Pressure Prediction and Hazard Avoidance through Improved Seismic Imaging – SEAM Phase III

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“One of the most important technologies for pressure prediction in the early well planning stage, that is pre-drill, is 3D seismic. . . . A significant barrier to improving the methodology has been the lack of accurate and precise data of the subsurface calibrated back to either well logs that are used in prediction or 3D seismic.” Research Partnership to Secure Energy for America (RPSEA) - August 14, 2013

Abstract
High quality seismic data are required for improving the quality of pre-drill pressure predictions and for assessing shallow hazards. However, a significant barrier to improving the current state-of-the-art in pressure prediction has been the lack of an accurately calibrated benchmark seismic dataset, tied to wells, which together can be used to test evolving technologies and methodologies. The SEAM Phase III research consortium will provide two such “industrial strength” benchmark datasets: one for deep subsalt pressure challenges and one for shallow hazards.

The datasets will be simulated on a highly realistic earth model constructed to include a range of typical deep pressure and shallow hazard anomalies, to be determined by consortium members. Well log and lab data, both public access and proprietary, will be used to establish rock, pressure and geophysical properties. Geomechanical and basin modeling effects will be considered. The model will be created by modifying and extending the existing SEAM Phase I Deepwater Subsalt Gulf of Mexico model (36 km x 40 km x 10 km). The datasets will be used to evaluate evolving technologies for predicting pressure and shallow hazards. Improved estimates of bed normal Vp will be the primary focus. Other approaches involving shear velocity and density will also be considered.

A proposed methodology for quantifying risk and uncertainty in pressure predictions, including geophysical and pressure transform ambiguities, will be developed. This methodology, the model and the simulations will provide fertile ground for ongoing industry and academic research into improved pre-drill pressure prediction and hazard avoidance.

Objectives
1. Establish benchmark seismic datasets for industry and academic use in investigating improved approaches for prediction of deep pressure and shallow hazards.
2. Propose a methodology for quantifying risk and uncertainty in velocity estimation for pressure prediction.

SEAM Phase I Deepwater Model
The SEAM Deepwater Model was designed to capture both geological realism and appropriate rock physics. This requires internal consistency across the domains of rock properties (e.g., percent shale, porosity of sand and shale, and compaction gradients), the intermediate level elastic and electromagnetic properties and the output geophysical simulations. By rooting the geophysical properties back to fundamental rock properties, any changes in the latter are guaranteed to change the former automatically, consistently, and with the appropriate correlations. Properties are geostatistically parameterized on a 20m x 20m x 10m grid. The model can be modified for other uses by the incorporation of parameters like pore-pressure and shallow gas charged reservoirs. Near-seafloor S-wave velocities are as low as 120 m/s and provide good opportunity to include a detailed representation of shallow drilling hazards that can be evaluated using high frequency seismic simulations.

Elastic parameter modeling from Rock properties

Seismic parameter modeling from Elastic parameters

Seismic Waves

P, S, gR, S, anisotropy, EM response, Grain size

Elasticity Inversion for rock/reservoir properties

AVO reflectivity inversion for elastic parameters

Geological and Geophysical properties at a selected location

Synthetic well logs from the model at North = 20 km, East = 24 km (location on cross-section below). Shown are vshale and 0-angle reflectivity (R) in black, porosity in blue, density in green, Vp in red. All depths are measured from the water bottom. Dashed lines are masterlayer boundaries. Green segments mark the depths of various reservoirs at this location: all reservoirs are turbidites except for the channel sands in the Upper Miocene at about 5000 m below the seafloor. The star corresponds to the Middle Miocene turbidite on the plat above.

Proposed Project Plan 2014 – 2018

Model Redesign
Pressure Simulation
Shallow Simulation
State-of-Art Report
Processing Trials
Methodology Report
Industry Workshop

Hit count is one measure of Illumination
Ray hits/ bin cell on top Oligocene for Phase I deepwater model with full azimuth recording. Red represents highest hit count density. Black represents areas where top Oligocene has been pierced by salt.

Shallow Hazards – Examples and Opportunities

• Gas charged sands
• Shallow water flows
• Full Waveform Inversion (FWI) for high resolution velocities
• Vp/Vs ratio for improved characterization of hazards

Approach
• Establish Industry Consortium of 10-15 leading companies
• Leverage industry funding with RPSEA research grant
• Prioritize pressure prediction and shallow hazard challenges
• Assemble relevant well and log data
• Modify SEAM Phase I model to include challenges
• Simulate oversampled anisotropic elastic seismic data (pressure prediction)
• Simulate high frequency elastic seismic data (shallow hazards)
• Test velocity estimation technologies on simulated data
• Develop methodology for quantifying risk and uncertainty