

Pore Pressure Prediction as a Prospecting Tool, Input to Risk, Volumes and Field Development*

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Abstract

Pore pressure predictions calculated from offset wells and interval velocity data have been used almost exclusively to design well casings and drilling mud weight programs. However, a pore pressure prediction also contains valuable information on how oil, gas and water is behaving in the subsurface and importantly how fluid pressures will effect top seals, fault seals and column heights in hydrocarbon prospects. Pore pressure can be used as an important input to pre-drill and post drill prospect evaluation by combining fault and horizon information, derived from geological maps, with an understanding of how fluid migration and pore pressures, derived from pore pressure predictions, can affect trap risk and volumes. The relevant data can be integrated and visualized by using a simple Exploration Pressure Plot. The use of pore pressure predictions as an exploration tool has the advantage that it does not require any additional computational work since a pore pressure prediction must be produced in order to design a well. The key change is a modification to the existing exploration workflow so that pore pressures are calculated during the initial exploration stage which allows them to be combined with mapped horizon and fault data to produce integrated geo-pressure / geometric trap scenarios. The advantages of the improved pore pressure workflow will be illustrated using two exploration / development case studies. The first, from Malaysian offshore Block Sabah 301 illustrates how the centroid concept or dynamic capacity model can be used to identify a state of catastrophic seal failure where up dip pore pressure transfer from adjacent synclines has pushed water pressure at the crest of the trap to leak off. This example further highlights how the analysis of the pressure data from the first exploration well is vital to produce a geologically valid trap model and avoid drilling additional high risk exploration wells. The second example from Central Asia illustrates the power of combining pore pressure/fluid migration data with structural fault seal and top seal analysis. The approach was used to define a new trap scenario based on "pressure balance" and provided a geological model which tied together several disparate and conflicting pieces of data. The outcome of the analysis was used to guide ongoing exploration and revealed a risk of early water break through into gas production wells.

Pore Pressure Prediction As An Exploration Tool

- ***Using Pore Pressure Predictions Is A Critical Part Of Prospecting***
- ***Pore Pressure Directly Impacts Exploration Risk & IP Volumes***
- ***Two Examples from Recent Exploration Projects***



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Pore Pressure Prediction As An Exploration Tool

How Do We Define Oil & Gas Traps?

During Exploration G&G Are Trying To Define a Valid Hydrocarbon Trap

Typically G&G Devote Most Time Defining the Physical Characteristics of a Trap
e.g., Geometry, Areal Extent, Net : Gross etc

Typically (*Especially Pre-Drill*) G&G Devote Relatively Little Time Analyzing
(Predicting) Fluid Behavior in a Trap

Fluid Behavior

Oil, Gas & Water

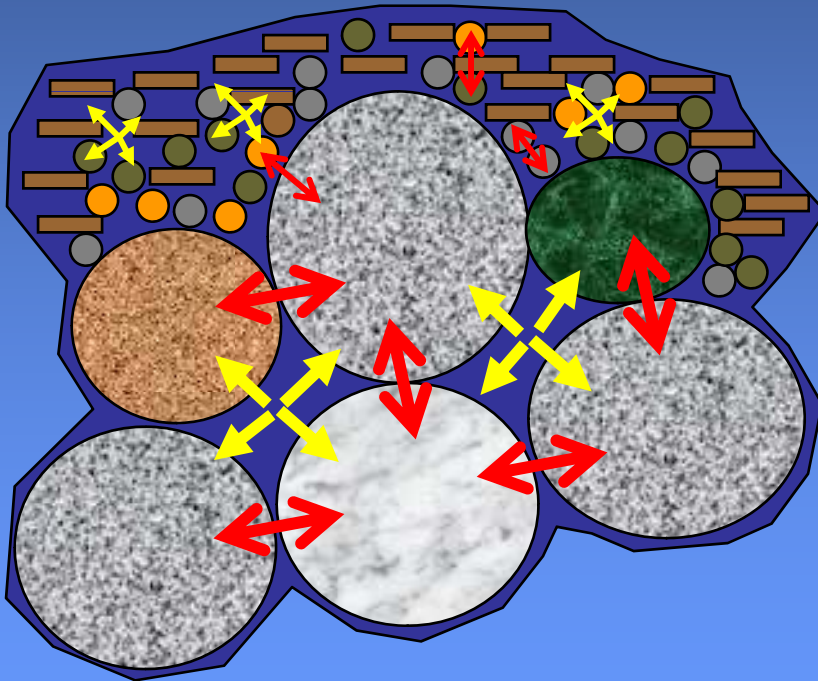
Pore Pressure

Pore Pressure Prediction As An Exploration Tool

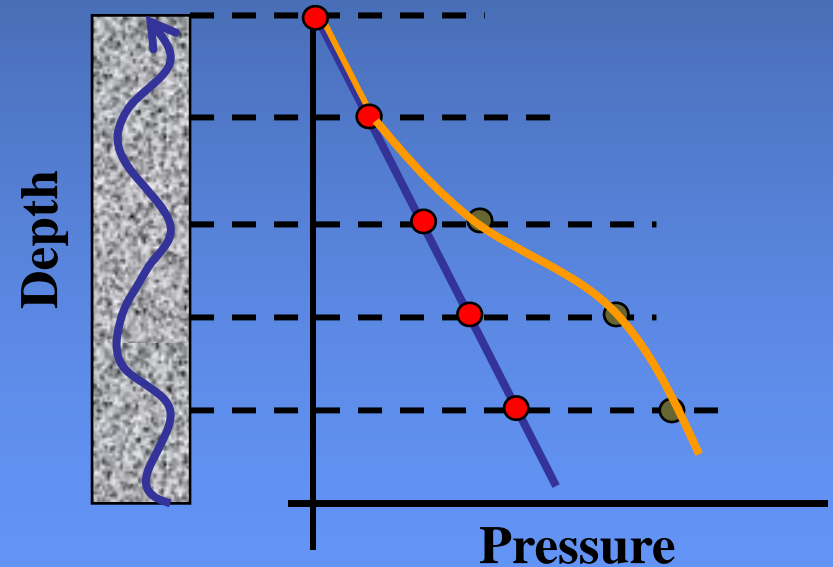
Pore Pressure

The Pressure of Fluids (Oil, Water & Gas) Trapped within Pore Spaces in a Rock

Shale Pore Pressure ~SEALS

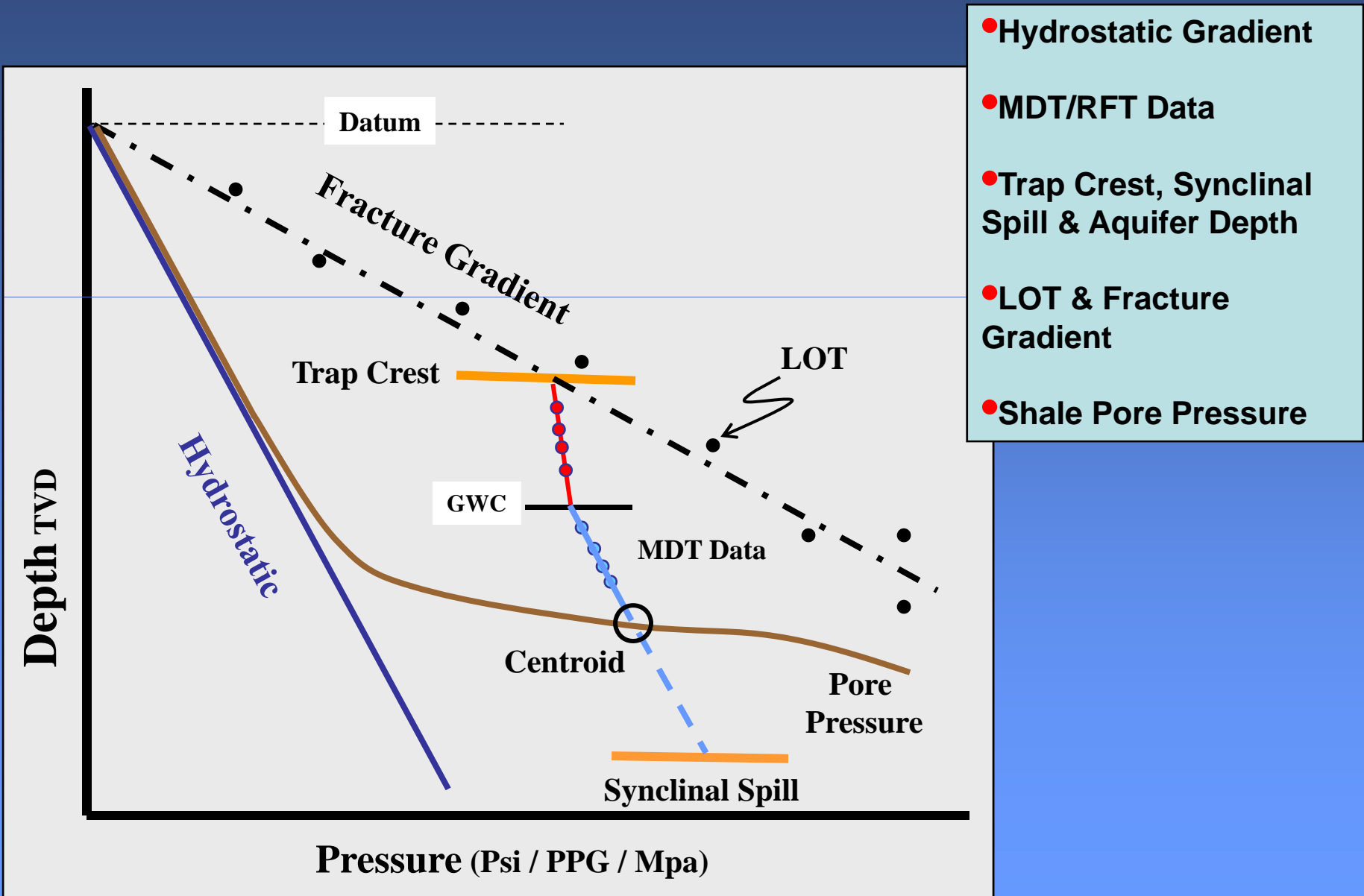


Sand Pore Pressure
~ RESERVOIRS / AQUIFERS



Pore Pressure Prediction As An Exploration Tool

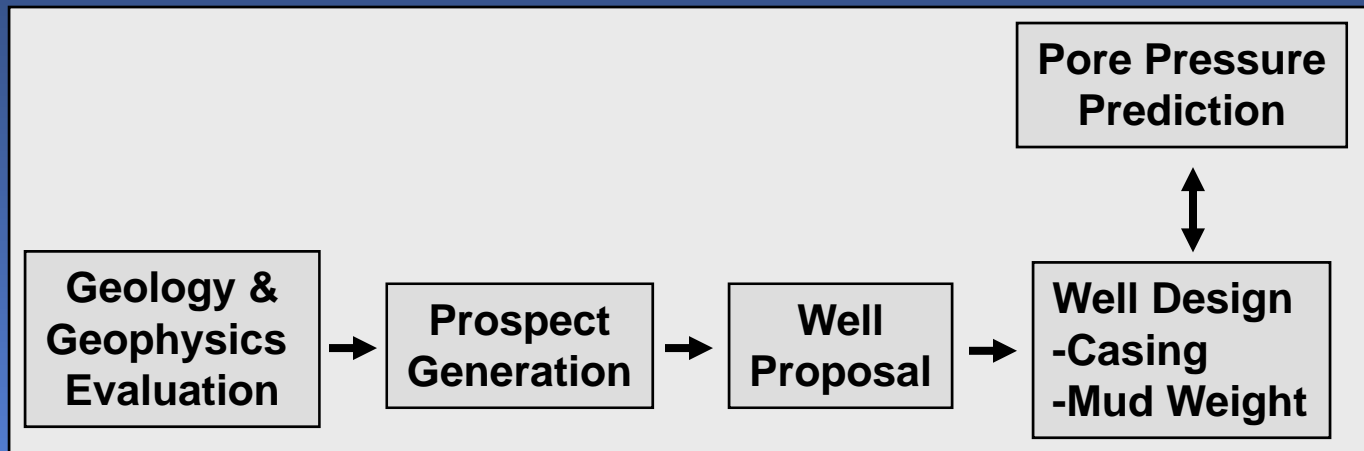
Exploration Pressure Plot



Pore Pressure Prediction As An Exploration Tool

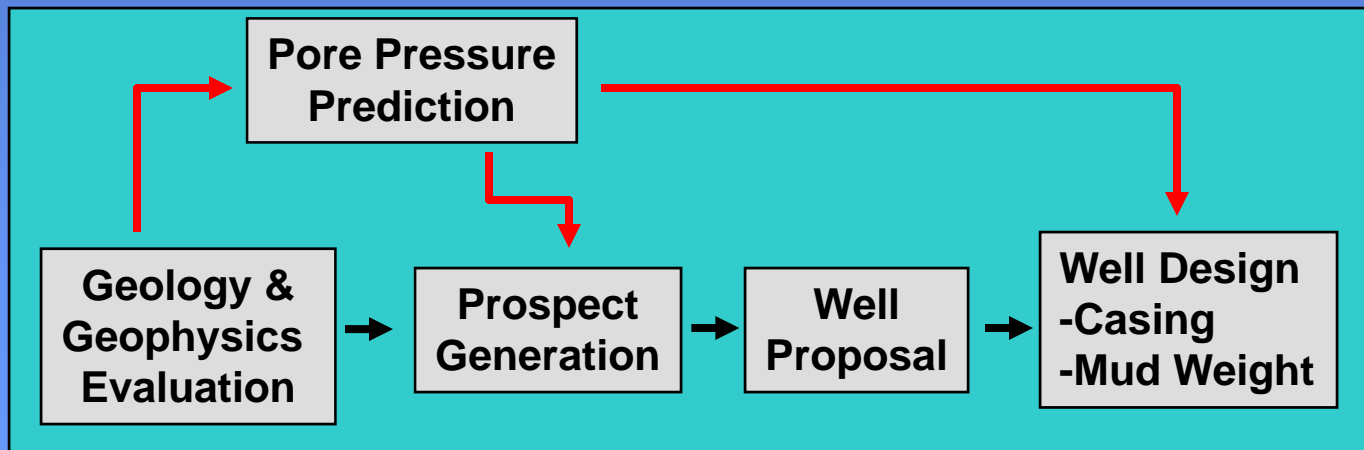
Pore Pressure / Prospecting Workflow

Workflow / Time Line



Typically, Pore Pressure is Calculated After Prospecting is Complete

Standard Workflow



Pore Pressure Calculated Early, as Part of Initial Prospect Generation

Better Workflow

Pore Pressure Prediction As An Exploration Tool

Exploration Pore Pressure Examples

- Two Examples from Recent Exploration Prospects
- Integrating Pore Pressure Had Significant Impact on E & D
- \$

Offshore Malay Basin

CATASTROPHIC TOP SEAL FAILURE

Early Inclusion of Pore Pressure Could
Have Reduced Number of Exploration
Wells

No Commercial Oil or Gas

Central Asia

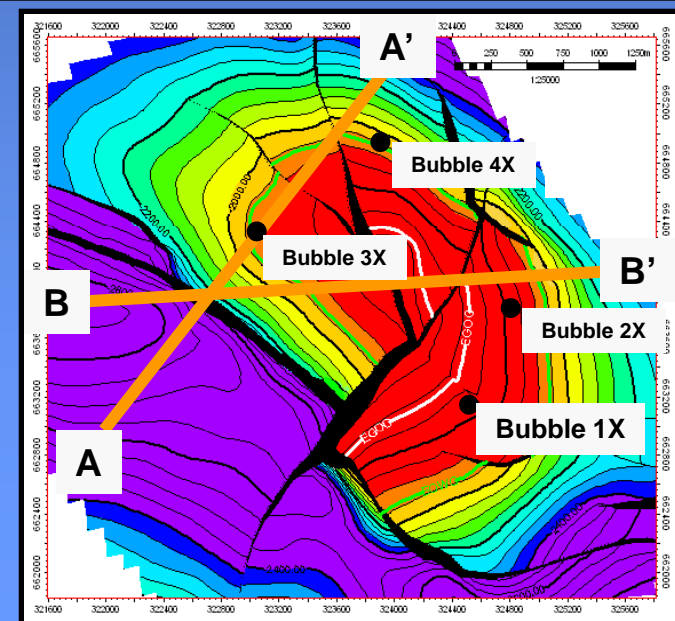
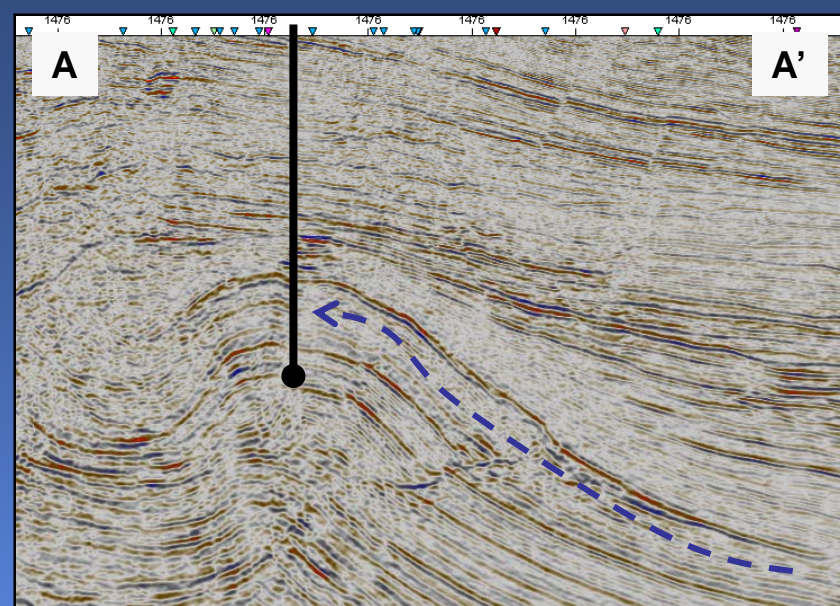
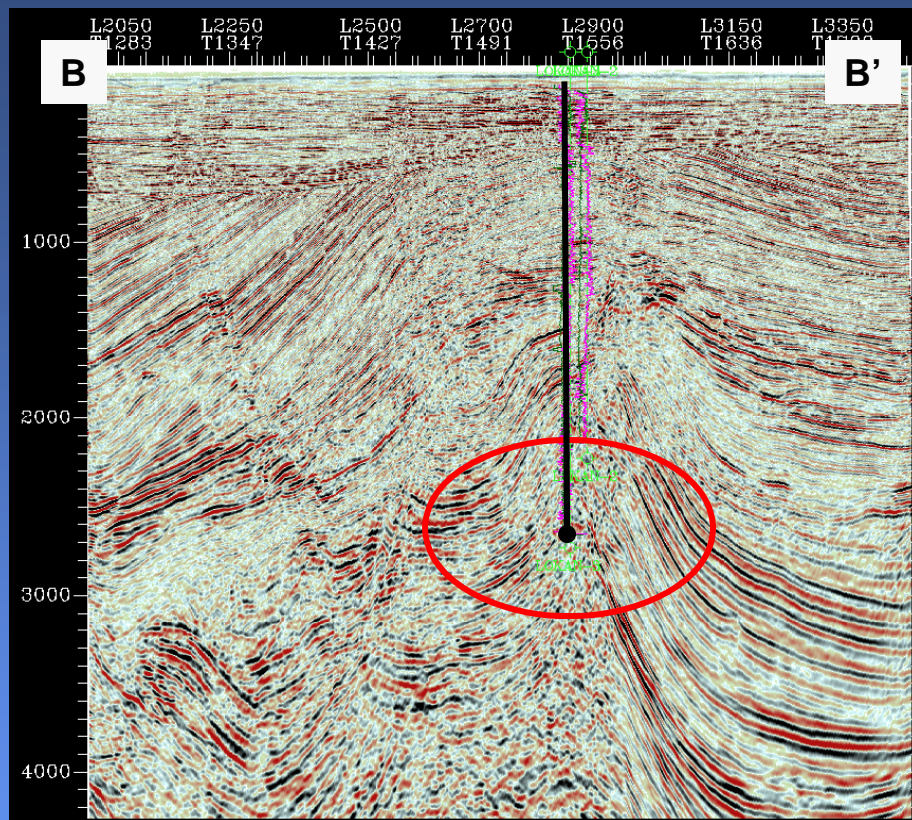
FLUID PRESSURE BALANCED TRAP

Understanding Pore Pressure Behavior
Impacted Future Exploration Plays

Impact on Ongoing E&D

Pore Pressure Prediction As An Exploration Tool

Example 1, Offshore Malaysia



● 4 Way Faulted Anticline

Simple Trap

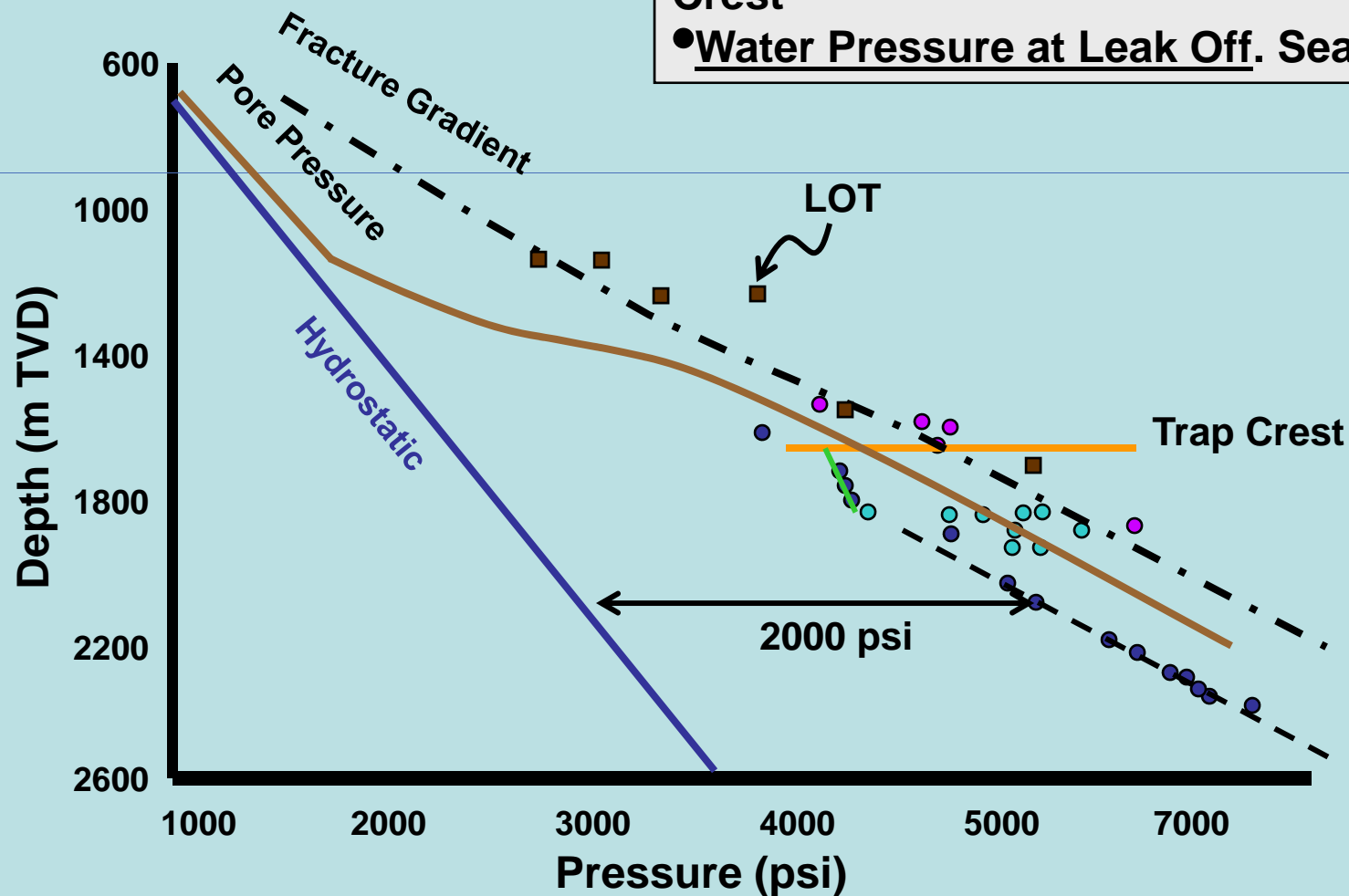
- Rapid Miocene Sedimentation
- Pliocene Uplift & Erosion
- Deep Aquifers

↕ Pore Pressure/
Top Seal Risk

Pore Pressure Prediction As An Exploration Tool

Catastrophic Top Seal Failure

- Geology. Rapid Miocene Sedimentation Followed by Uplift & Erosion
- Deep Aquifer. Increase Water Pressure at Trap Crest
- Water Pressure at Leak Off. Seal Failure



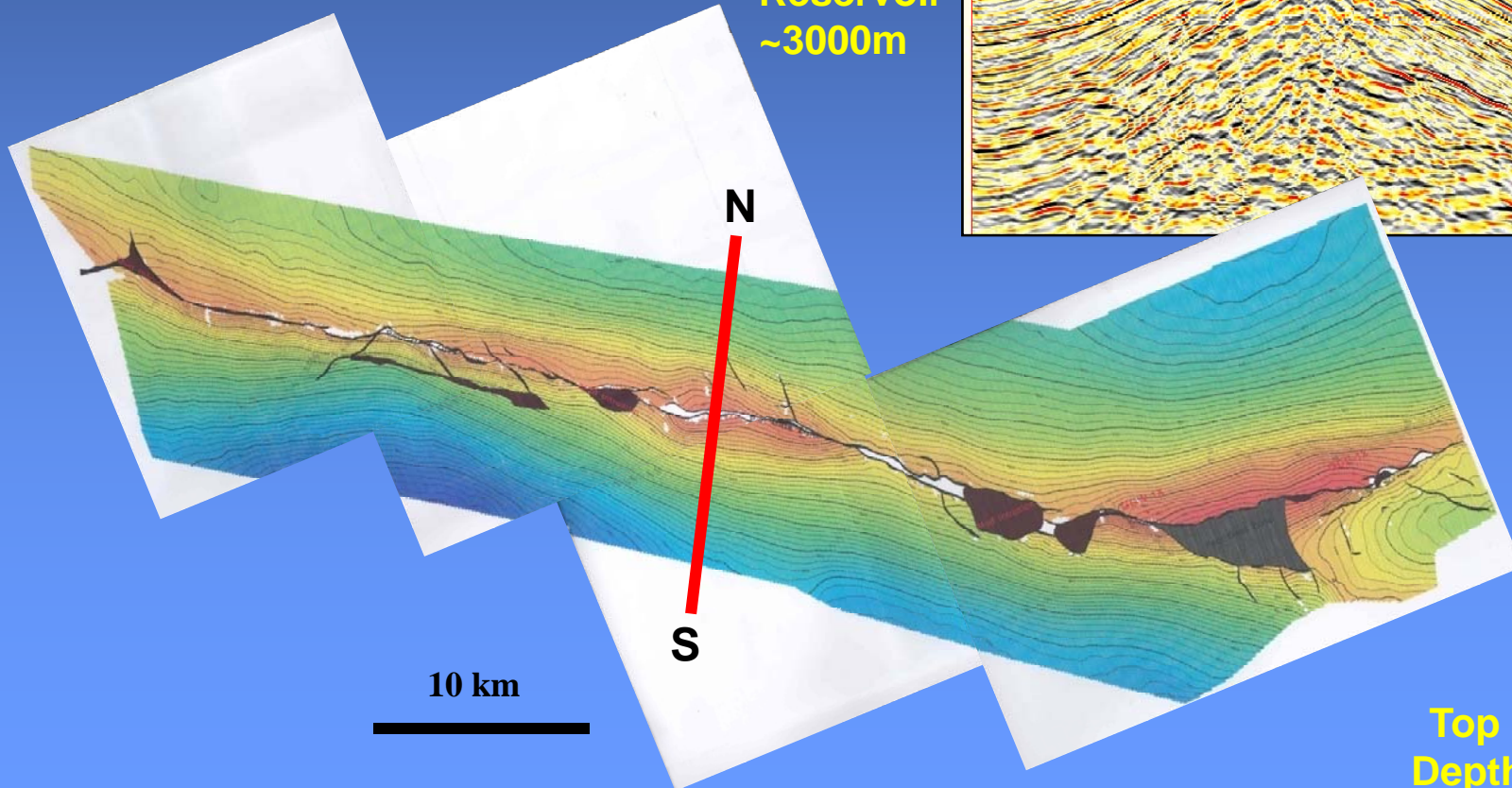
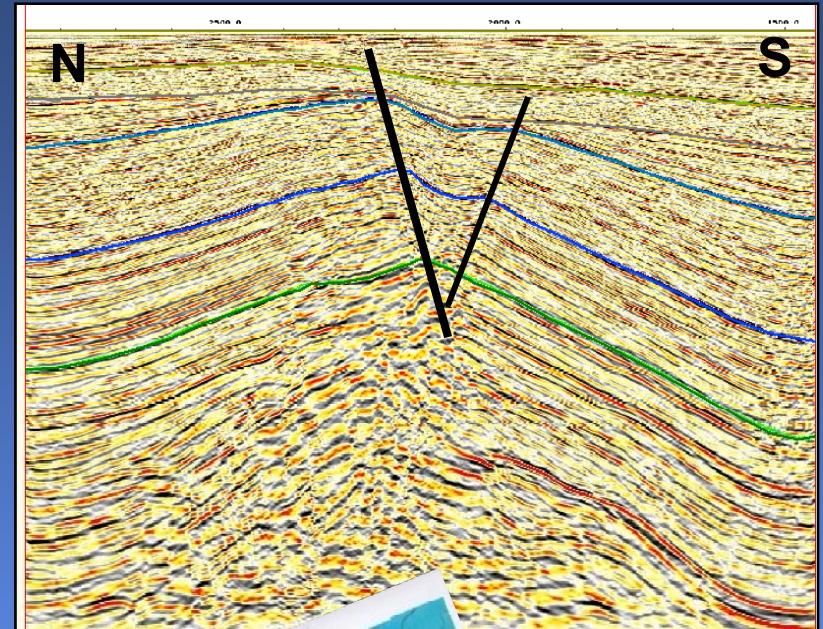
Pore Pressure Prediction As An Exploration Tool

Example 2, Central Asia

- Anticlinal Ridge with Crestal Faults
- Multiple GWC & OWC Contacts N. Flank
- Exploration Potential on S. Flank
- Trap Not Filled to Spill

Plio-Miocene

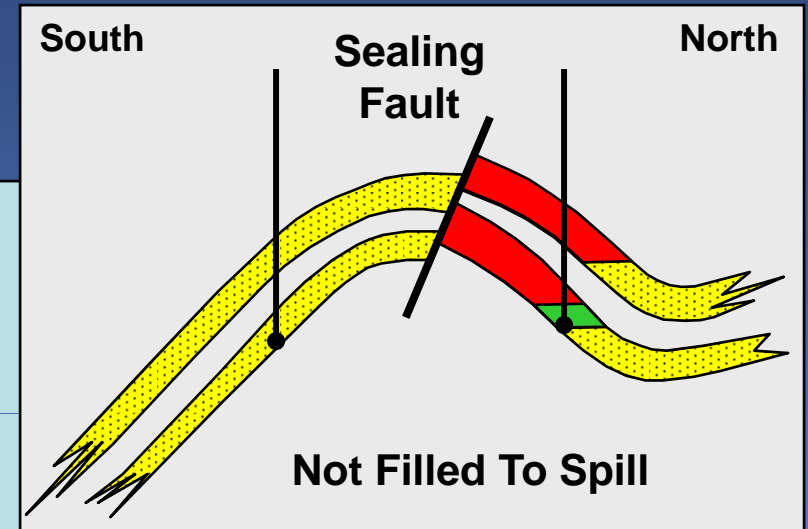
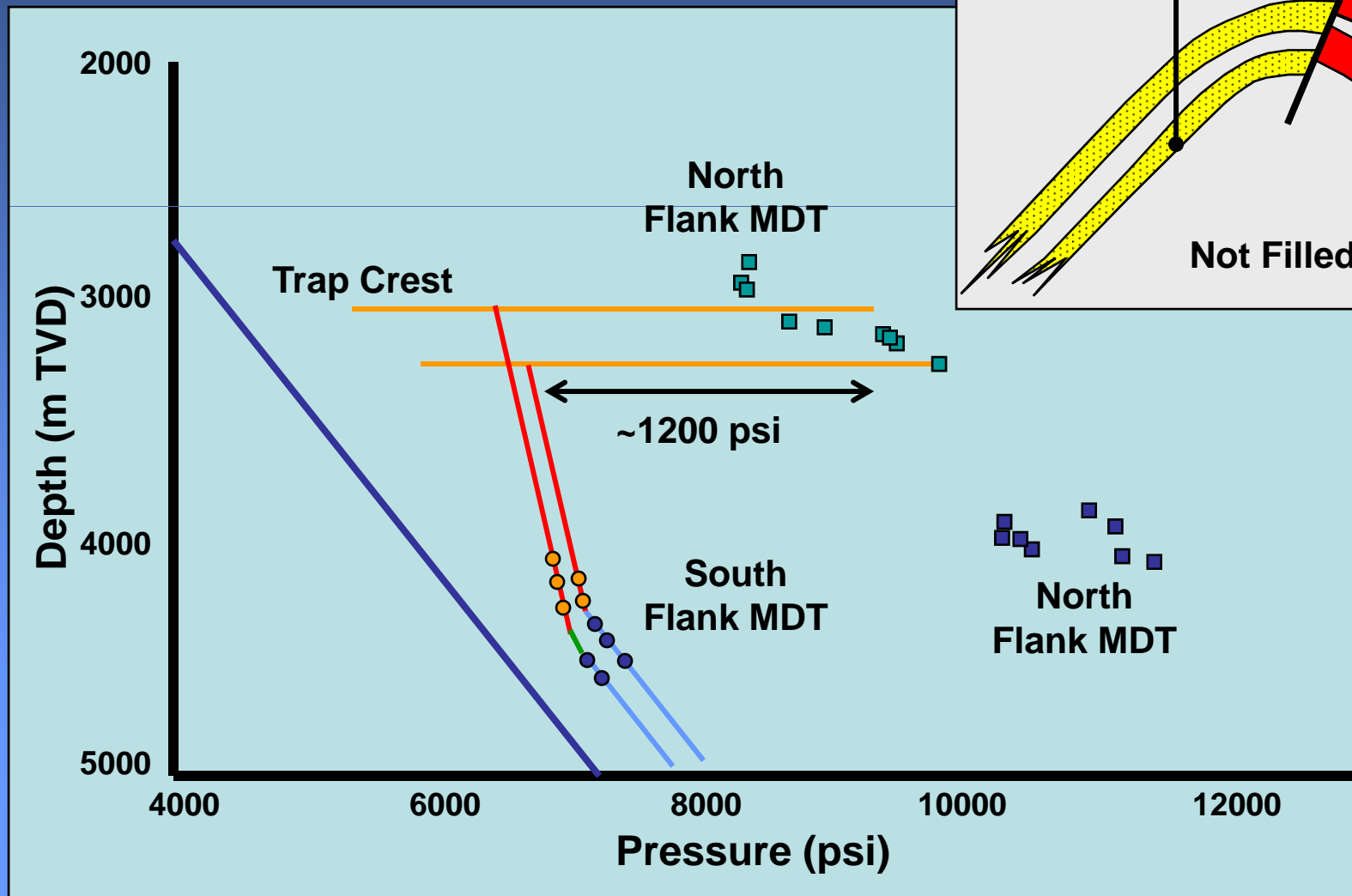
Reservoir
~3000m



Top Reservoir
Depth Structure

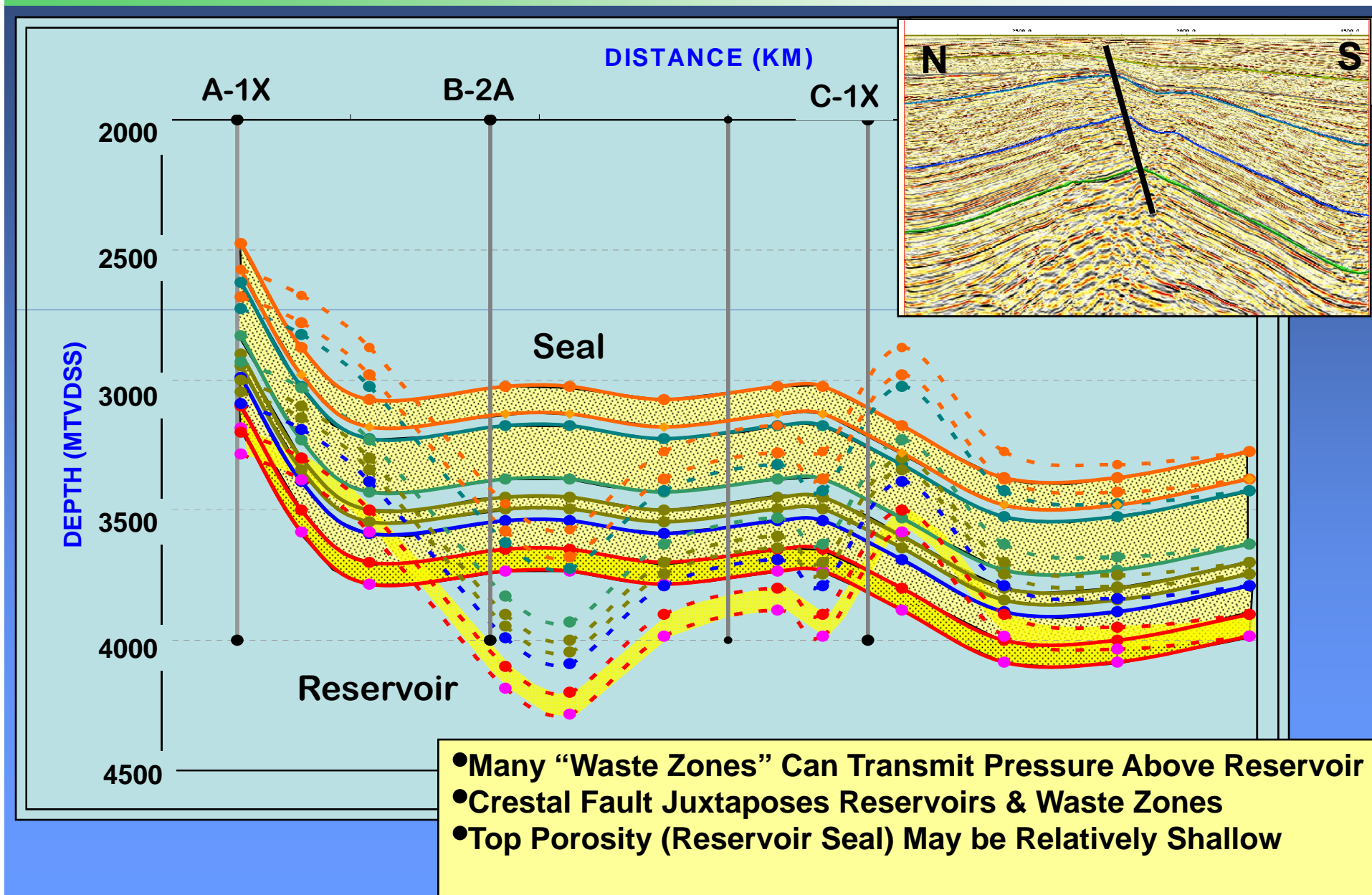
Pore Pressure Prediction As An Exploration Tool

Trap Model Without Pore Pressure



Pore Pressure Prediction As An Exploration Tool

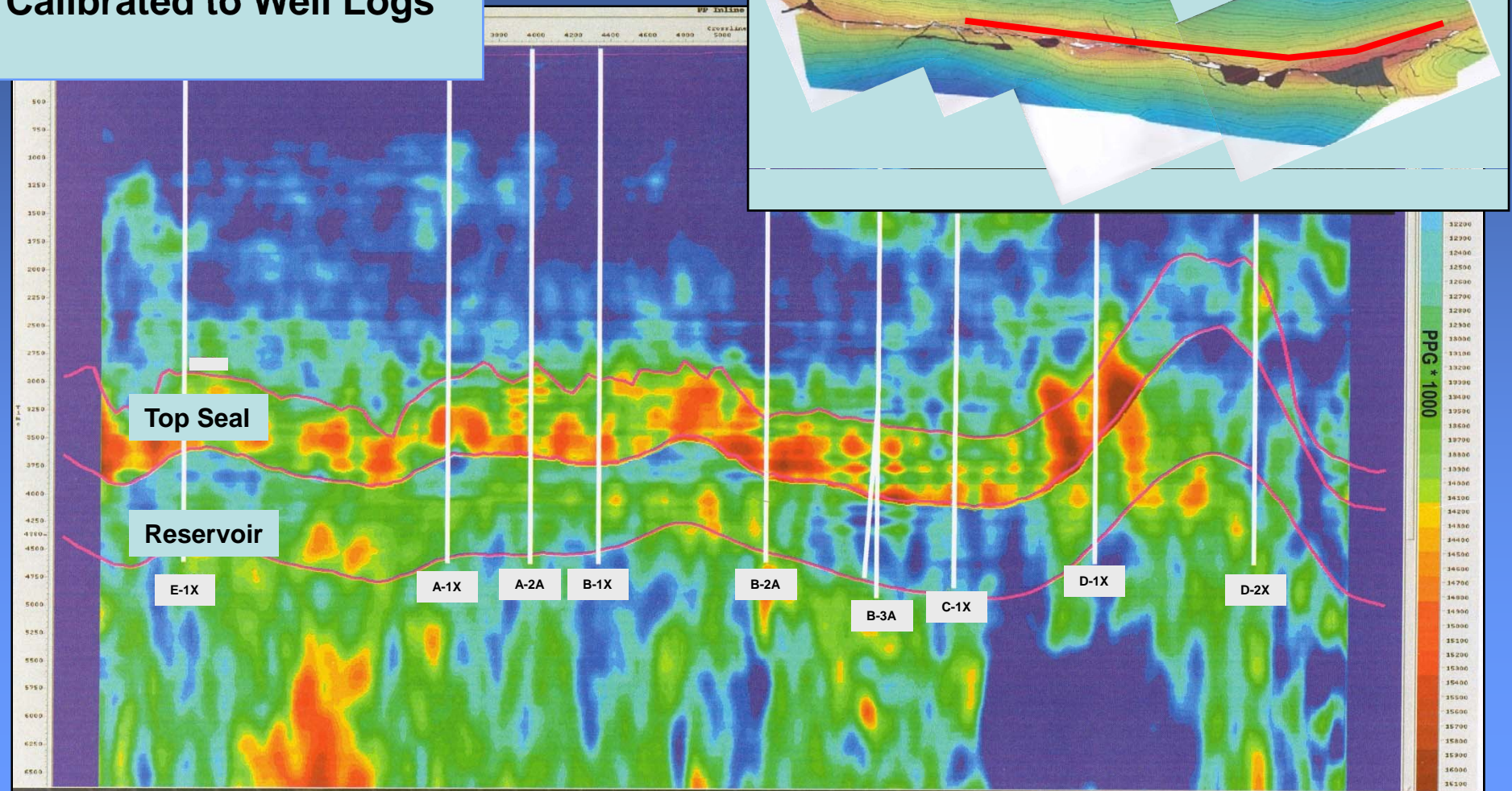
Top Seal & Fault Seal(?)



Pore Pressure Prediction As An Exploration Tool

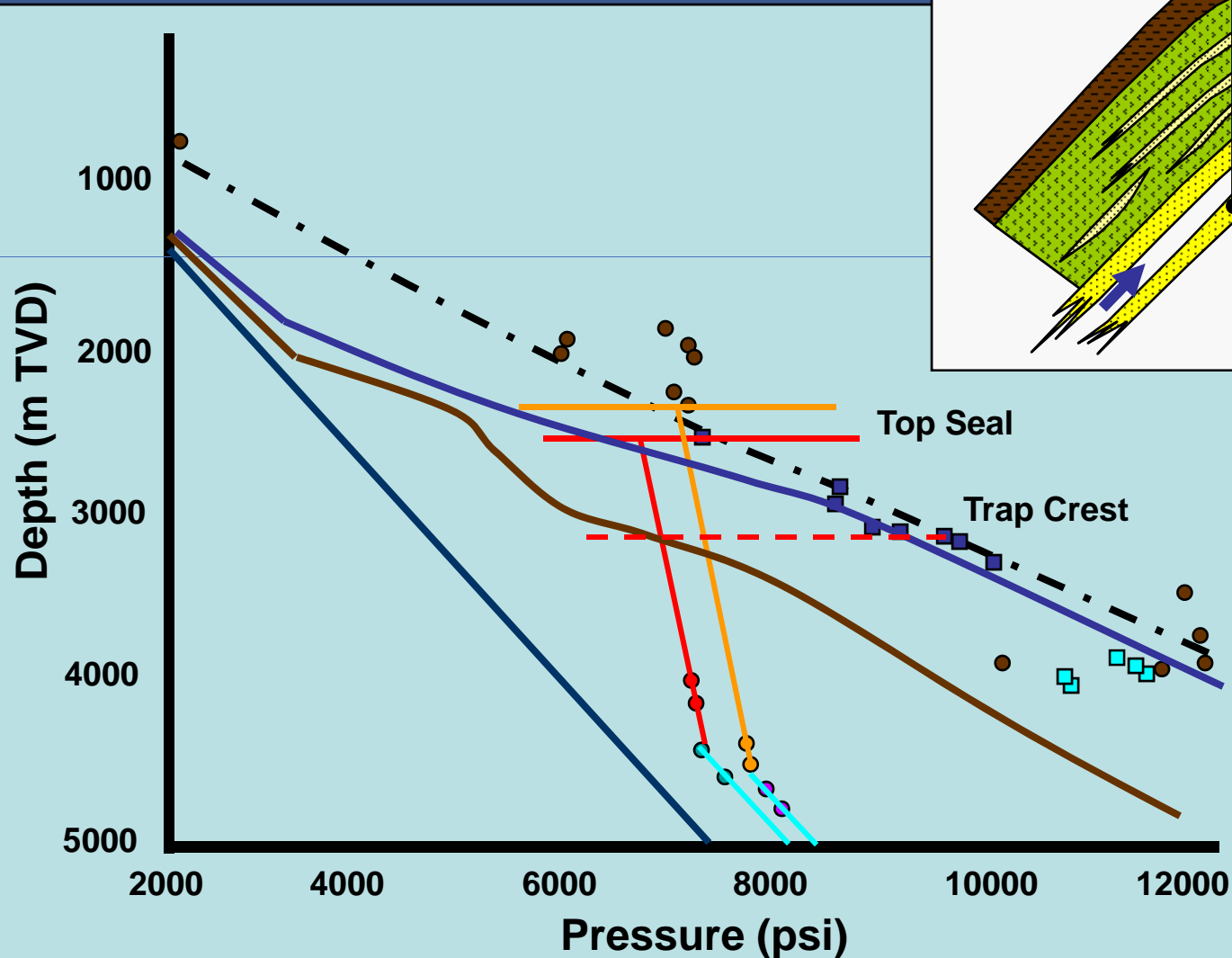
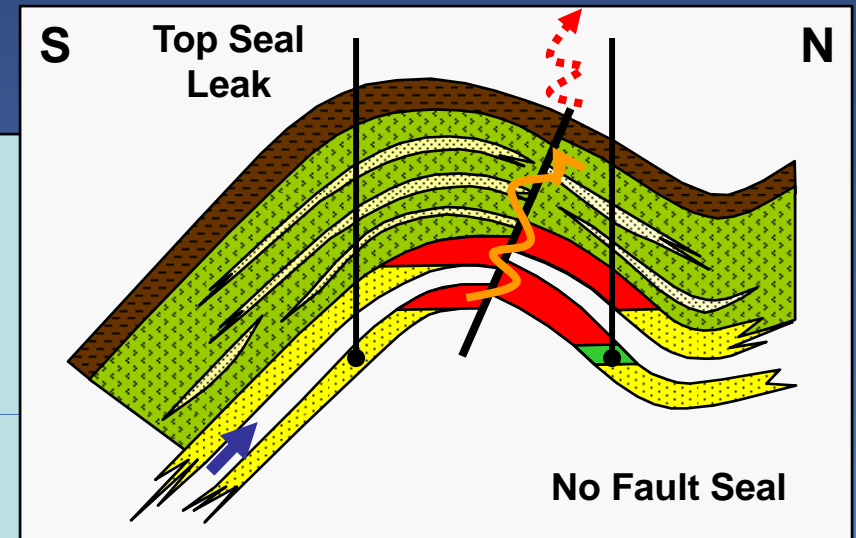
Pore Pressure from Seismic

Inline from Pore
Pressure Volume
Calibrated to Well Logs



Pore Pressure Prediction As An Exploration Tool

Trap Model with Pore Pressure Data

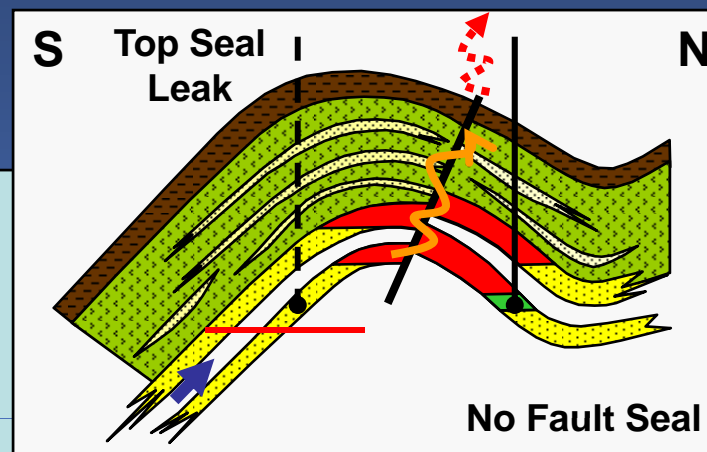
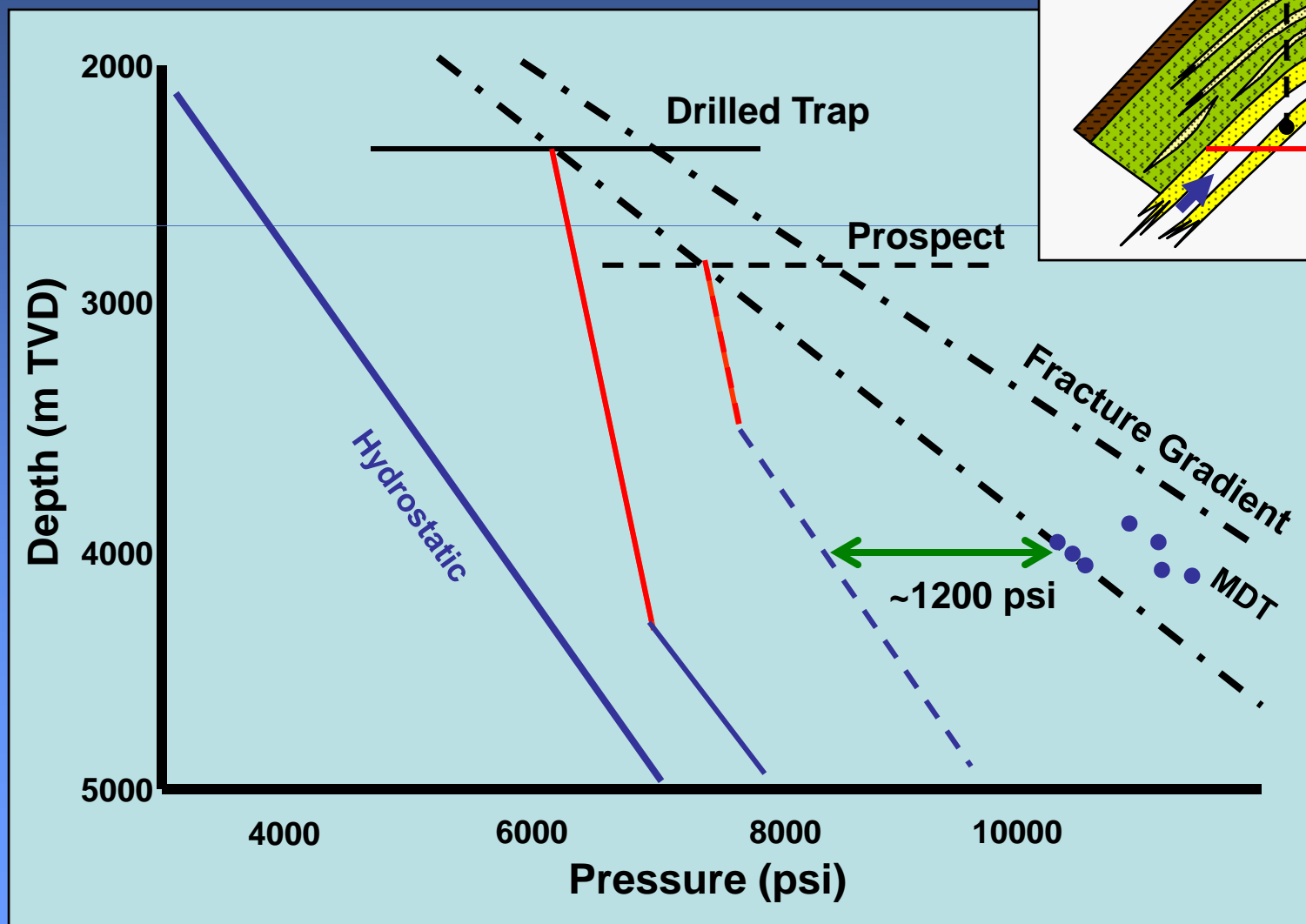


North Flank Gas Column is Balanced by South Flank Water Pressure

Pore Pressure Prediction As An Exploration Tool

Implications for Exploration

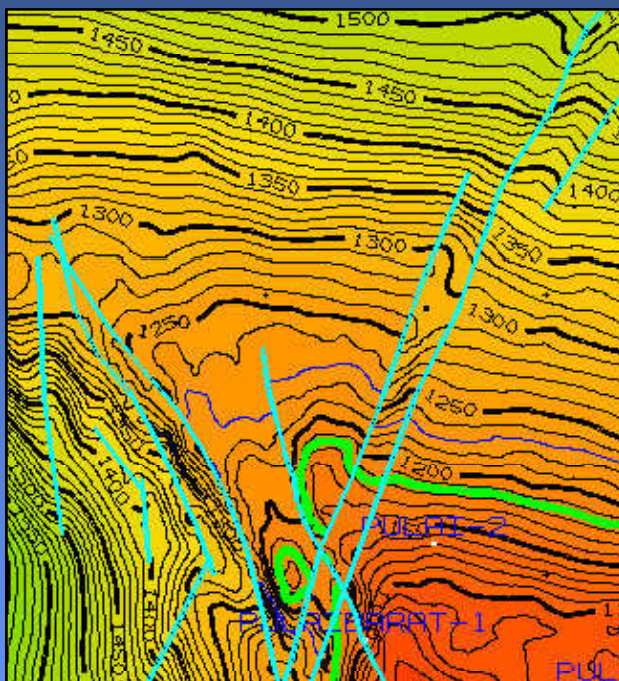
Calculate Pore Pressure Required to Get 500m Gas Column South Flank



Pore Pressure Prediction As An Exploration Tool

Conclusions

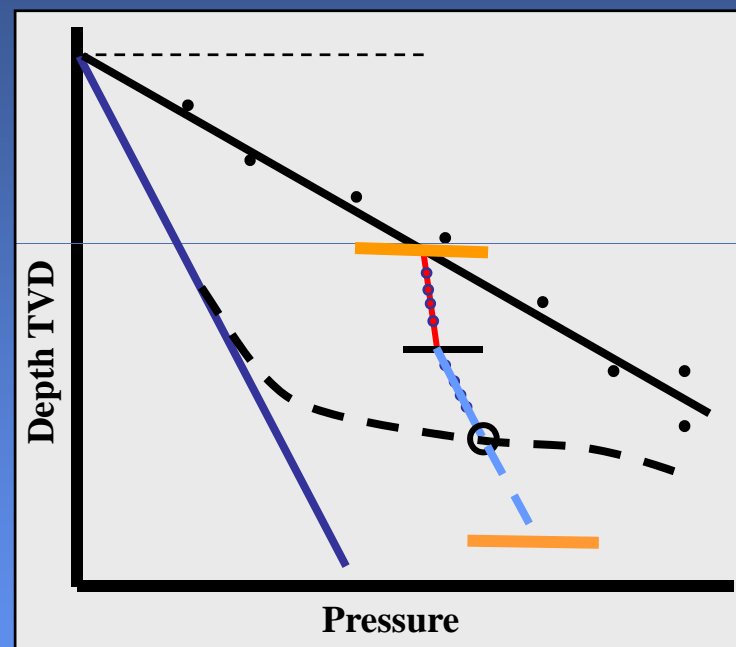
GEOMETRY



Exploration Depth Map

+

FLUIDS (Oil, Gas & Water)



Exploration Pressure Plot

An Exploration Workflow That Uses An Understanding of Fluid Behavior & Pore Pressure Addresses Risks and Uncertainty that Can Not be Assessed from Geological Maps

Pore Pressure Prediction As An Exploration Tool

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