Reducing Structural Uncertainty on a Deepwater Gulf of Mexico Subsalt Field Using TTI WAZ Imaging

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Abstract

Many prospects and development projects in the deepwater Gulf of Mexico are located beneath complex salt canopies. A detailed and accurate anisotropic velocity model is required to produce high quality subsalt imaging. This model results in better well ties and reduces reservoir structural uncertainty.

Reservoir scale mapping and field development well planning benefit from a detailed interpretation and model building workflow. This talk will show the uplift acheived from wide azimuth seismic acquisition and anisotropic Reverse Time Migration imaging on a major subsalt field development in deepwater Gulf of Mexico, USA.

Introduction

The case study for reducing structural uncertainty with seismic imaging improvements is for a large oil field in the deepwater Gulf of Mexico (Swanston et al., 2011). The field was discovered in 2002, and is located 300 km south of New Orleans, LA, USA in ~1250 meters of water. The primary Miocene reservoir section is at a depth of 7000 to 8000 m subsea, below a thick salt canopy and trapped against a near-vertical salt face with structural dips approaching 80 degrees.

Seismic acquisition and imaging technologies continue to evolve at a rapid pace as computers dramatically increase in speed and decrease in cost. Seismic imaging has progressed from isotropic post-stack depth migrations on narrow azimuth (NAZ) 3D seismic data to tilted transverse isotropy (TTI) anisotropic 3D pre-stack depth migrations on wide azimuth (WAZ) 3D seismic data (e.g., Regone, 2006). With advances in data acquisition, pre-processing, and migration techniques, re-imaging can provide a significant uplift.

A 2009-10 3D WAZ re-imaging project for this field delivered enhanced structural imaging for future development. This project benefited from the positive attributes of multi-client 3D WAZ seismic data acquisition including increased azimuth, fold, offset, and improved suitability to multiple attenuation.

TTI multi-azimuth Gaussian Beam (GBM) (Hill, 2001) and Reverse Time Migration (RTM) provided salt-flood volumes for model building. Detailed salt interpretation created an earth model calibrated to well data. The final fullsalt RTM volume resulted in a higher confidence subsalt structural image that has helped to reduce uncertainty and is currently impacting decisions in the field development.

Methods

The anisotropic sediment velocity field was constructed using multi-azimuth TTI tomography calibrated to well control. The top of salt (ToS) was picked from GBM and Kirchhoff datasets migrated with turning rays. We refer the readers to Thomsen (1986) for the definitions of the Thomsen parameters (V_p, δ, ε), Alkhalifah and Tsvankin (1995) for the definition of the η parameter, and Zhou et al (2004) for a description of anisotropic tomography.

We followed a standard “top-down” approach, using sediment and salt-flood migrations, to construct the salt model. The overhangs and final Base of Salt (BoS) were picked from GBM and RTM migrated data sets.

The subsalt velocity model was initially built as a three-layer model calibrated to interval velocity changes measured in well checkshots, VSP’s, and sonic logs from BoS through the base of the reservoir section. This layered model was further refined with one iteration of TTI velocity tomography, and subsalt velocity scans. The final 2010 TTI velocity profile improves the match to well VSP data and enhances gather flattening and imaging.

We calculate depth uncertainty due to velocity by analyzing velocity variations between alternative models, assuming that the modes are independent and their variations are normally distributed.

Results

A comparison of seismic volumes on a strike line across the field demonstrates the imaging improvements achieved over NAZ imaging in 2006. The WAZ data substantially improves S/N and event continuity. The 2010 reprocessing has delivered significant enhancement in multiple attenuation, event positioning and resolution.

Well-seismic miss-ties have been significantly reduced from previous data sets at the reservoir level and the mean value is close to zero. This has allowed us to make maps directly from interpretations on the new volume without a depth adjustment scaling factor as was previously required. The improved accuracy of the velocity model affects the lateral positioning of migrated events. This positioning can be critical for three-way prospects closed against salt.

Careful revision of the velocity/anisotropy model for the 2010 reprocessing eliminated the need for a post-migration depth-correction. The seismic volume tied most well control within a +-50m tolerance. More weight was given to models that tied well control in the uncertainty analysis. Depth uncertainties of portions of the structure with thicker anisotropic suprasalt sediments were reduced to 30-70% of previous values.

Conclusions

The 2010 WAZ TTI RTM volume is a step-change compared to previous NAZ products. The WAZ data provides higher confidence and better interpretability of reservoir compartmentalization, faulting, and volumetrics. This yields an improved understanding of prospect geometry and volumes and facilitates more accurate estimation of prospect risk, resource and value.

Better well-seismic time-depth relationships, steeper dip resolution, higher bandwidth, and higher signal-to-noise ratio (S/N) all improve decision making for well placement, yielding reduced non-productive time while-drilling and optimizing drill locations. This enhances project economics by lowering costs and accelerating production.

The results have impacted the development project by reducing structural uncertainty in the subsalt reservoir section. These changes may yield substantial cost savings and deliver increased reserves.

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