Dirty Vs. Clean Salt: Their Impact on the Subsalt Wilcox Deep Water Exploration Plays*

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Abstract

This study explores the possibility that risks in the sub-salt Wilcox Deep Water frontier at the Sigsbee Escarpment in the Gulf of Mexico exploration play can be attributed to the salt type. Drilling through and below the salt can be costly and lead to the abandonment of the whole project.

As the salt mass toe creeps down-dip near the mud line, it creates potential traps formed as thrust folds and faults of the older underlying sediments. A clean salt mass is usually driven down-dip by gravity/ buoyancy. On the other hand, dirty salt is pushed down-dip by the sediment influx, in addition to buoyancy. Occasionally, sediments intrude into the salt body and are carried within as rafted blocks. This causes a challenge in testing the subsalt traps in this deep-water frontier play. Moreover, in both dirty and clean salt cases, plowing the older sediment underneath the salt creates subsalt gouges that represent a substantial drilling hazard.

The Jack prospect (Walker Ridge block 759) is a part of the emerging Wilcox-equivalent salt toe belt. The rafted sediment blocks and the subsalt gouge made this prospect very expensive to test. The borehole experienced multiple losses of circulation and had to be sidetracked several times. This was due to the narrow drilling window created by the pressure kicks released from the imbedded sediments throughout the salt section. On the contrary, St. Malo (Walker Ridge block 678) is an adjacent prospect on the same trend, but was drilled through clean salt. It was tested with a minimum of difficulties, compared to the Jack prospect.

Tracking the mechanisms of the salt movements and their history as dirty or clean types can predict the risk of testing a prospect along this new exploration fairway.

References

Chowdhury, A. and S. Lopez-Mora, 2004, Regional geology of deep water salt architecture, offshore Gulf of Mexico: Transactions Gulf Coast Association of Geological Societies, v. 54, p. 113-120.

Stromboe, E.G., R. Stokes, and J. Lewis, 2007, Appraisal Update and Review, Jack and St. Malo Projects, Deepwater Gulf of Mexico: HGS Bulletin, v. 50/3, p. 27-33.

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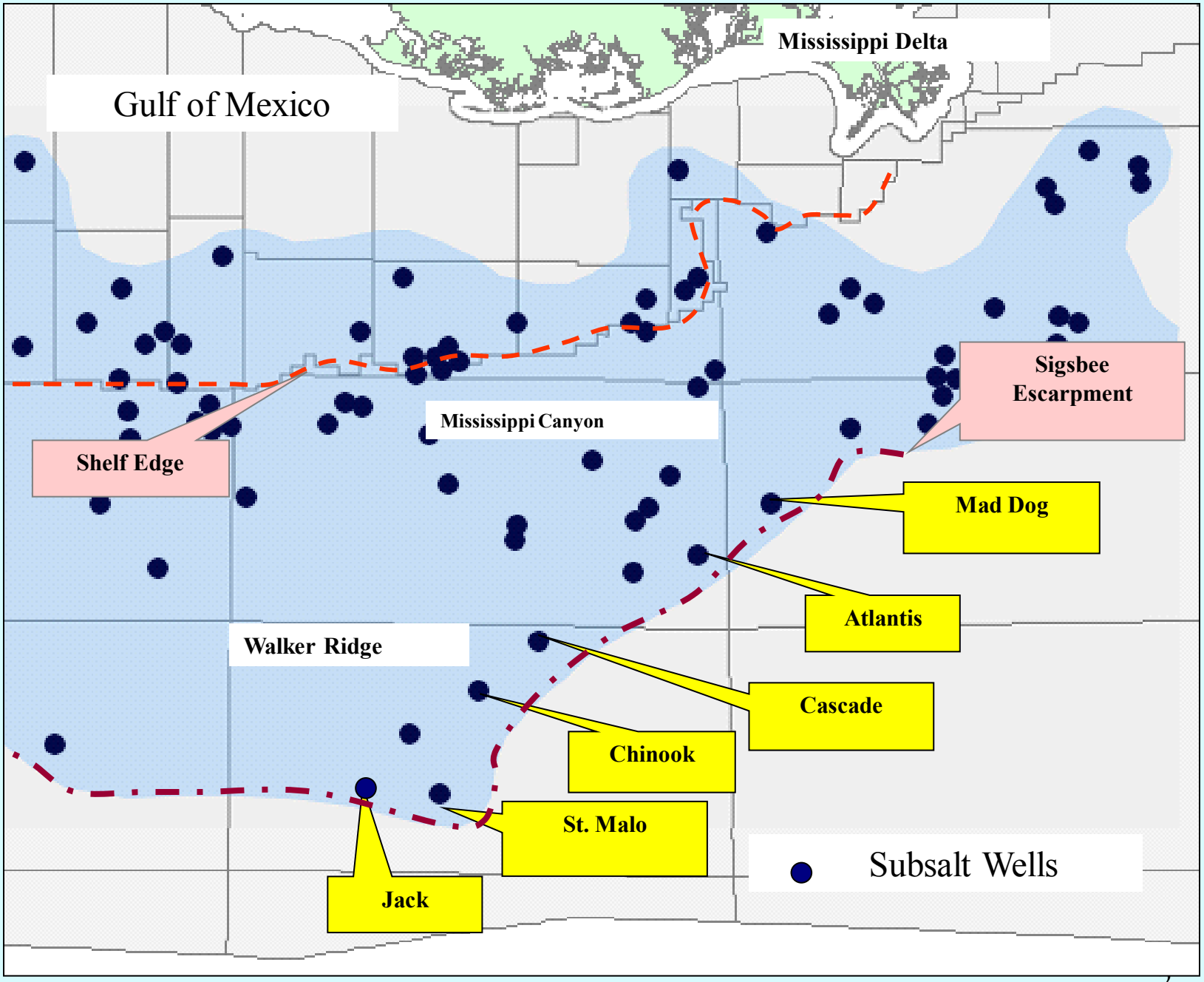
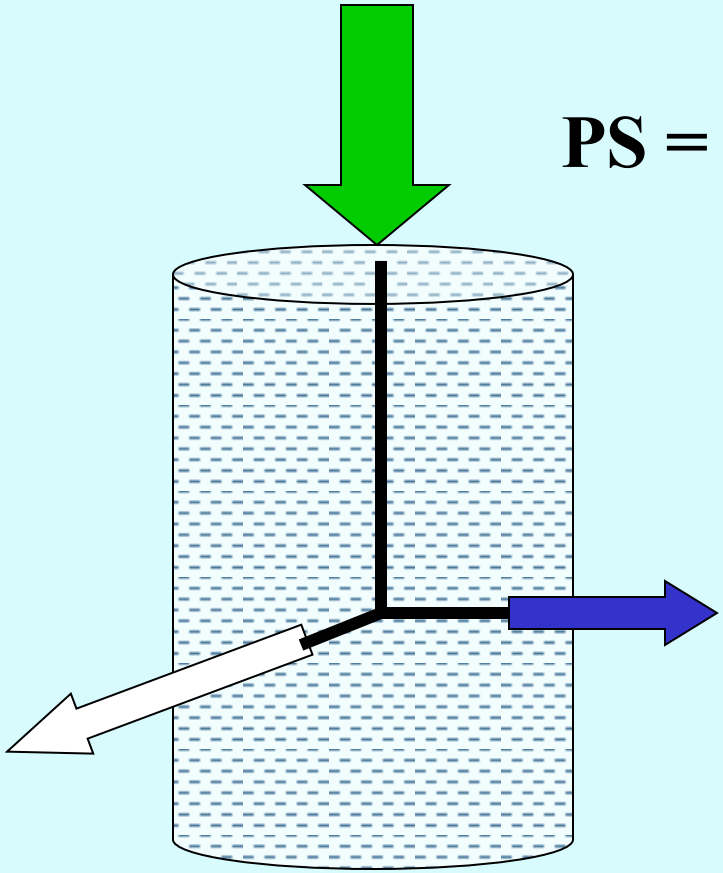

Mississippi Delta
Gulf of Mexico
Sigsbee Escarpment
Mississippi Canyon
Shelf Edge
Mad Dog
Atlantis
Walker Ridge
Cascade
Chinook
St. Malo
Jack
Subsalt Wells

Salt's Unique Petrophysical Properties

- **Low Density**
- **Impermeable Seal**
- **Ductile Nature**

Subsurface Stresses

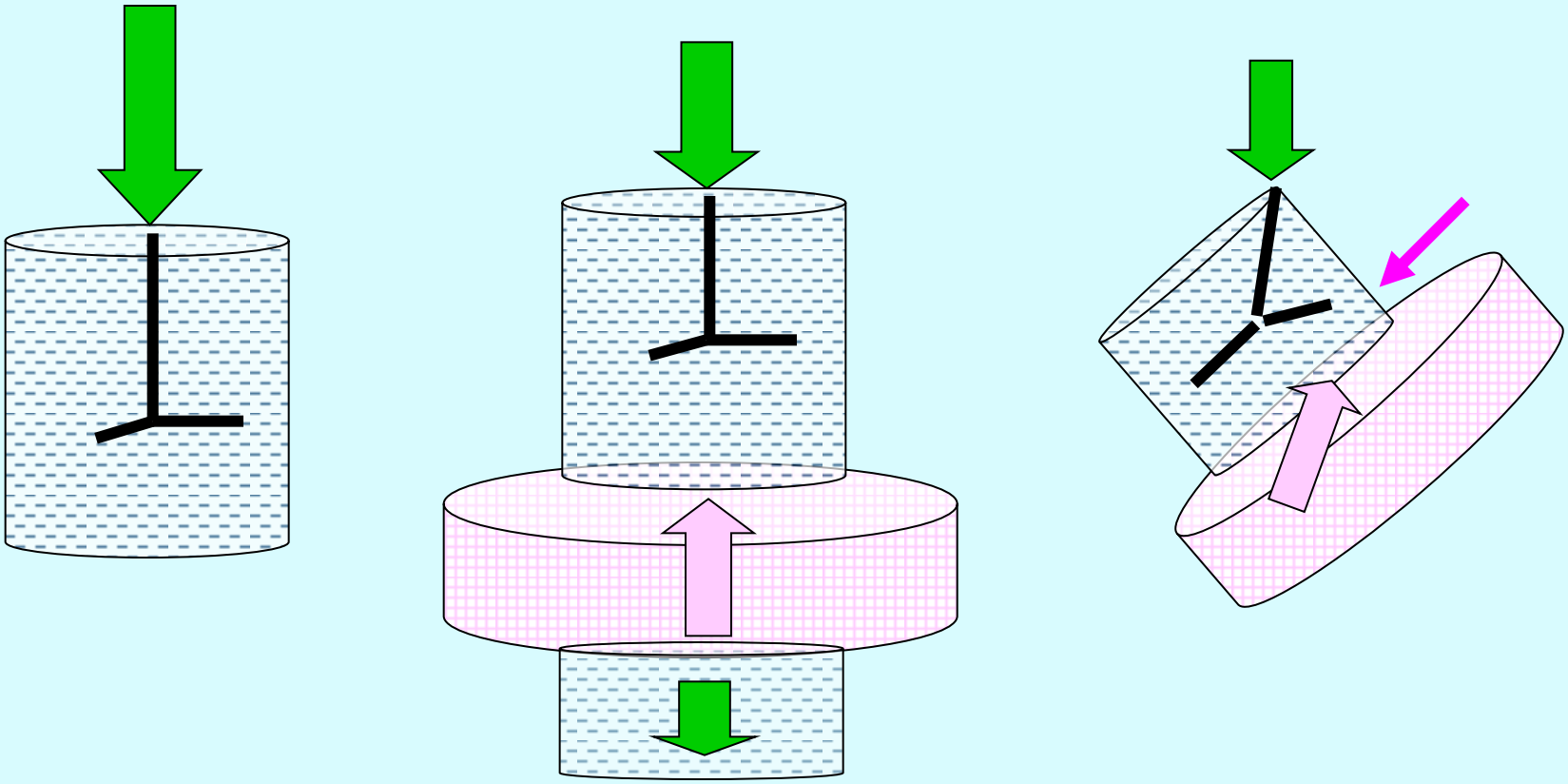


PS = +/- OB

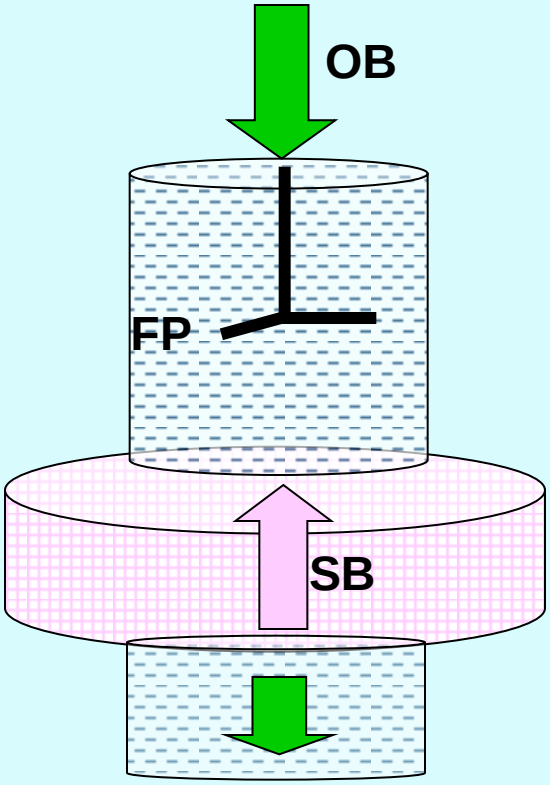
MS = FP = LOT

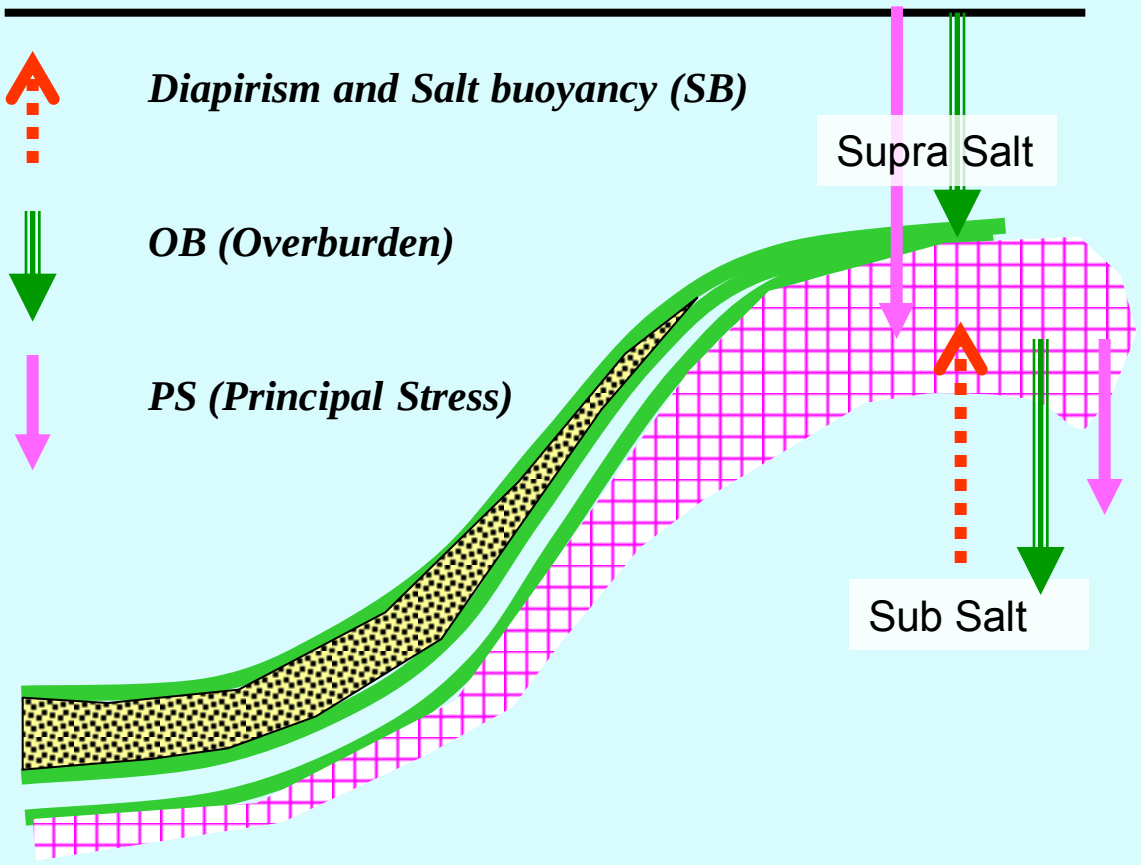
IS

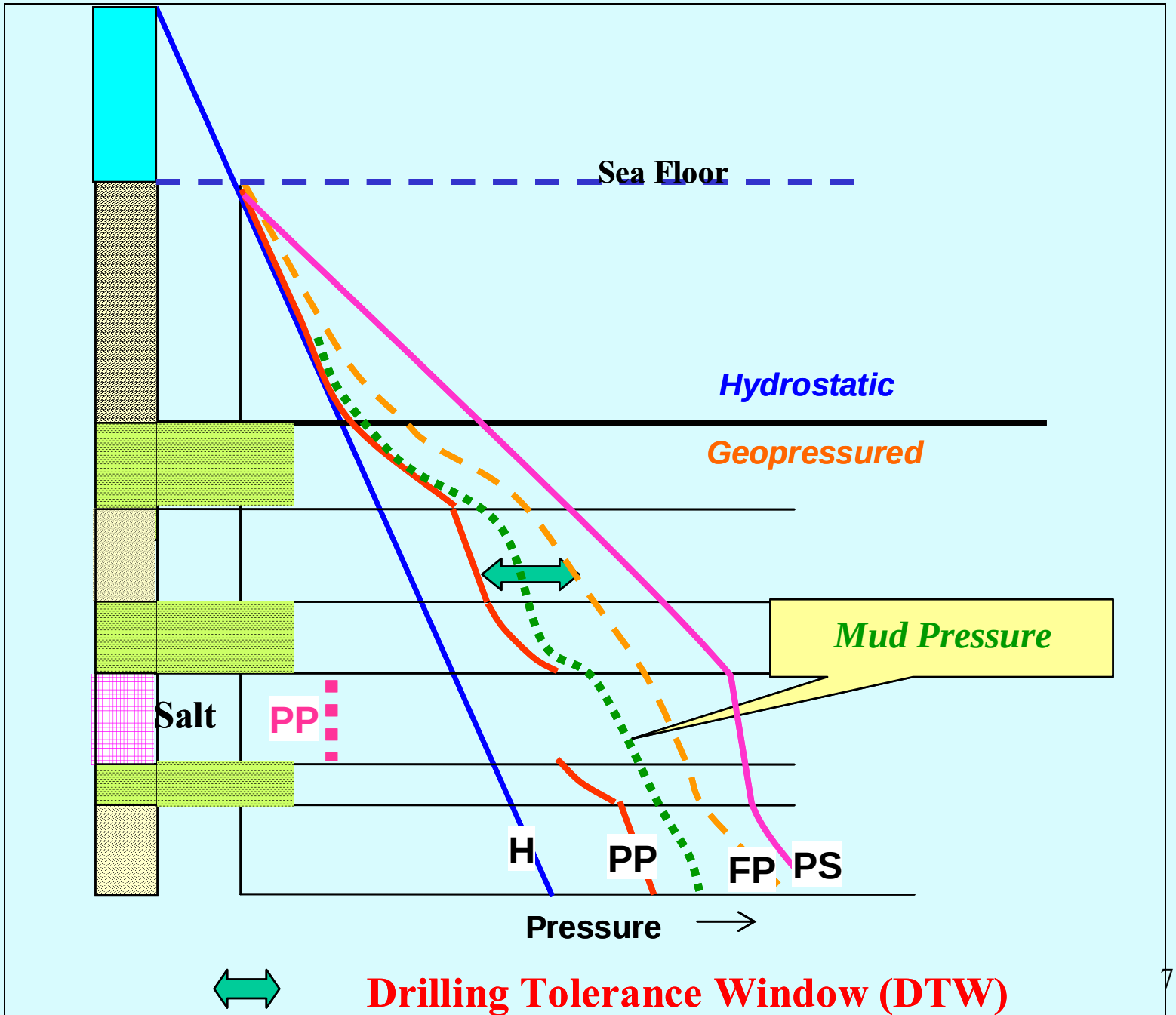
Salt impact on subsurface
Stresses orientation and magnitude



Stress Generic Model



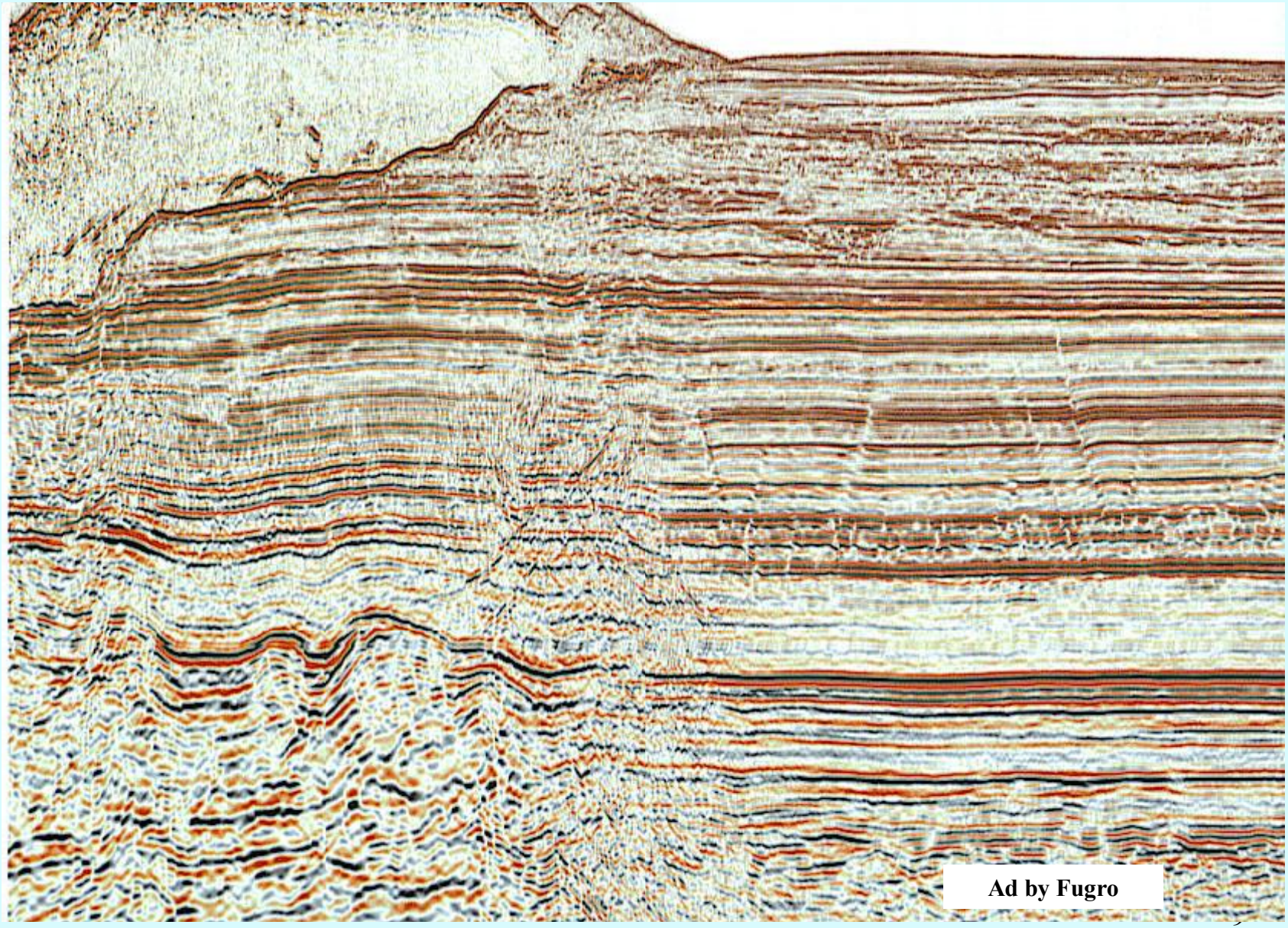



Sea Floor
Hydrostatic
Geopressured
Mud Pressure
Salt
PP
H
PP
FP
PS
Pressure
Drilling Tolerance Window (DTW)

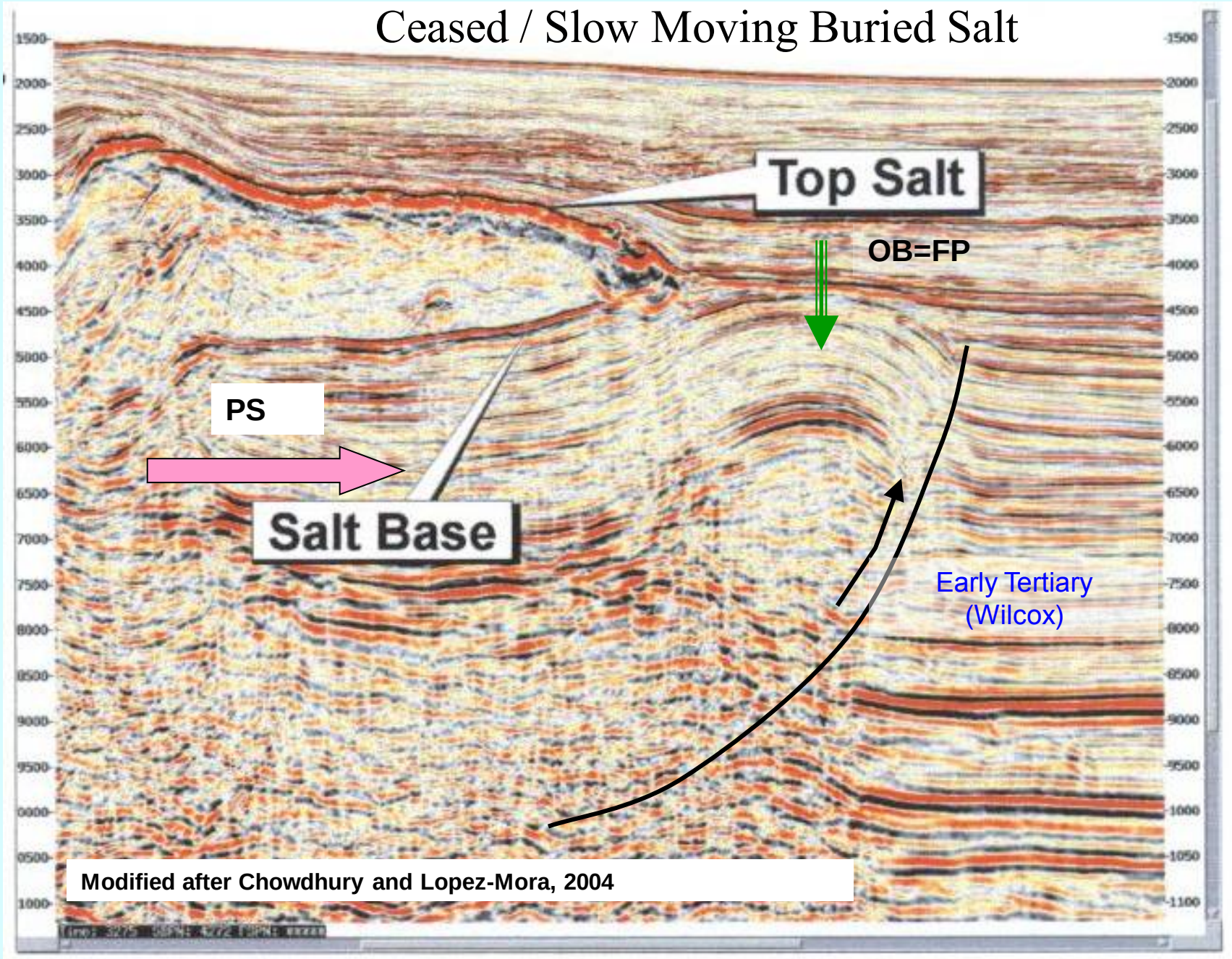
Salt Toes at the Sigsbee Escarpment

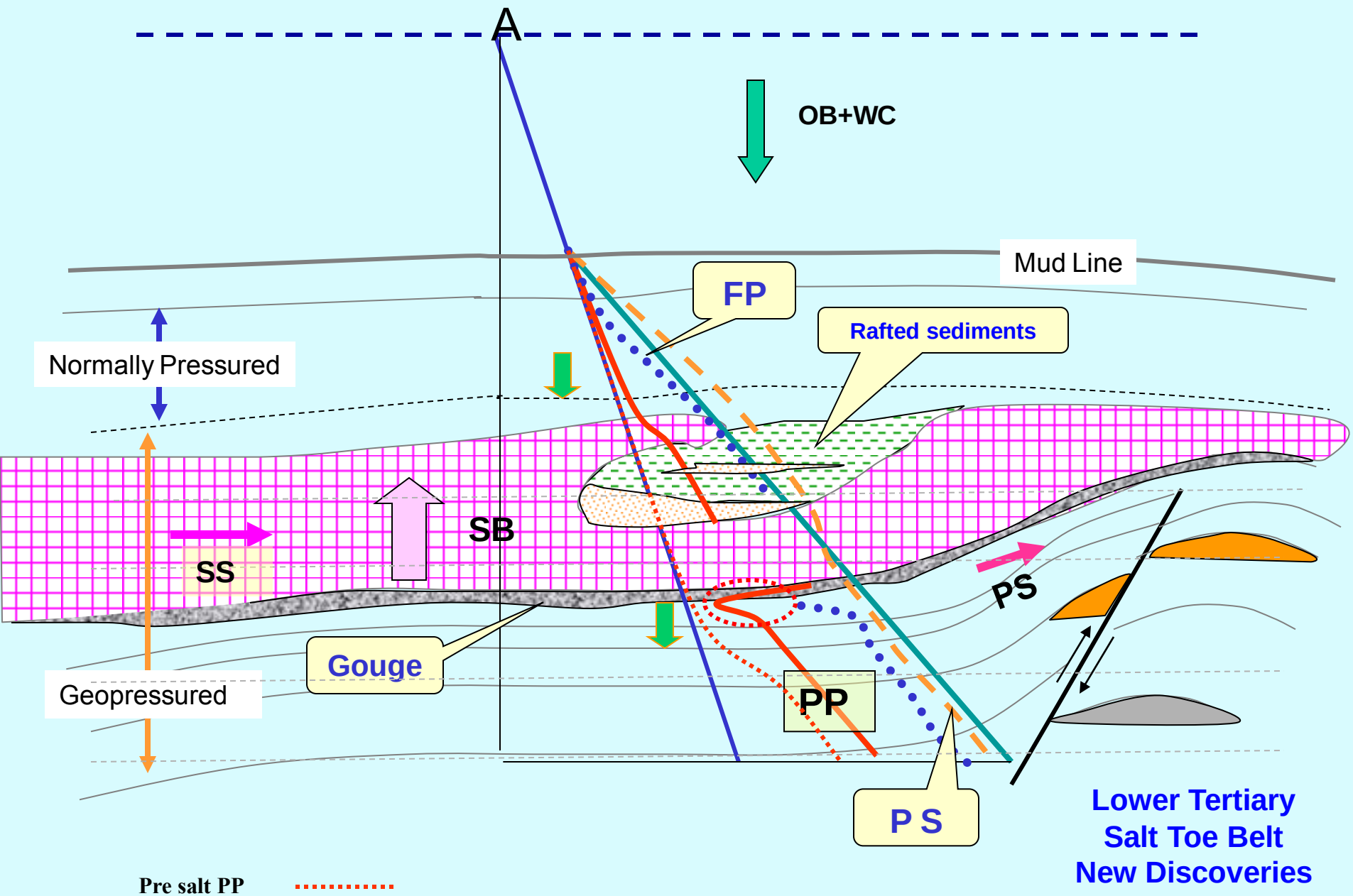
- Creeping / shallow
- Ceased and / or slow movement under sediment cover

Shallow Salt



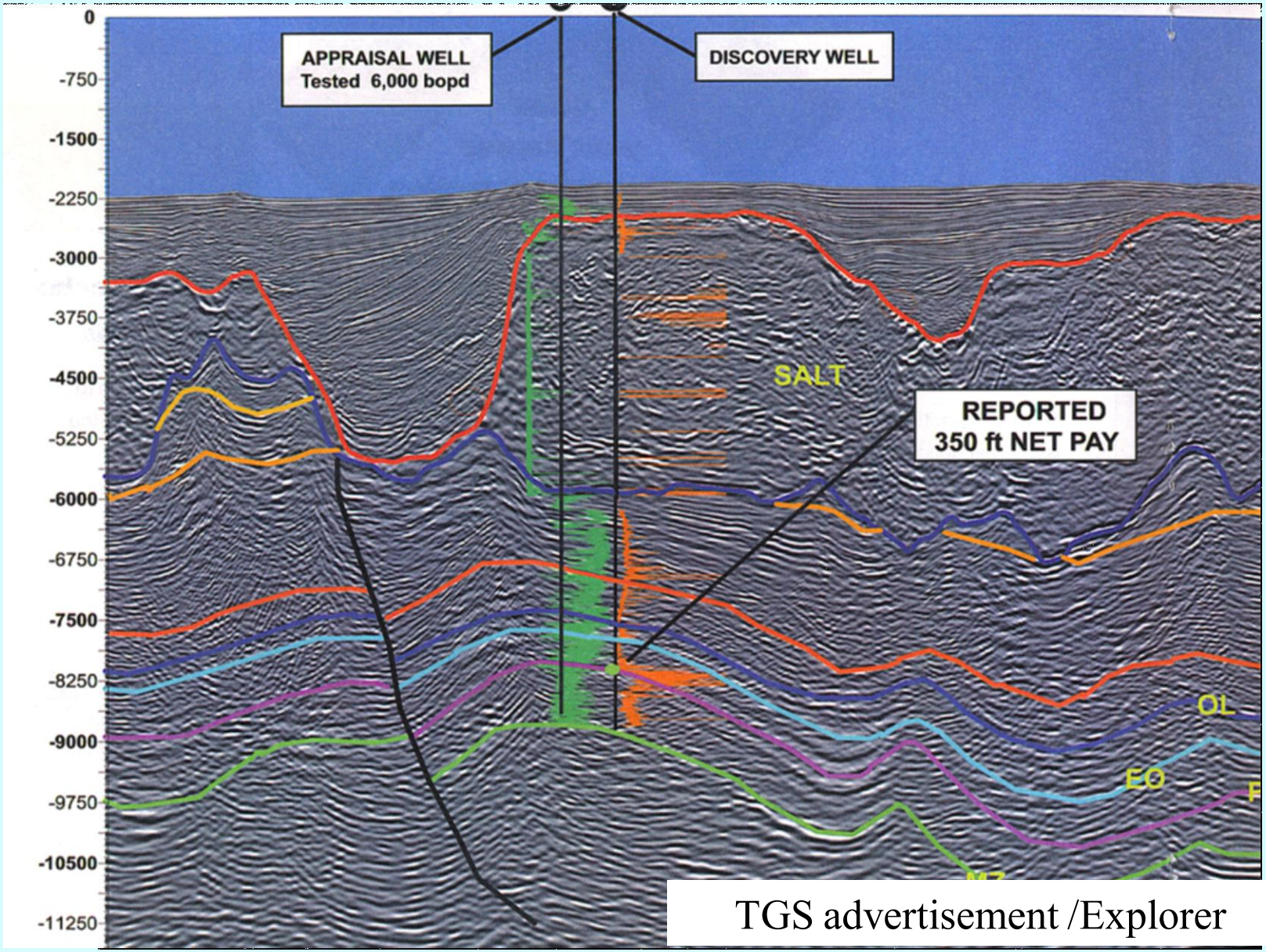
Ceased / Slow Moving Buried Salt





Geopressure Model for Salt Toe

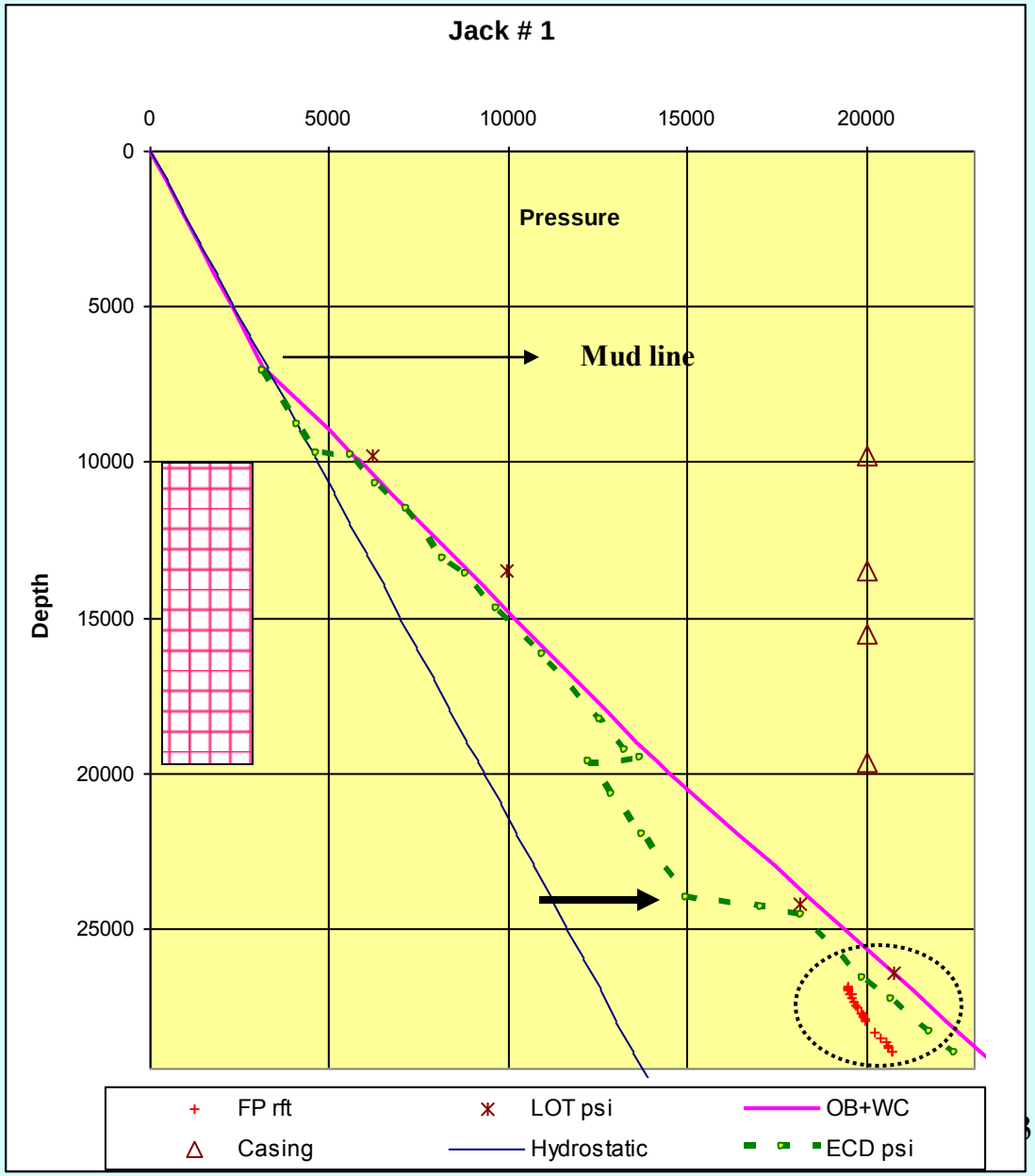
Jack Discovery (Walker Ridge block 759)



TGS advertisement /Explorer

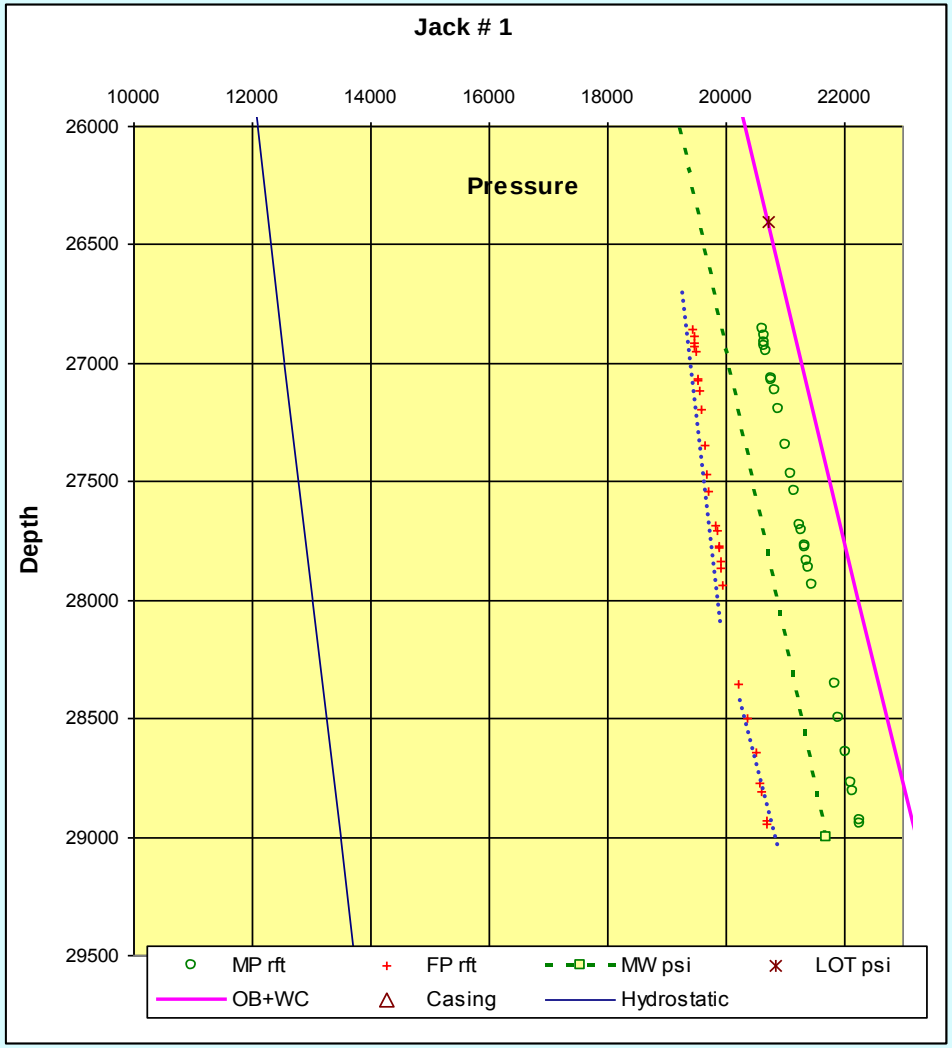
Jack #1

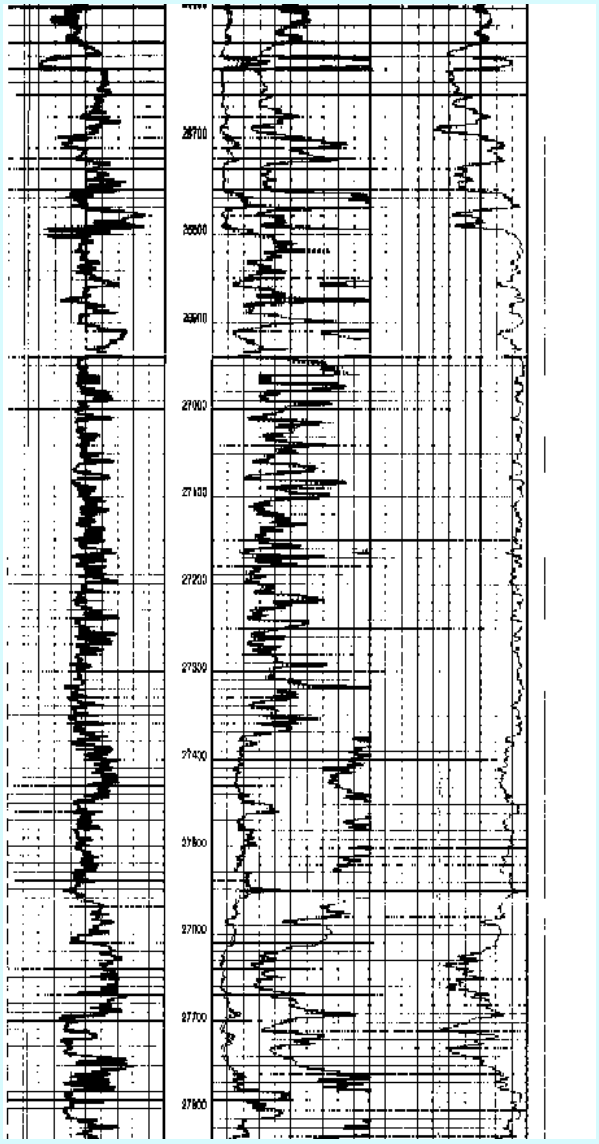
Geopressure Profile in psi vs. depth



→ High SC / Good Seal

Jack #1 Wilcox pay zones





Mobility range from 0.1 to 10 MD

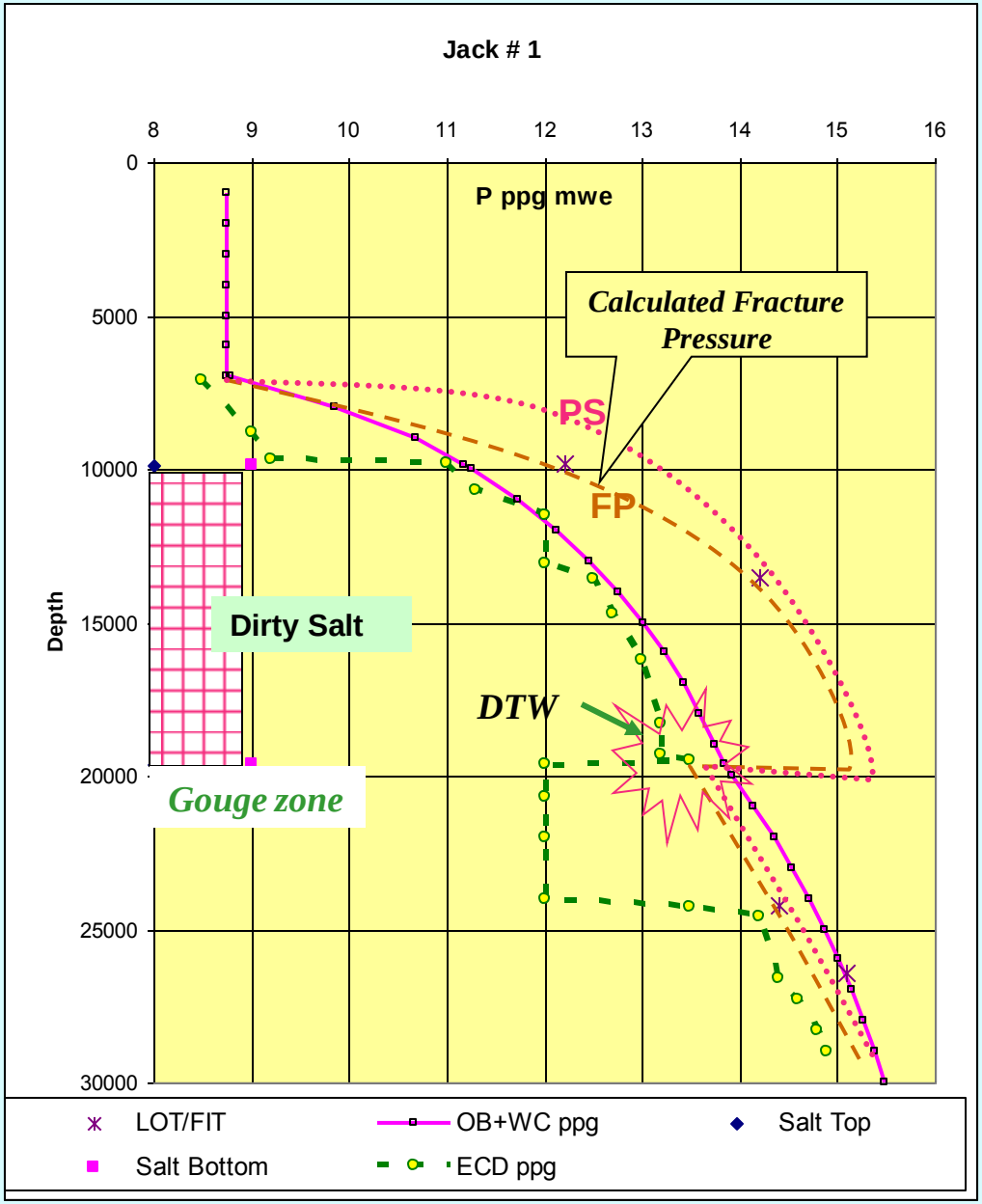
Tested 6,000 bblo/d

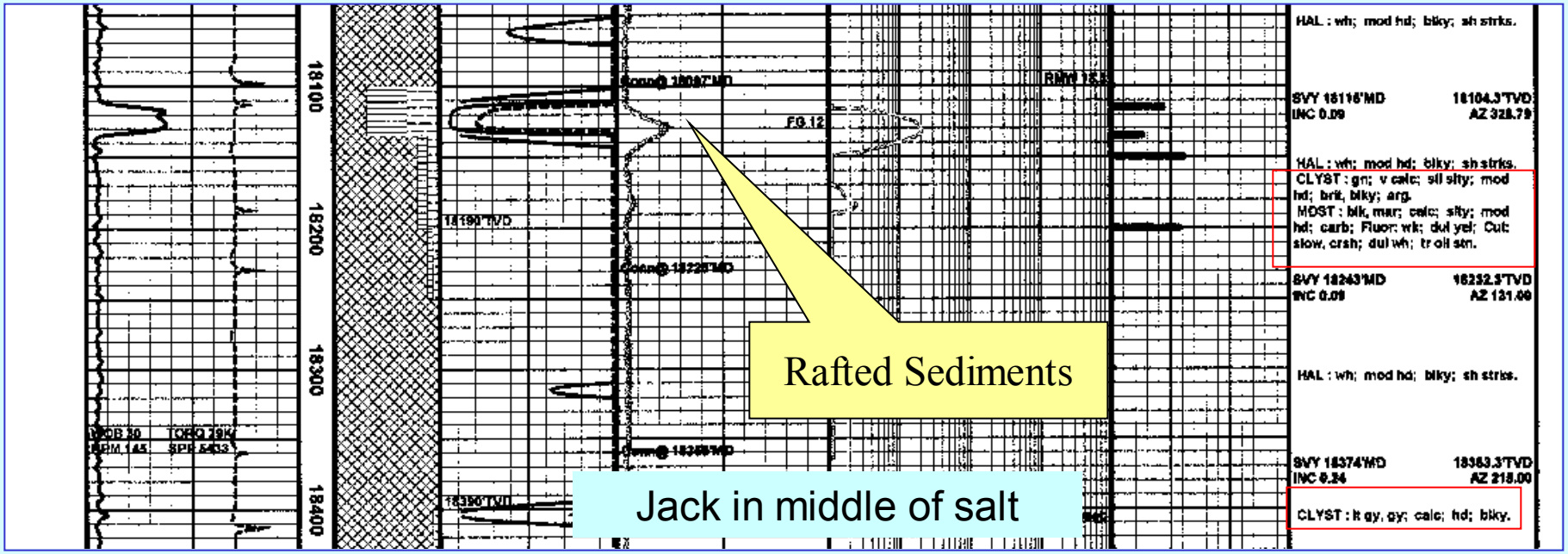
Jack #1

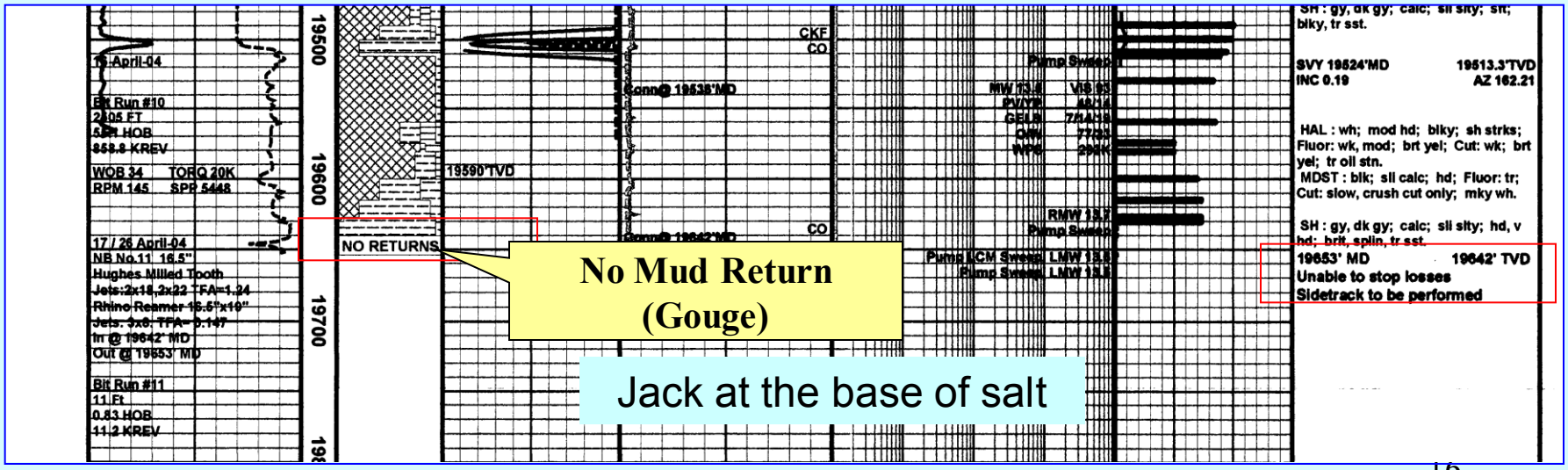
in ppg mwe

Drilling Challenges:

- **LOC, cut MW in salt, Csg**
- **LOC, no recovery at base of salt , STR.**




Rafted Sediments
Jack in middle of salt
HAL : wh; mod hd; blky; sh strks.
SVY 18116'MD
INC 0.09
18104.3'TVD
AZ 328.79
HAL : wh; mod hd; blky; sh strks.
CLYST : gn; v calc; sil slty; mod hd; brit, blky; arg.
MDST : blk, mar; calc; slty; mod hd; carb; Fluor: wk; dul yel; Cut: slow, crsh; dul wh; tr oil stn.
SVY 18243'MD
INC 0.09
18232.3'TVD
AZ 131.09
HAL : wh; mod hd; blky; sh strks.
SVY 18374'MD
INC 0.34
18363.3'TVD
AZ 218.00
CLYST : lt gy, gy; calc; hd; blky.


No Mud Return
(Gouge)
Jack at the base of salt
NO RETURNS
19590'TVD
SH : gy, dk gy; calc; sil slty; sft; blky, tr sst.
SVY 19524'MD
INC 0.19
19513.3'TVD
AZ 162.21
HAL : wh; mod hd; blky; sh strks; Fluor: wk, mod; brt yel; Cut: wk; brt yel; tr oil stn.
MDST : blk; sil calc; hd; Fluor: tr; Cut: slow, crush cut only; mky wh.
SH : gy, dk gy; calc; sil slty; hd, v hd; brit, splin, tr sst.
19653' MD
19642' TVD
Unable to stop losses
Sidetrack to be performed

Jack Discovery Assessments

- **The Good**
  - High flow rate (Jack #2 = 6,000 bblo/d)
  - Large SC with gross pay over 2500’
  - Large Structural Closure

- **The Bad**
  - Water depth / thick shallow salt / gouge zone
  - Dirty Salt (2 Csg) / rafted sediments
  - Side tracks at the sub-salt section
  - Low perm / frac job
  - Seismic challenges

- **The Ugly**
  - Cost of drilling and testing ($ 250 mm) /Jack 2

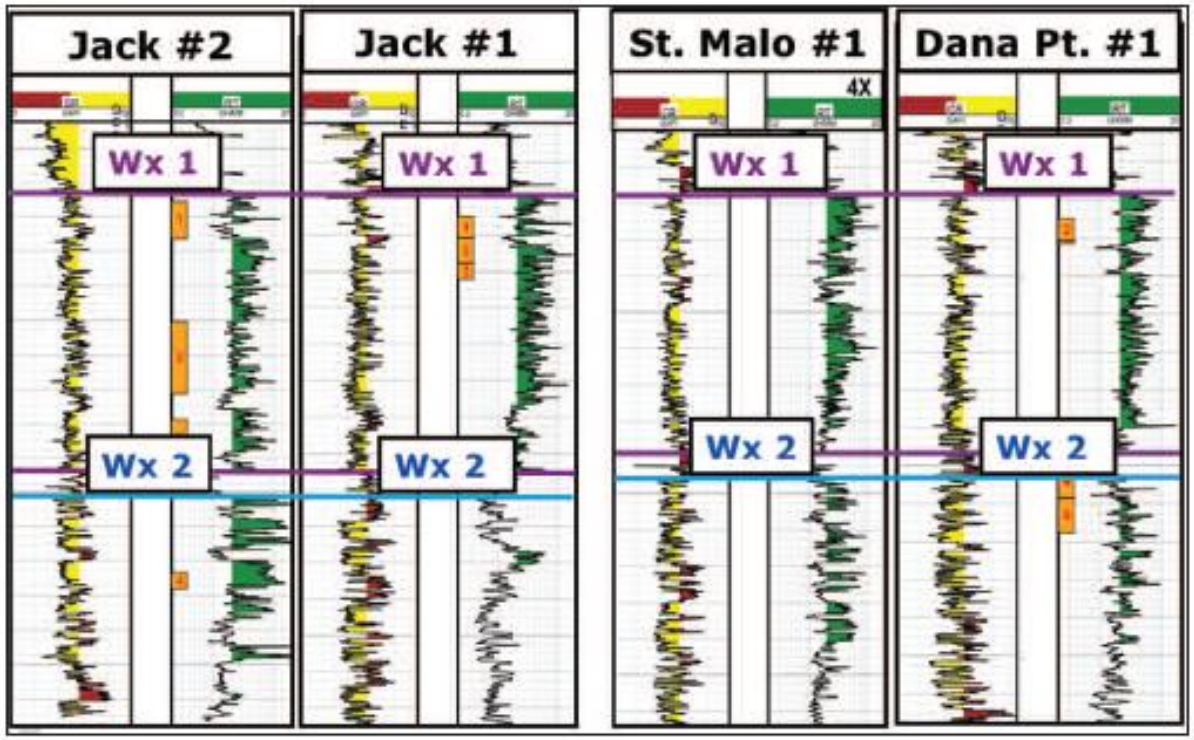


Figure 2: Stratigraphic cross-section through wells at Jack and St. Malo discoveries showing Wilcox 1 and Wilcox 2 pay sands.

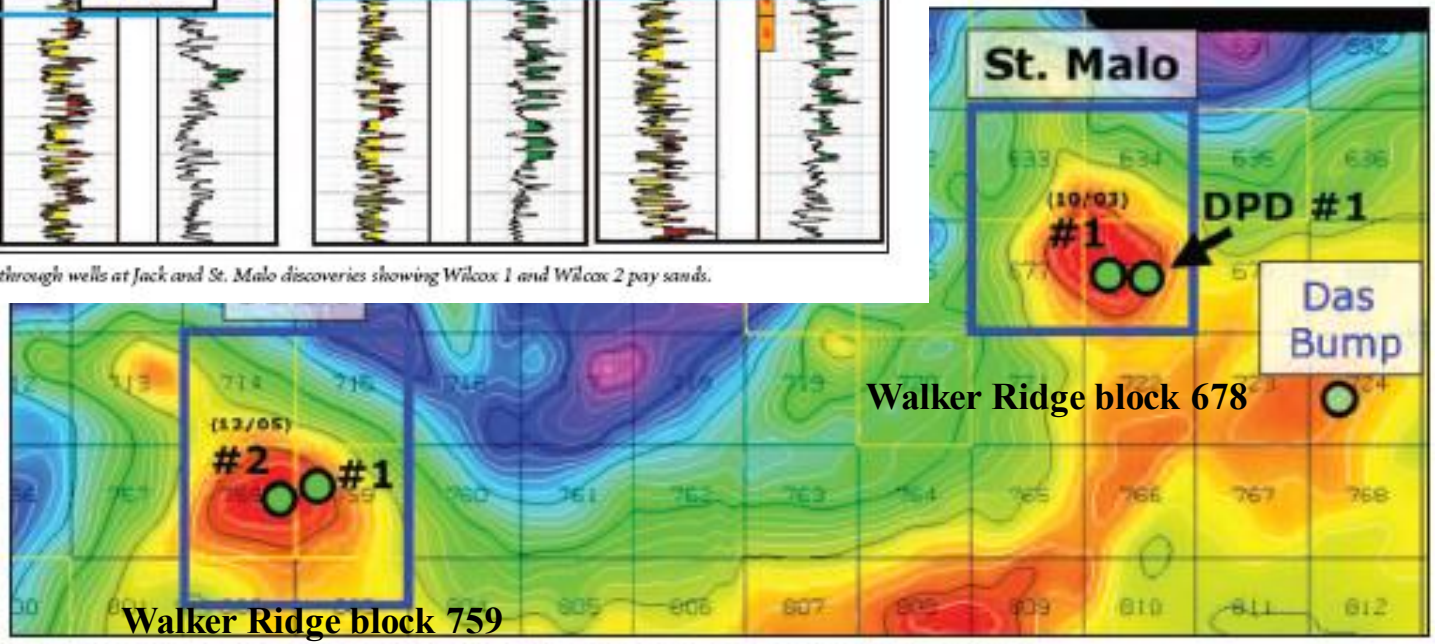
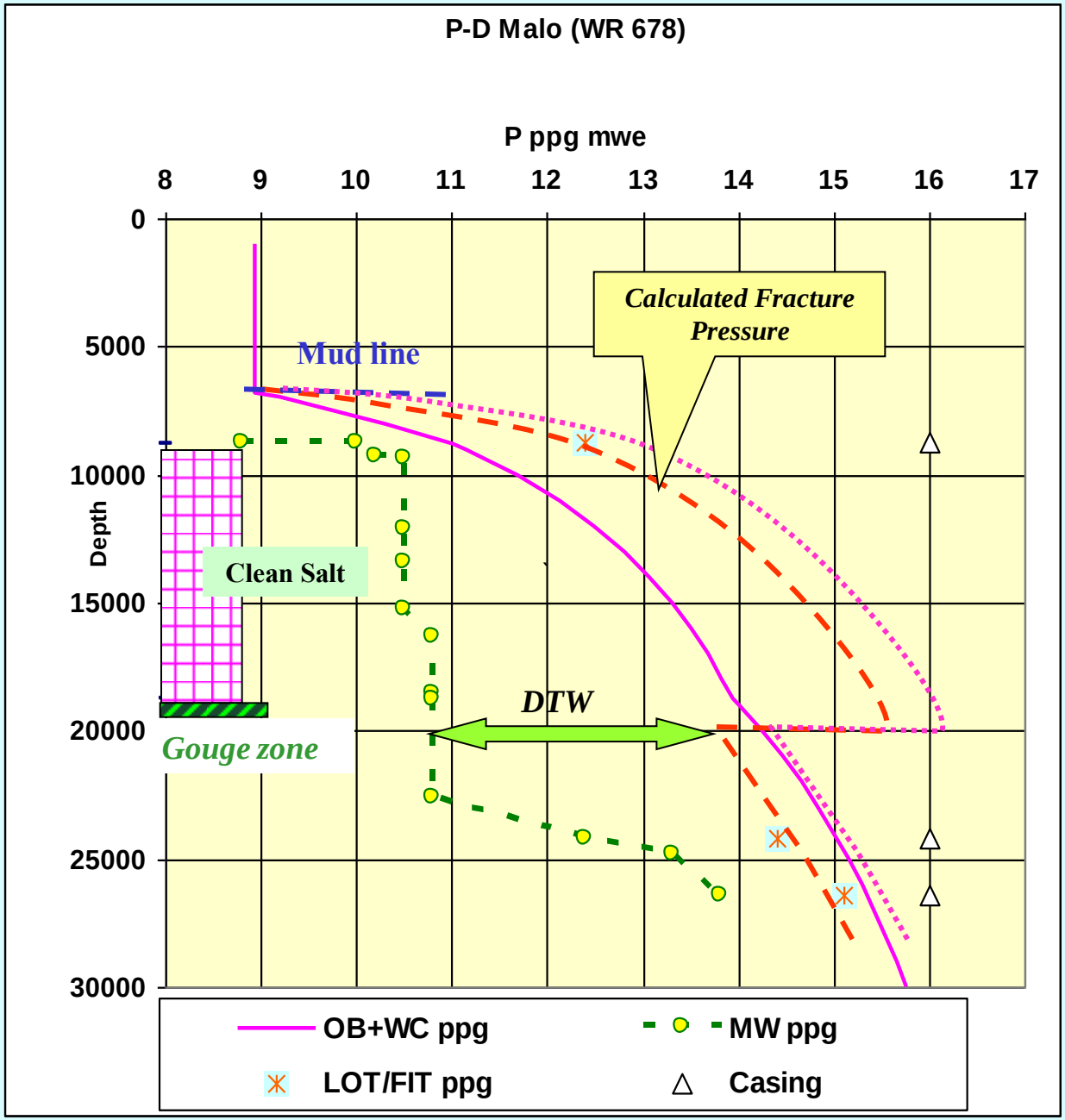


Figure 3: Wilcox Structure map showing relationship of Jack and St. Malo features in sub-regional trend.

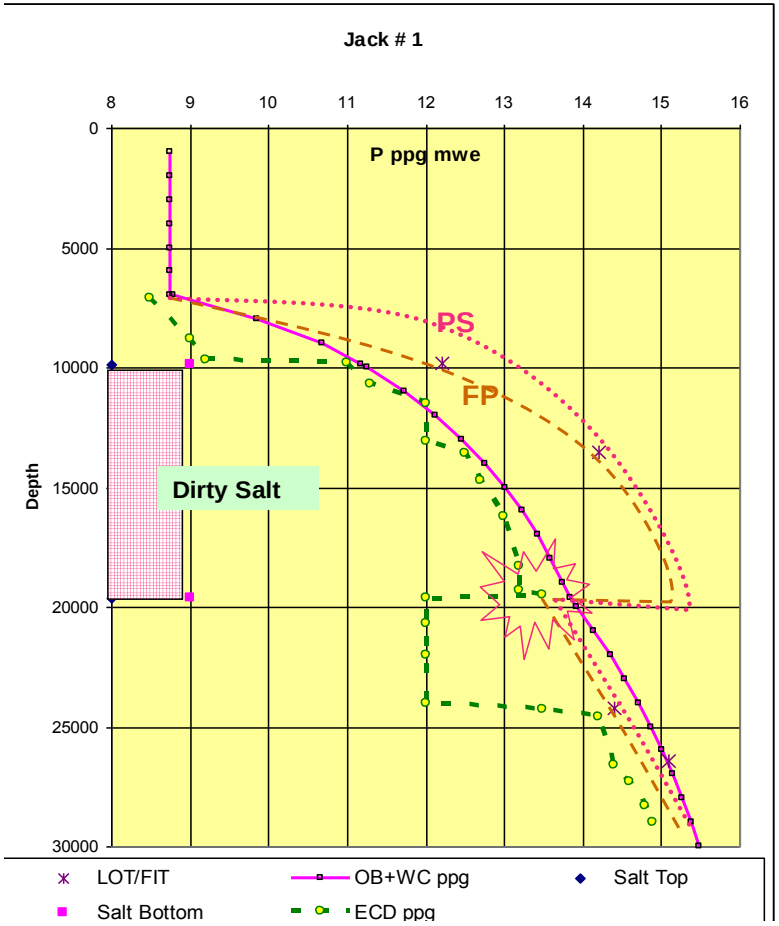
General Luncheon Meeting continued on page 33

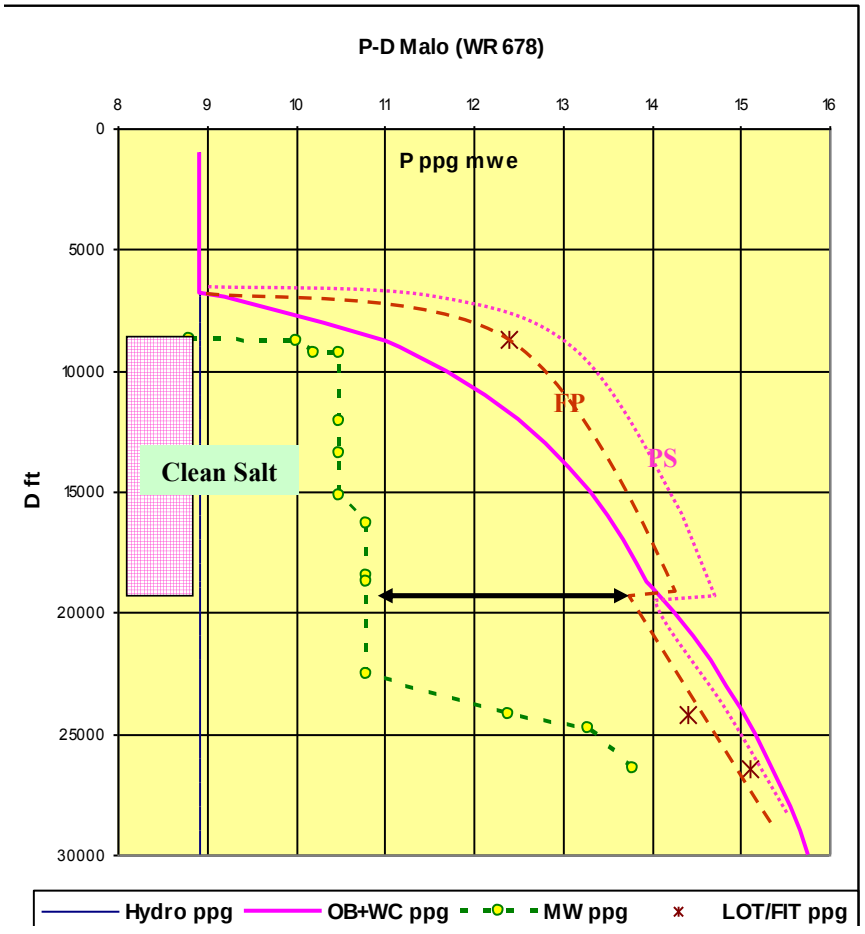
After HGS 2007

St. Malo geopressure profile



Jack (dirty salt) vs. Malo (clean salt)





Summary:

- D.S. has sediment inclusions (troublesome)
- D. and C. Salt can have Gouge zone

Recommendations:

Prospect Generation:

- Salt emplacement history (moving / ceased)
- Up-dip sediment feeder system

Pre-spud :

- Prepare mud and casing programs if D or C.
- Clean Salt (Injected) vs. Dirty (Rafted sediment)
- Gouge zone and drilling hurdles

Recommendations (Cont):

During Drilling:

- Avoid excess MW increase in D S.
- Watch out for the gouge zone
- Side track as soon troubles started

Thank You