# Typhoon-Boris Gulf of Mexico oil field – a spectrum broadening case study

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**Summary**

In this paper the methodology of spectrum broadening of 3-D seismic data is applied to the Typhoon-Boris oil field in the Gulf of Mexico. The Typhoon-Boris oil field is located in the Green Canyon part of the deepwater basin of the Gulf of Mexico. The field was discovered in the year 2001, an appraisal well was drilled in year 2002 and first oil production started in February 2003. The Typhoon-Boris field after careful amplitude preservation processing was discovered as a set of bright amplitude anomalies. The seismic bandwidth in the zone of interest has a peak Fourier transform frequency at about 14 Hz. Due to the narrow bandwidth of the 3-D seismic data and the need for high resolution stratigraphic and structural interpretation of the field, 3-D spectrum broadening was applied. Spectrum Broadening is a new technology which estimates robustly the amplitudes of the high frequencies using the amplitudes of the low and medium frequencies. The resulting spectrum broadened 3-D seismic volume contain high resolution structural and stratigraphic information which correlates well with wide bandwidth well log synthetic seismograms.

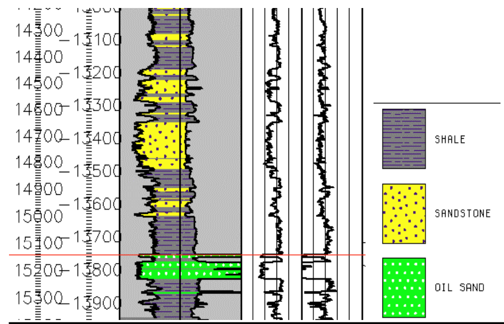


*Figure 1. Electric log of oil pay sand (Courtesy of Little et al., 2004).*

**Field information**

The Typhoon-Boris field is located in the central Green Canyon fairway at about 700 m depth of water in the Gulf of Mexico. The field is a deepwater turbidite sand up-dip pinchout trap. As has been previously reported (Little et al, 2004) the reservoir has excellent rock properties with the primary reservoir called B4 having 100 ft of thickness, a net to gross close to 100%, porosity of about 30% and permeabilities in the range of 500 to 1300 millidarcies. An example of the electric log of the oil saturated sand is shown in Figure 1 (Courtesy Little et al., 2004).

**Spectrum Broadening Technology**

Spectrum Broadening is a relatively new technology which extends the seismic bandwidth at most up to the Nyquist frequency, by estimating the amplitudes of the high frequencies by using the amplitudes of the low and medium frequencies. This estimation has some level of similarity to the dealiasing interpolation of spatially aliased data (Gulunay and Chambers, 1997). The estimation is done using local small 3-D spatiotemporal windows which slide through the 3-D stacked migrated volume. In these small windows, transfer functions between low/medium and high frequency amplitudes are developed which are then applied to the original 3-D seismic data to generate the spectrum broadened 3-D resulting volume. No apriori information such as well logs, is used by spectrum broadening. During the estimation of the high amplitude

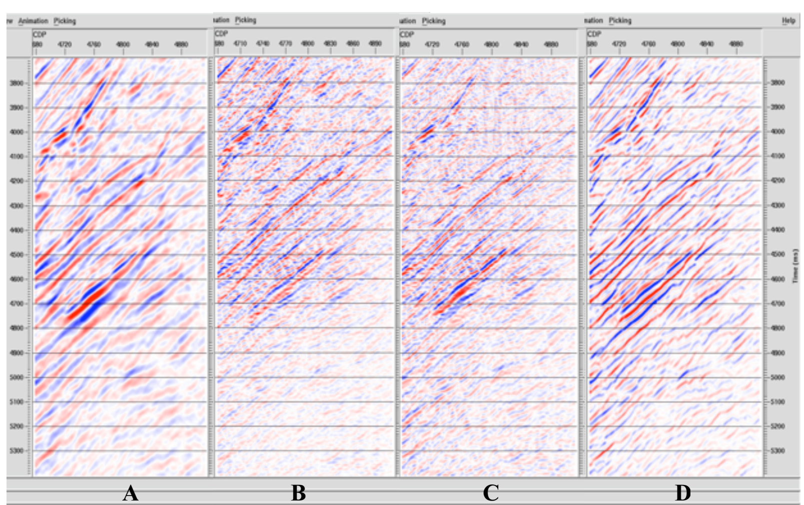


*Figure 2. Comparison of spectrum broadening (D) versus spectral whitening (C) and q-inverse filtering (B) results. Original data shown in A.*

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frequencies the following criteria are followed:

a) The noise is not increased
b) No time shifts of identified events occurs
c) Wavelet has low-wavelet ringing
d) The original dynamic range is preserved
e) Low-pass band-pass filtering of spectrum broadened data to the original data bandwidth does not generate erroneous events not existing in the original data
f) The relative amplitudes within a volume or between multiple offset volumes such as near offset and far offset volumes are preserved.

A comparison of the spectrum broadened results with spectral whitening and q-inverse results is shown in Figure 2. The resulting 3-D spectrum broadened volumes contain high-resolution reflection events and small scale faults not identifiable in the original data. The correlation of the spectrum broadened data to well-log synthetic seismograms generated with wider bandwidth is robust as can been seen from Figure 3.

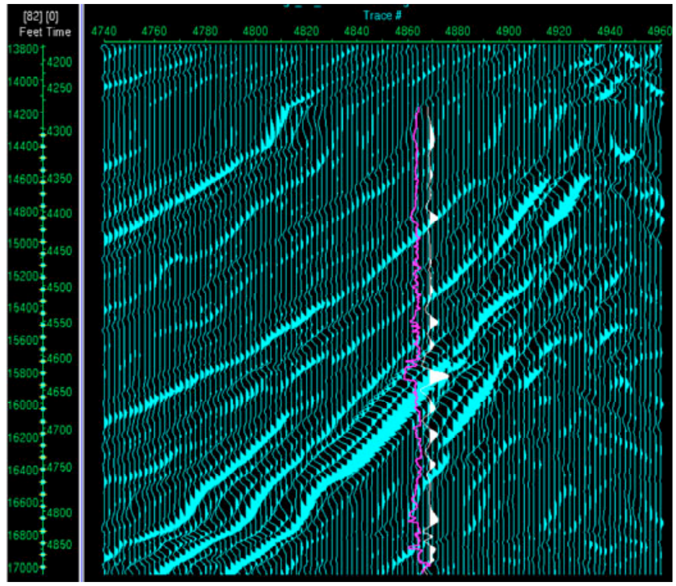


*Figure 3. Correlation of spectrum broadened results with wide bandwidth well log synthetic correlations.*

**Application of Spectrum Broadening to Typhoon-Boris seismic data**

There are several subjects where the spectrum broadening has impacted the Typhoon-Boris 3-D seismic interpretation. In this paper we list four of these subjects. First the interpretation of the 4th order reflection events/packages is now more interpretable than with the original narrow bandwidth data (Figure 4). Second, improved fault resolution is obtained as it is viewed in the figures 5a and 5b through voxel opacity views. Third, a better pressure compartment understanding for the wells 236 #2 and 237 #3ST3 is obtained using the spectrum broadened data. More specifically, for the vertical well 236 #2, there is a different pressure measurement than for the deviated wells 236#1 and 236#2 WBP1 in the B4 reservoir. From the spectrum broadened data (Figure 6) it is clear that there is a difference at the peak of the sand reflection event between these three wells and there is a also a hint of difference between the wells 236 #2 and 236#2 WBP1. In the case of well 237 #3ST3 we see substantially improved small scale fault definition as well as significantly improved definition of the B2 wet-pay-wet sequence (Figure 7). Fourth two important well drilling decisions were made based on the spectrum broadened result interpretation. For the purpose of drilling well 237 #1ST the visibility of a possible flow barrier improved with spectrum broadening. Based on the flow barrier observation it was decided to

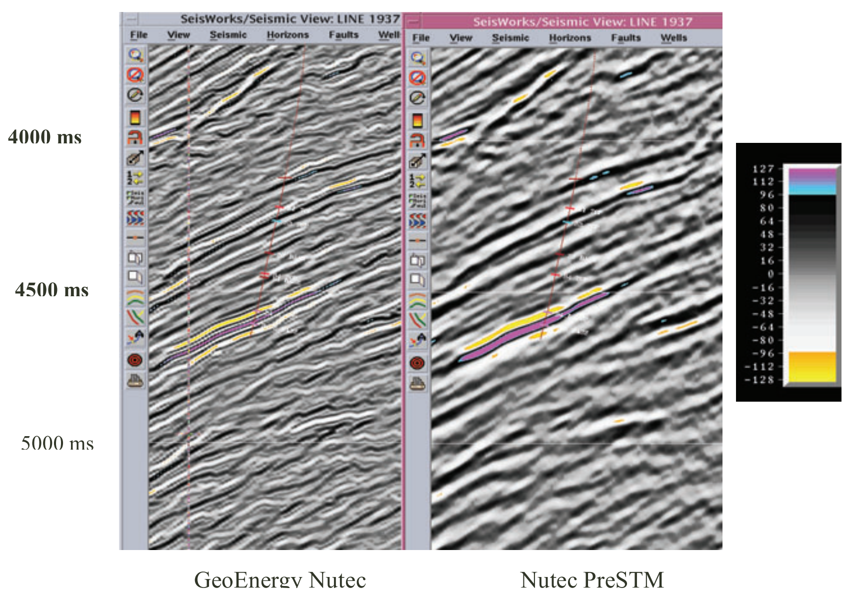


*Figure 4. Interpretation of reflection events/packages on high resolution spectrum broadened results.*

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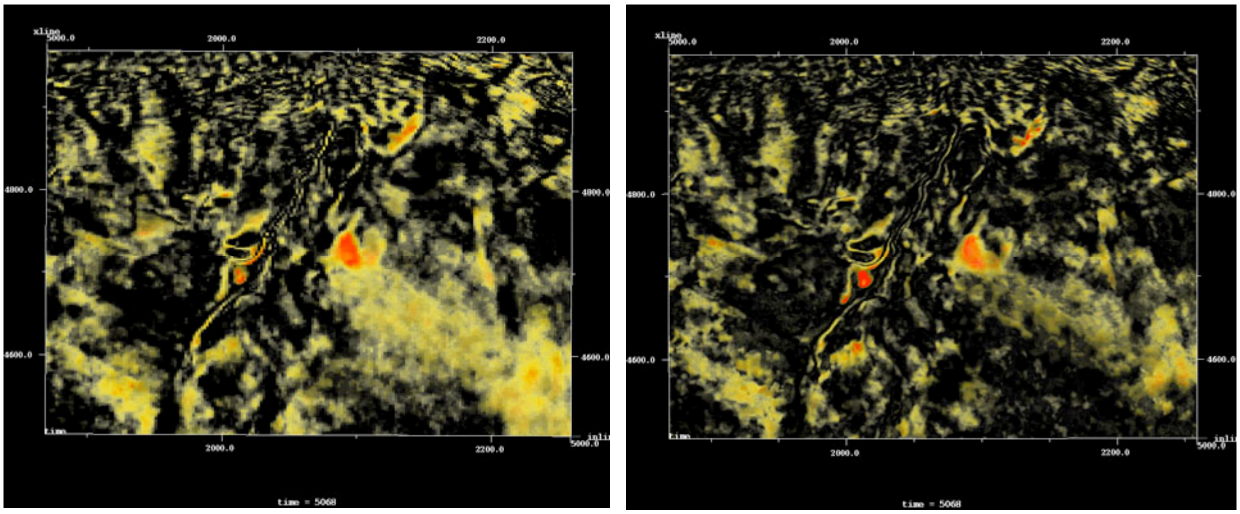


*Figure 5. Voxel opacity views of original data and spectrum broadened results over the B4 reservoir showing significant resolution improvement after spectrum broadening.*

drill the development well to downdip producer of the main reservoir. The development well has been in production now since July 2004. Also for the downdip drilling of well 236 #2BP1 the development well was moved to the other side of possible flow barrier. With this drilling decision there was a tradeoff between a possible small amount of incremental reserve for higher certainty of uncomplicated access to the main B4 reservoir amplitude as shown in Figure 8. The 236 #2BP1 well is drilled now and the drilling/flow results will be known by summer 2005.

**Conclusions**

The narrow bandwidth of 3-D seismic data in the Typhoon-Boris oil field necessitated the use of spectrum broadening for getting reliable wider bandwidth seismic data. The spectrum broadened data generated are consistent with the original data, in terms of generating only geologically meaningful reflections events tied to well log synthetic seismograms. Further examination of spectrum broadened data reveals small scale faults and pressure compartments in two reservoirs. Finally careful examination of the spectrum broadened results leads to two well placement drilling decisions in order to avoid flow barriers. One of the wells has been drilled successfully with the second well currently being drilled. Overall spectrum broadened results yield reliable high resolution stratigraphic, structural and pressure compartment information which could not be obtained from the interpretation of the original 3-D seismic data.

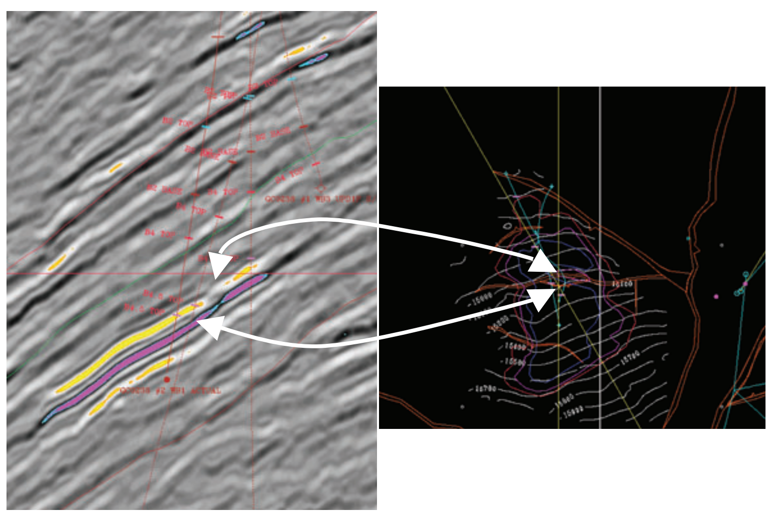

*Figure 6. Development well 236 #BP1. Pressure compartment separation in spectrum broadened data.*

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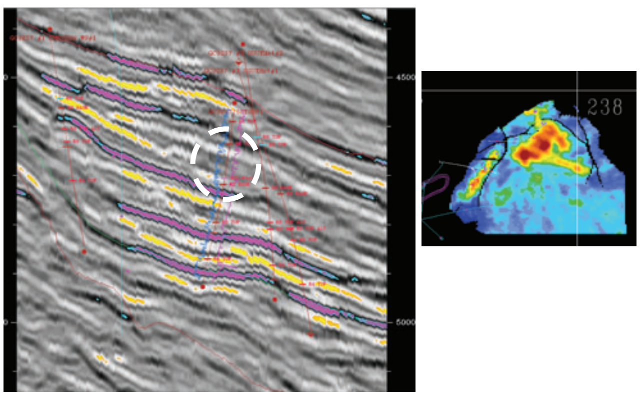
### References


1. Little, B., Duncan, G, Tomich, K., Taylor, C. and M. Glinsky: The Boris Oil Field in the Gulf of Mexico – A Geophysical Case Study, ASEG 2004.
2. Gulunay, N. and R. Chambers, Generalized f-k domain trace interpolation, 67th Annual International Convention, SEG, 1100-1103.


### Acknowledgements

We would like to acknowledge Mr. John Savage of BHP Billiton for providing us with his comparison between spectrum broadening versus spectral whitening/q-inverse filtering methods.



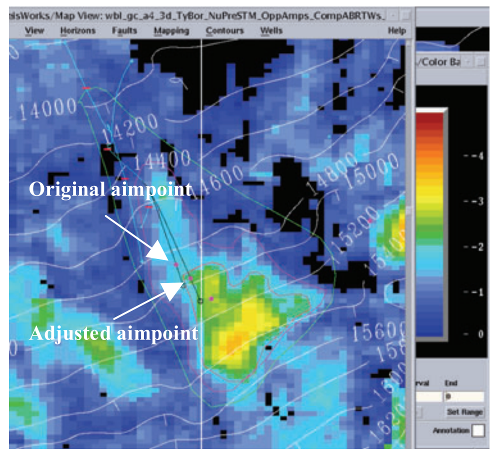




*Figure 7. High resolution and structural interpretation and separation of the B2 wet-pay-wet sequence.*

*Figure 8 Location of development well 236 #2BP1 on the Spectral Broadened B4 reservoir composite amplitude map.*

EDITED REFERENCES

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