Exploring the Geopressure Risk in Deep Water Frontier Plays

Case Histories from GoM

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Geopressure Analysis Services
(G.A.S.)
Deposition, Basin subsidence, Tectonic and Stresses magnitude and path history

PS, IS and MS are Principal, Intermediate and Minimum Stresses

Geology of Stresses

Courtesy of TGS Ad
Subsurface Geopressure Profile

Rocks, Fluids and Stress

Predicted PP  Measurable PP  Fracture pressure

G.A.S.
Geopressure Drilling Tolerance Window (DTW)

Unconfined Hydrodynamic
Confined Geopressed

TOG
Top of Geopressure

MW pressure

Safety Limit

Predicted PP
Measurable PP
Mud Pressure

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Impact of Mud line depth on DTW:

G.A.S. Oil vs. Gas entrapment

Shallow vs. Deep Water PP profiles:

- Impact of Mud line depth on DTW:
  - W.D. = 7000'
  - Mud Line (sea floor)

- Oil vs. Gas entrapment
 Challenges due to Transgression and Regression

Impact of P Transgression (T) and P Regression (R) on DTW:
Strong Transgression (T)

Transgression and Regression

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Well abandonment in DW due to the proximity of Mud and Formation Pressures
Flow – Kill – Breakdown (LOC)
FKB Cycle

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Compartmentalization and Sealing Capacity:

Compartmentalization based on MPP
The Impact of HYDROCARBON on the DTW

Mississippi Canyon 296 (ENI)

The thick gas column led to more reduction of the DTW

Immediate south of DW Horizon block MC 252 (BP Deep Horizon)

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The narrow DTW in addition to the presence of hydrocarbon led to serious drilling challenges.

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The Impact of Dirty Salt on the DTW
Stresses models (generic)
(due to low salt density and very low permeability)

2.3 g/cc @ 20 % porosity

1.9 g/cc LOW DENSITY Impermeable

Resultant Vector

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Principal Stress vs. Overburden in Salt Basins (due to salt perturbation)

Diapirism / Buoyancy

OB (Overburden)

SS (Shear Stress)

PS (Maximum Principal Stress)

Pre-Salt Sediment
The Salt Toe at Sigsbee frontier plays

Modified after Rowan 1999

Frontier GOM Discoveries
Modified after Chowdhury and Lopez-Mora, 2004

PS = TS
MS = OB
IS
TS = Tectonic Stress

OB = FP

Slow Moving Buried Salt

Early Tertiary (Wilcox)
Geopressure Model of Salt Toe

- OB+WC
- FP
- Rafted sediments
- Mud Line
- Normally Pressured
- SS
- SB
- Gouge
- PP
- PS
- Tertiary Salt Toe Belt
- New Discoveries
- Pre salt PP
- Top of Geopressure
- G.A.S.

Gouge

Mud Line
Paleogene

Chevron Jack #1

P-D Plot

ppg mwe

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Jack #1 Mud log

- Rafted Sediments
- Jack at the base of salt
- No Mud Return (Gouge)
- Jack in middle of salt

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Chevron
St. Malo #1
P-D Plot
ppg mwe

Gouge zone ?

Clean Salt

DTW

Calculated Fracture Pressure

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Jack vs. St. Malo Discoveries
BP
Atlantis #1
P-D Plot
ppg mwe

Challenges:
- LOC @salt base
- Csg in Salt
- Several Bypass & ST

Pressure MWE

Calculated Fracture Pressure

Dirty Salt
DTW
FKB
Gouge zone

G.A.S.
Hadrian #1
P-D Plot
ppg mwe

Exxon - Hadrian - KC919 #1
Pressure MWE

Calculated Fracture Pressure

Clean Salt
Gouge zone
DTW

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Atlantis vs. Hadrian Discoveries

BP - Atlantis - MC 699 #1

Calculating Fracture Pressure

Dirty Salt

DTW

FKB

Gouge zone

Calculated Fracture Pressure

BP - Atlantis - MC 699 #1

MW LOT-FIT Csg PS mwe

Exxon - Hadrian - KC919 #1

Calculating Fracture Pressure

Clean Salt

DTW

Gouge zone

Calculated Fracture Pressure

Exxon - Hadrian - KC919 #1

MW LOT-FIT Csg PS mwe MDT ppg
The importance of integrating the prospect’s geological building blocks with Seismic PP Predictions:

- Deposits geometry and facies changes

Velocity (Porosity Index)

Communication

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Seal – Reservoir Interface

Pressure

predicted Seal Pressure
Reservoir Pressure
Pressure Transgression
Pressure Regression
Proposed Mud pressure
- Salt emplacement and displacement impact on geopressure setting and Risk Assessment
Pore Pressure Prediction Modeling Challenges

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Challenges of PPP Model Calibration in a pay zone?
Conclusions

- Pore pressure is predicted in seals and measurable in reservoirs.
- The DTW (FP – PP) window size dictates feasible prospect’s drilling prognosis.

**Factors Reduce DTW**

- Increase of water depth to the sea floor (mud line) reduces the DTW
- PT and PR cause the disparity between seal and reservoir pressures
- Hydrocarbon column reduces DTW
- Dirty Salt reduces DTW

The most troublesome spots along the bore hole trajectory is the seal – reservoir interface.

- Establishing the geological building blocks for geopressure prediction goes hand in hand with prospect generation and forecasts drilling challenges.
- Bore hole instability, bypasses, side tracks, F-K-B cycle, possible blow-out, and failure to reach the prospective target are common in Deepwater due to the narrow DTW.
- Prediction’s Model Calibration challenges

Oil vs. Gas in Deep Water
Thank you