PS Challenges at Droshky Field, Green Canyon Block 244, Gulf of Mexico: The Journey from Discovery to First Oil and Beyond*

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Abstract

Marathon discovered the Droshky Field in Green Canyon Block 244, Gulf of Mexico, in March 2007, and the project was put on a fast track to development in July 2007. A delineation drilling program in 2008 was followed by a development drilling program in 2009, culminating with the field coming onstream in July 2010.

Significant subsurface-related challenges were encountered during the development process. The results of the delineation drilling program indicated that the down-dip portion of the field was not in communication with the up-dip area. By the end of the development drilling program, 22 separate reservoir compartments had been identified. These compartments were imaged in different lateral positions depending on which seismic volume was used.

The seismic data were inverted to acoustic impedance (AI), and this volume was used to create a structural framework for the static geocellular model. Sands were distributed through the model based on a relationship with AI. Over time, this workflow was refined in order to accurately reflect the complexity of the reservoir. Prior to development drilling, multiple completion intervals in three of the producing wells were picked based on the final dynamic reservoir model. Post-drilling, while the individual zones to be completed in each well changed, overall 105% of the prognosed completion net pay was encountered. Subsequent history matching of production resulted in further refinements to the workflow as the implementation of localized seismic imagining.

The lessons learned in dealing with these challenges can be applied to future developments in the Gulf of Mexico and elsewhere.

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Field Background

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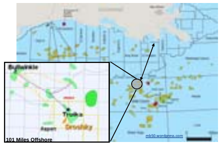
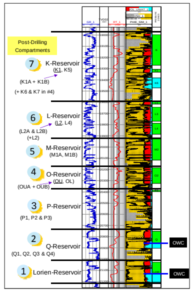
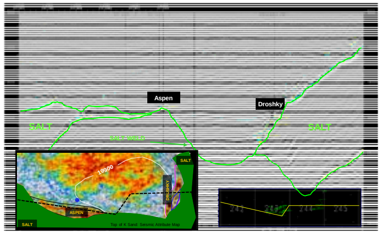




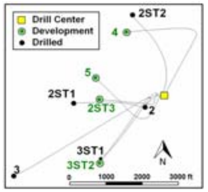
Conceptual development plan: drilling production wells and tying them back to Shell Offshore Inc.'s (Shell) A-Bullwinkle platform located in G.C. block 65

Field located within a relatively small intraslope salt-withdrawal minibasin. Structure controlled by salt movement. Max. structural dips of up to 35º

Well 2ST1 encountered 982 TVD feet of net pay. OWC encountered in the Q and Lorien reservoirs.

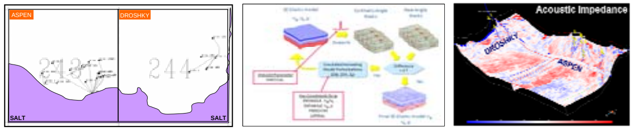


All seismic data courtesy of WesternGeco

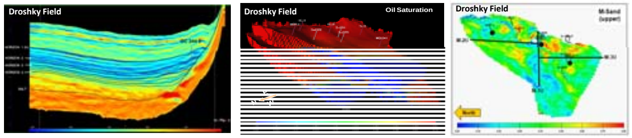


Basin Model – 2007 Sanction Model

Basin study purpose: evaluate the pressure sensitivity and basinal connectivity between the Droshky and Aspen fields, and quantify the magnitude of hypothesized pressure depletion. Rock properties were distributed in the model based on a correlation to acoustic impedance. Production from Aspen could result in up to 750 psi depletion in the L-sand at Droshky if fields are connected; there appears to be limited connectivity based on Aspen History Match and Droshky MDT analysis.

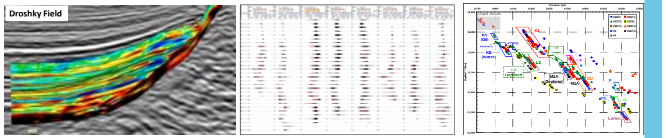


The initial stratigraphic framework adopted by the subsurface team included the seven major reservoir divisions defined during exploration activities. The downdip limits were set to include aquifer support based on observed performance at Aspen.

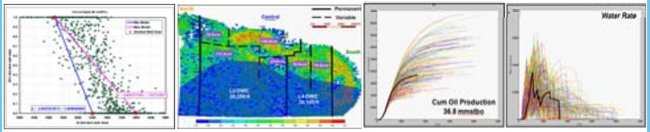


Delineation Phase 2008

Reservoir compartmentalization continued to be a major focus during the 2008 Model Study. Based on the updated inversion data volume, after three delineation wells were drilled, a total of 22 probable and 13 possible discontinuities were introduced into the dynamic model.

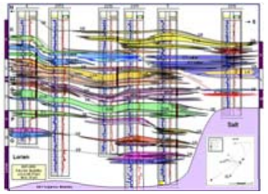


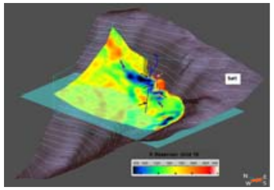
Six potential well locations were identified in this model. Dynamic stochastic modeling was performed field-wide and on each potential development well, in order to evaluate the recovery potential of each location. Interference effects between wells were excluded for this evaluation since each evaluation represented a single well development.

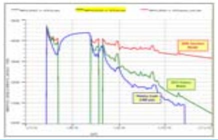


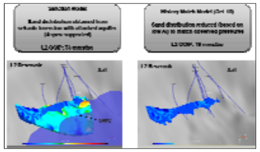
Development phase 2009 – History Match 2010

Based on previous geological analyses and MDT pressures from the existing wells, a channelized system was used as the basis for the stratigraphic framework. The reservoir was divided in flow units, where intermediate shales were isolated and not taken in to account as part of the reservoir units



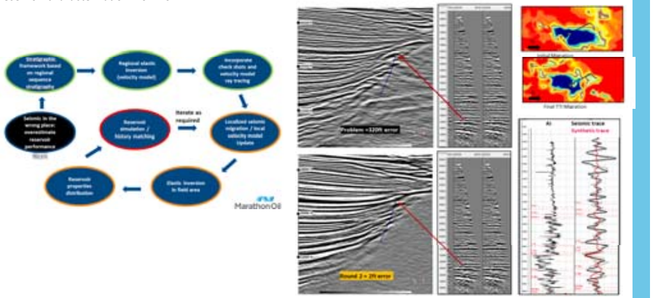




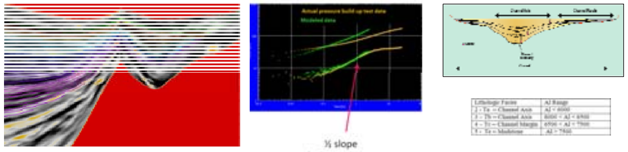


History Match / Re-Modelling

Localized Seismic Imaging (LSI) was performed in the field for re-positioning the seismic data integrating well velocities, checkshot data, and initial velocity field as main inputs. This methodology provided a better seismic tie to all the wells in the reservoir and puts the seismic in the "right place" both laterally and vertically and had a direct impact in the overall reservoir characterization workflow.

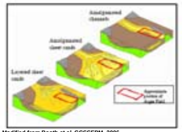


Integration of data as evidence for a channelized system: 1. Initial core data analysis; 2. SSIS (Sequence Stratigraphic Interpretation System) automatically interprets seismic data. Some individual channels were identified from seismic, and were used as a guide in the manual interpretation; 3. Build up test interpretation.

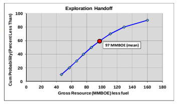


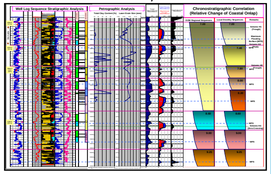
Static Model

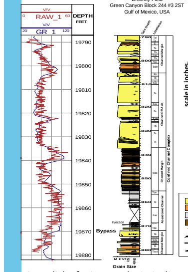
Several geological scenarios were analyzed to develop the field from the beginning of the project. An amalgamated sheet sand model was used in 2007 as a sanction case. A confined channel model was used for history match and forecast purposes.

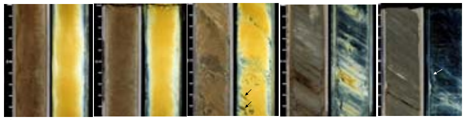


Modified from Booth et al, GCSSEPM, 2006









fine-grained, massive Ta; possible dewatering features displayed in plain light but not in UV light;.core depth 19816-19814 ft.

fine- to very fine-grained sandstone with planar lamination, Bouma Tb division; core interval 19799-19798 ft;

fine-grained massive sandstone with mudstone rip-up clasts; note rounded to subrounded clasts (arrows) are aligned, which indicated traction along bed base; note sharp contact between Ta bed and overlying current-ripple lamination, Tc bed. This sharp contact indicates the beds were likely deposited from separate flows; core depth 19807-19805 ft;

Laminated mudstone and sandy siltstone, Bouma Td division, with sparse burrows; core depth interval 19871-19870 ft

Laminated mudstone, Bouma Tde division, with abundant *Chrondrites sp* and sand-filled *Diplocraterion sp?* (arrow) burrow; core depth interval 19869-19868 ft

A 92 ft. conventional core was obtained in the K reservoir interval in well 3ST2.

Core lithofacies analysis indicates that the Miocene material was deposited from turbidity currents that traversed a small, intraslope basin. Production data confirmed that most of the turbiditic material was deposited within confined channels rather than as lobes in an unconfined system. The deep-water origin of these rocks is indicated by the abundance of sediment gravity flows, which are organized into sharp-based, aggradational to coarsening-upward packages

Conclusions

The three significant methodologies (seismic inversion, collocation of the seismic image with other reservoir data, and higher seismic resolution) greatly improved the overall geological understanding of the field. This integrated technology, along with core descriptions and the analysis of the depositional environment, allowed us to conclude that Droshky was deposited as channelized system sourced from the north. The final 3D geocellular model is consistent with seismic, check-shot, log, biostratigraphic, and core data, and resulted in a much more accurate production history matched model. We were then able to offer a more realistic prognosis for the field development.