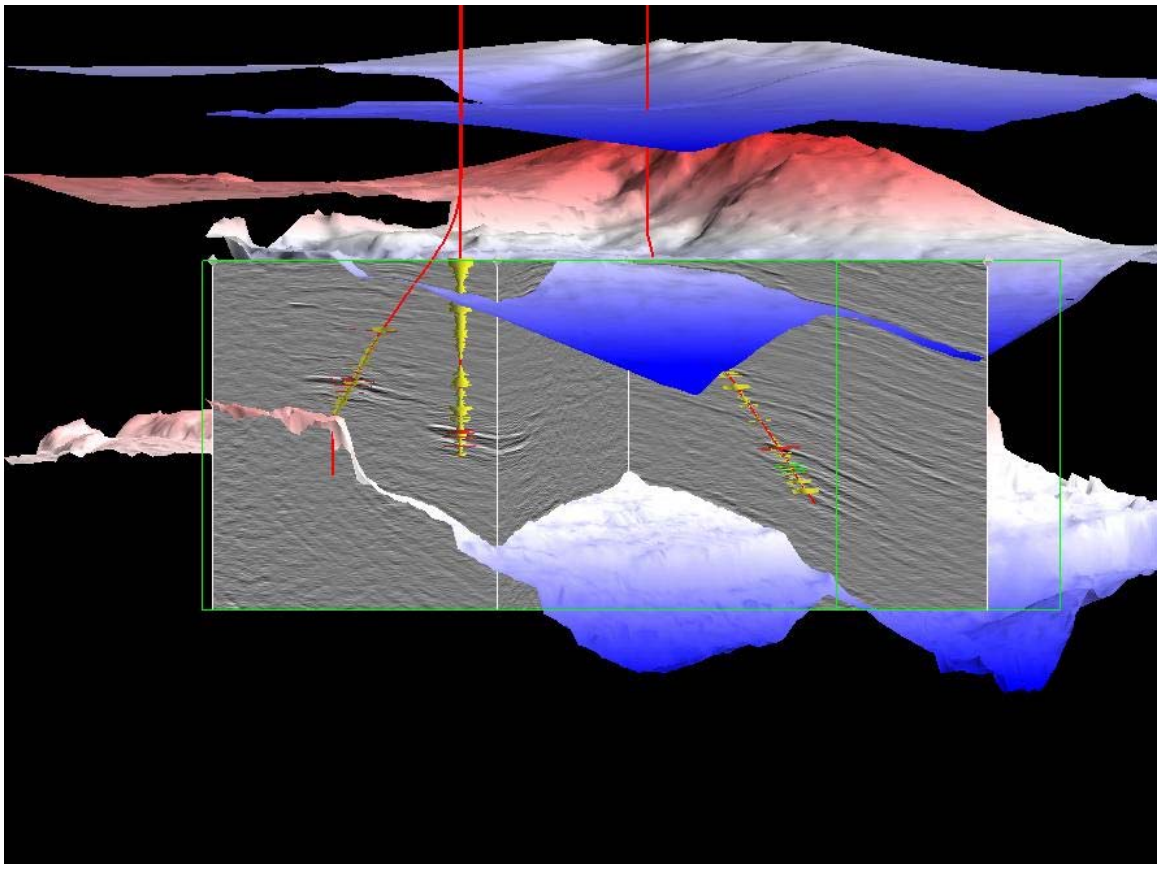

Figure 3. Seismic amplitude data along three intersecting planes.

The data is displayed on three intersecting planes, two of which include the wellbore trajectories for wells 1, 2, and 3. We will look more closely at comparisons of the seismic data and the wellbore data.

In Figure 4 we show the seismic anomalous absorption attribute colored so that blue represents very low anomalous absorption and red indicates high anomalous absorption. On each wellbore the gas saturation curve is shown in red. Seismic data near wells 2 and 3 show high (red) values of seismic attenuation in zones that correspond closely to the gas saturated zones in each well. In well 1 we also see a zone of high attenuation at the gas saturated zone. Note that well 1 just missed a much larger zone of high seismic attenuation. This substantial anomaly would be a very attractive target for a sidetrack well at some future time.

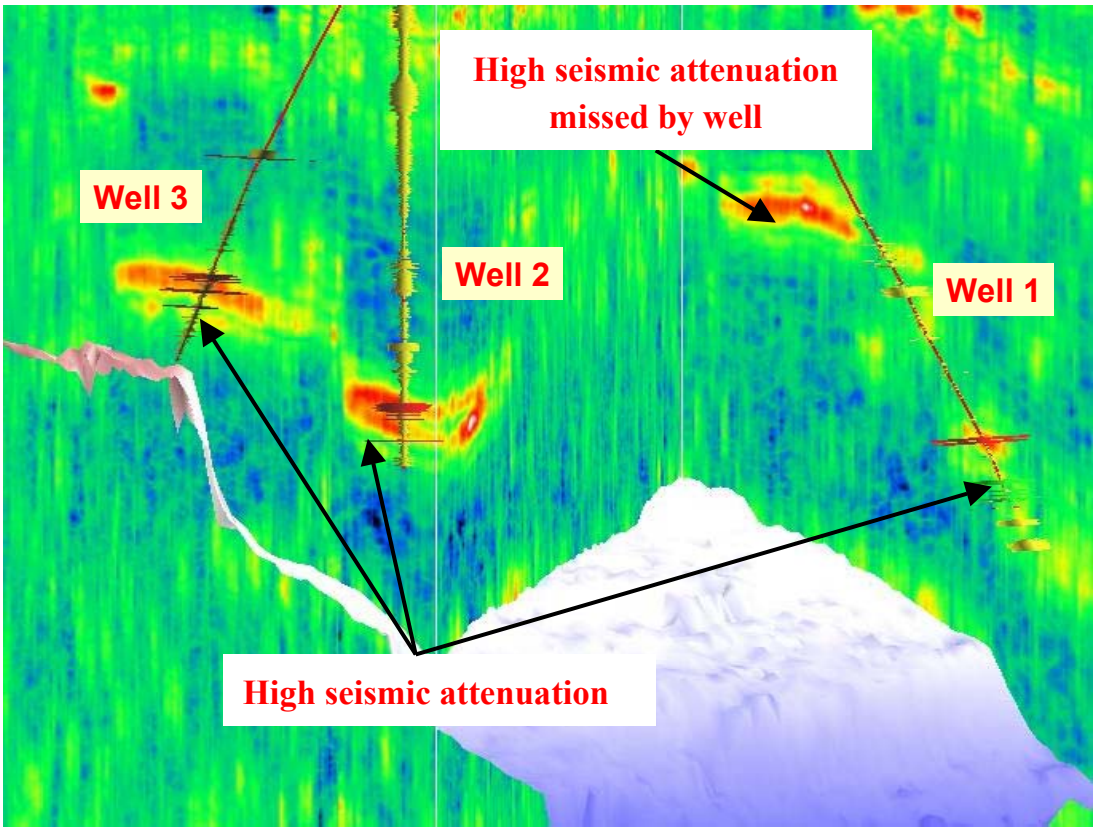

Figure 4: Anomalous seismic absorption volume with wellbore paths.

In Figure 5 we show the numerical values of the anomalous absorption attribute extracted along the path of the wellbore. This figure demonstrates that the methods we have developed for both seismic and well log computation of Q are giving consistent results. Of course the well log attenuation is much higher resolution than the seismic anomalous absorption attribute. The results confirm that Q or attenuation is a powerful tool for detection of hydrocarbons and can help in selecting new drilling targets.

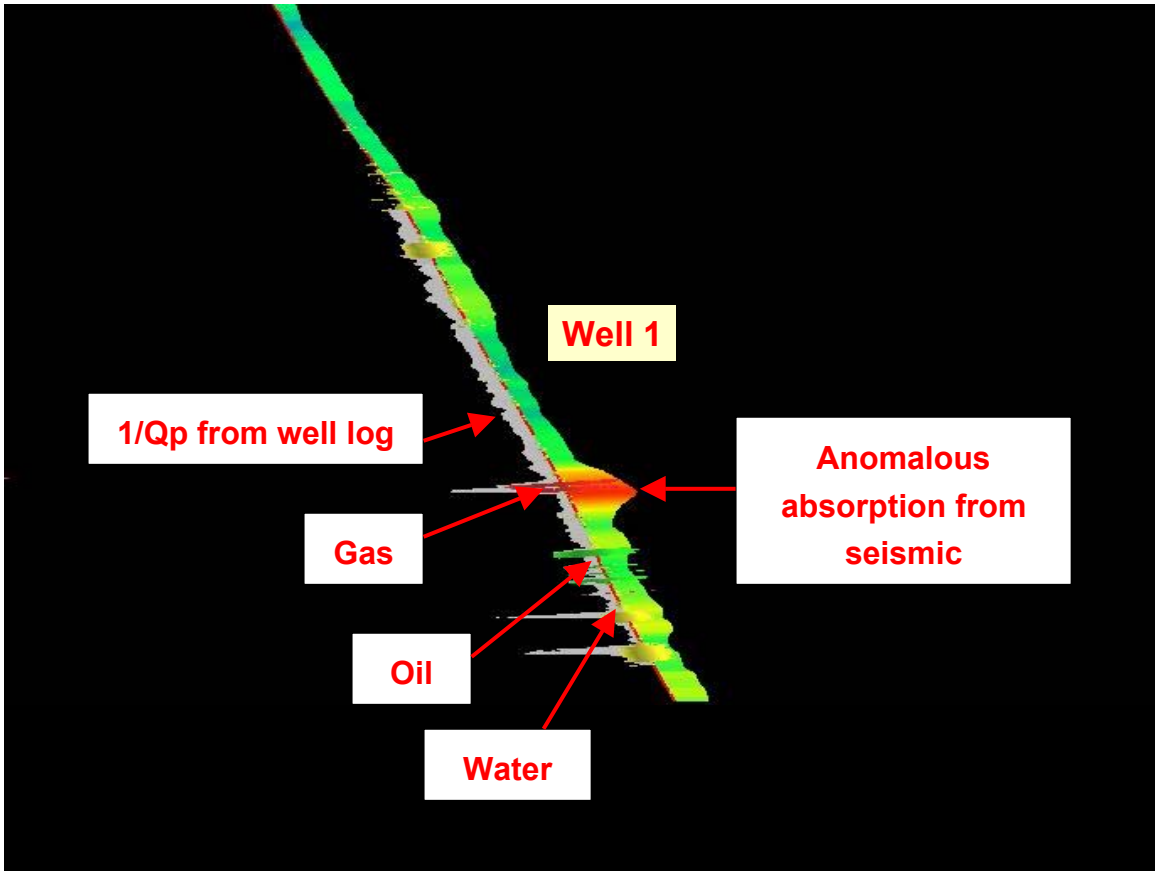

Figure 5: Comparison of attenuation from well log and seismic data.

Attenuation from Sonic Log Waveforms

We have recently begun to work with a consulting company called Supersonic Geophysical in California on the possibility of extracting meaningful attenuation information from full waveform sonic log data. We were able to obtain this data on Burlington Well #1. Using a spectral decomposition method similar to the one we use for seismic data, this group computed Q values along a portion of the wellbore near the major gas zone. The results of this analysis are shown in Figure 6. While the results are noisy, they suggest that this method may give similar values to the computations we have

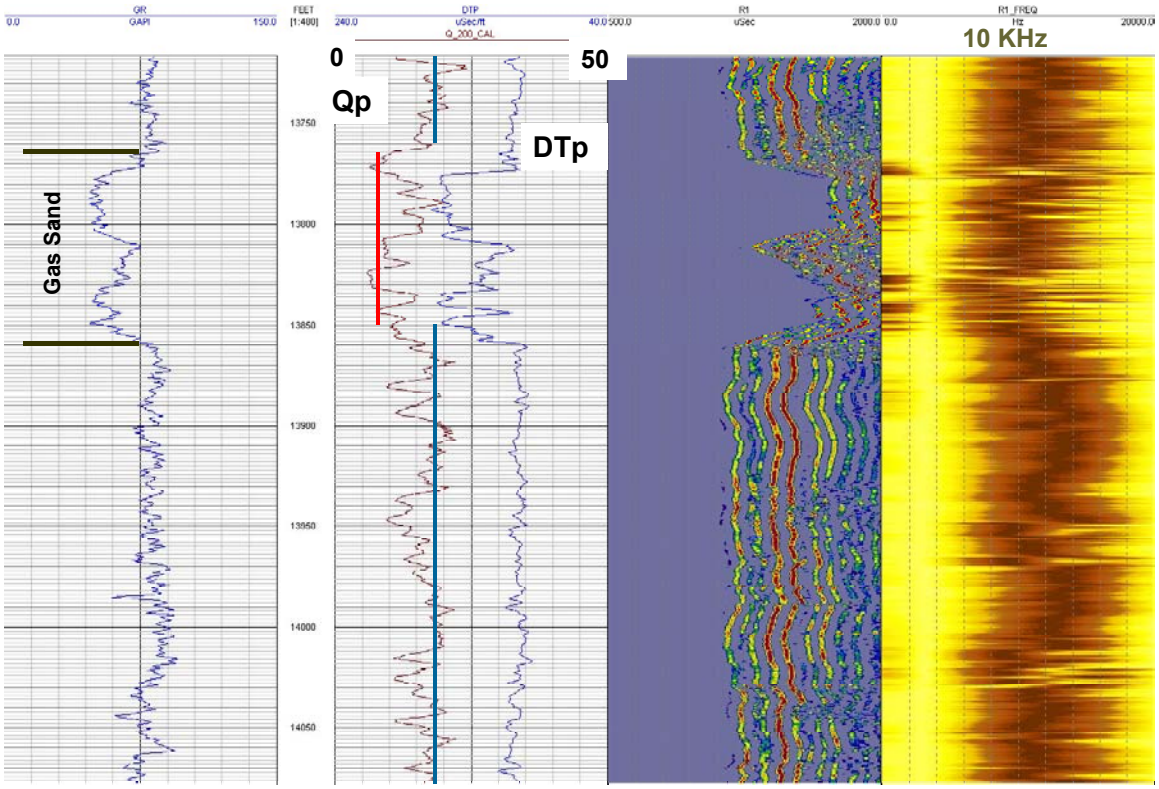

Figure 6: Qp from sonic waveforms in Well 1.

Conclusions

Results of this work demonstrate;

1 Well log derived Q corresponds to gas saturated zones in well log
2 Seismic anomalous absorption is high in regions of know gas production
3 Q from well logs and seismic appear to be in good agreement
4 Qp can be computed from well log waveform data, but may be too noisy for routine use.

References

Dvorkin. et al; Seismic Attenuation for Reservoir Characterization, Quarterly report, DOE Project DE-FC26-01BC15356, Rock Solid Images, April, 2002.

Work Planned for Next Period

We will compute some new Q related seismic attributes on the Burlington-Seitel data set. One example will be called Energy Absorption Attribute (EAA) and is based on a spectral analysis. The EAA algorithm is designed to detect a sudden increase in the rate of exponential decay in the relatively higher frequency portion of the spectrum. In addition we will show results from a hybrid attribute that combines attenuation with relative acoustic impedance to give a better indication of commercial gas saturation.

Problems Encountered This Period

No significant problems have been encountered in our work so far. While it is too soon to tell if we can obtain reliable Q estimates from sonic waveform data, we are hopeful that it will work in at least some cases. We are still awaiting new data sets from industry contacts, but we have been assured that some new data will be forthcoming soon.