Mississippi Canyon high resolution reprocessing: applications for shallow drilling hazard and geologic evaluation

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Summary

A joint contractor-company project was undertaken to evaluate the practicality and utility of shallow high resolution reprocessing of large deepwater exploration 3D seismic surveys. An approximately 575 square mile subset of a regional Mississippi Canyon survey in the deepwater Gulf of Mexico was selected and the upper six seconds of the dataset was reprocessed with focus on maximizing resolution in the shallow, usually suprasalt, sediment column. The intent was to not create new technology, but to utilize advances in computing power to cost effectively create a large regional 3D survey suitable for enhancing the ability to interpret and characterize the deepwater shallow overburden. The result was the creation of a high quality 3D dataset used extensively for shallow hazard analysis, shallow water flow unit characterization, and regional geologic interpretation.

Introduction

The central and western Gulf of Mexico is extensively covered by regional 3D seismic surveys, most acquired by seismic contractors on a multi-client (non-exclusive) basis. For the most part, these have been processed to focus on the deeper oil and gas prospectivity, largely ignoring the shallow section. It is not unusual for oil and gas companies to reprocess small portions of these surveys for improved shallow resolution, but the cost of doing this on a proprietary basis is relatively high. Given the huge advances in computing speeds over the past decade, there may be a largely missed opportunity to reprocess some of these surveys regionally at a higher resolution in the shallow section, making them available to all operators at a much lower per block cost. This project was designed to test the feasibility and practicality of processing a regional 3D dataset for shallow resolution.

Significant resources are spent in the Gulf of Mexico acquiring shallow overburden data to assist in the characterization of sea-bottom conditions, identify shallow drilling hazards such as gas accumulations, assist with well casing design, and predict zones that may be candidates for shallow water flow; this represents just a very partial list of uses of shallow overburden focused data. The types of data collected include high resolution 2D and 3D seismic, multibeam bathymetry, subbottom profiler, side-scan sonar, and ROV video, among others. All of these high resolution, shallow investigation methods have advantages and limitations. In general, resolution is high, but depth of investigation and areal coverage are limited with these methods. Regional 3D seismic surveys do not have these disadvantages. The objective of this project was to investigate if a 3D regional survey could be processed efficiently to increase resolution to the point where it was another useful tool for shallow section evaluation.

Survey and Processing Flow

A Mississippi Canyon (MC) survey comprising about 900 OCS blocks (each 4.8 km x 4.8 km) acquired in 2000 with 8 km streamers, 12.3 sec., at 64 fold was selected for the project. An approximately 65 block subset (Figure 1) was processed as high resolution pre-stack time migrated data using the steps and parameters outlined below. A deepwater area (> 3000') was selected to avoid interference from the water bottom multiple. The processing was designed to improve seismic resolution in the shallow section.

Limit offset to 3000 m and 6 s
Decon to zero phase
Input 2 ms navigation merged data
Spherical divergence and gain correction
Swell noise attenuation
Cold water statics
Noise attenuation
Velocity analysis (800 m X 800 m)
3D pre-stack Kirchhoff migration (300 m – 1675 m)
Velocity analysis (25 m X 40 m)
Stack (425 m – 1300 m)
Output raw migration – SEGY- 25 m x 40 m
Spectral shaping, acquisition footprint, FXY decon, filter and scale

The 2 milliseconds, 6 second records with limited offset provided enhanced vertical resolution in the shallow section when compared to the 4 milliseconds conventional processed data . The Kirchhoff pre-stack time migration and dense velocity analysis helped achieve the best stacked data volume. These results provided optimal positioning and high resolution for detailed geologic interpretation.

Results

The MC reprocessed survey provided a much higher quality view of the shallow subsurface. Compared to high resolution 2D data, the frequency content was lower in the upper 1000' or so of section, but the 3D migration provided a sharper image in more complex areas (Figures 2, 3, 4). The deeper section was imaged significantly better in the reprocessed volume, as frequency attenuation tended to equalize the two methodologies, but the advantages of 3D migration and the larger airgun sources in the 3D survey evidenced themselves. Fault resolution was much improved over the original conventional processing, and in most cases faults were more easily interpretable than in the 2D high resolution data. The original processing of the 3D survey left significant acquisition artifacts and relatively poor seismic amplitude discrimination within the shallow section; artifacts were largely removed and amplitude response was much improved in the reprocessed volume, providing a much clearer view of stratigraphic features (Figures 5, 6).

From the offshore operator's viewpoint, the high resolution reprocessed volume quickly became the preferred volume within the company for interpreting the shallow section in this area. The increased fault resolution is extremely useful in well casing design and optimizing well placement. Although 2D high resolution data had been acquired in the area, the advantage of having a 3D migration makes the reprocessed volume more reliable in identifying potential shallow gas hazards in many instances. The reprocessed volume has been especially useful in assessing shallow waterflow risk, as units with high risk can be mapped in 3D and sub-regionally for maximum characterization. The volume frequency content also makes it acceptable for well shallow hazard analysis, based on MMS NTL No. 2007-G01 requiring a frequency content of 50 Hz or greater across the first second of section below the seafloor.

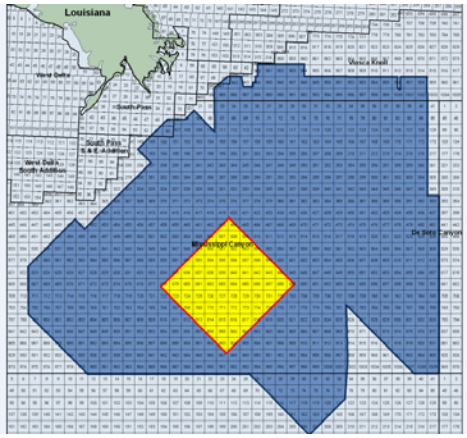

Figure 1: Mississippi Canyon 3D survey and reprocessed subset (yellow)

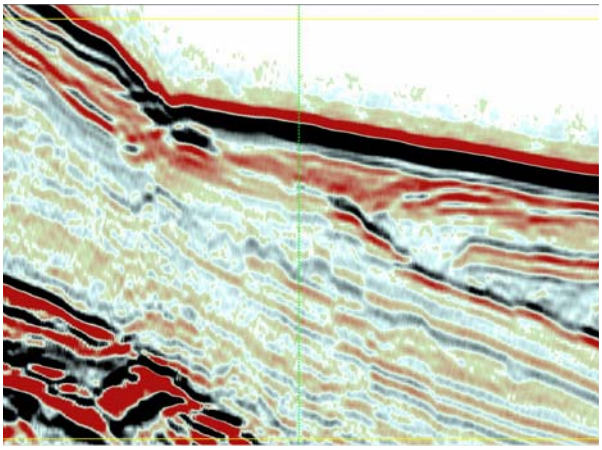

Figure 2: 3D seismic cross section with conventional processing (2000-2500 ms)

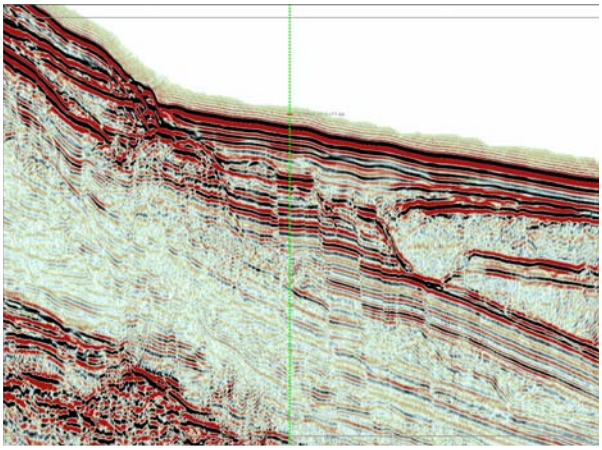

Figure 3: High resolution 2D seismic cross section

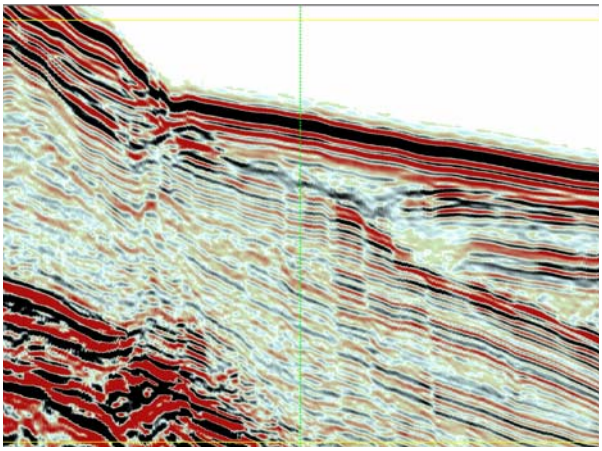

Figure 4: 3D seismic with high resolution reprocessing

Conclusions

Regional 3D surveys are already acquired, and the reprocessing costs are fairly small due to huge advances in computer power over the past decade. Areal coverage is another advantage; the survey used in this case covers virtually all of Mississippi Canyon. Having access to large areal datasets, instead of the more common "postage stamp" site investigation datasets opens many opportunities for assessing potential hazards to drilling and other operations. While frequency response is not as high as that attained by 2D high resolution seismic in the very shallowest section, the advantage of the high quality 3D migration offers greater interpretability of the reprocessed volume, plus a solid 3D volume with which to interpret zones of interest in great detail. Depth of effective investigation is greater with the reprocessed 3D volume, compared to standard 2D high resolution data.

Regional 3D high resolution reprocessing has proven itself as being a very useful and cost effective shallow overburden analysis tool. The authors believe that this represents a largely unexploited opportunity for utilizing a huge existing database in the Gulf of Mexico.

Acknowledgements

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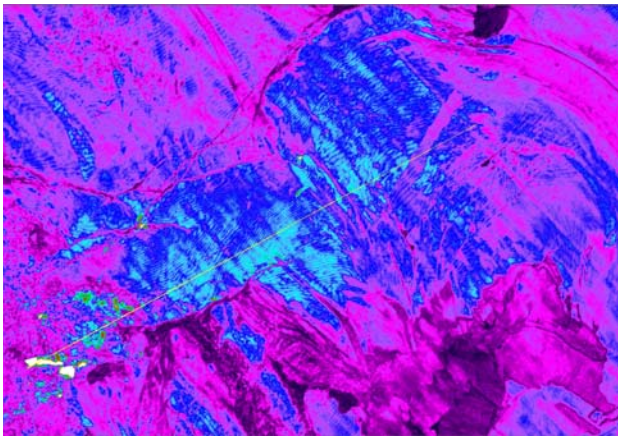

Figure 5: Shallow horizon amplitude extraction (conventional processing)

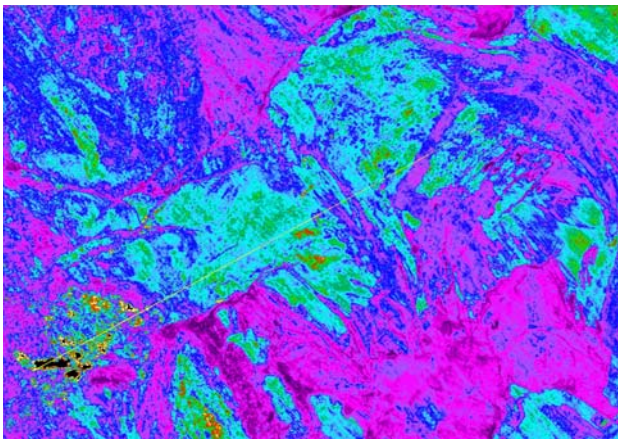

Figure 6: Shallow horizon amplitude extraction (high resolution reprocessing)

EDITED REFERENCES

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REFERENCES

No references