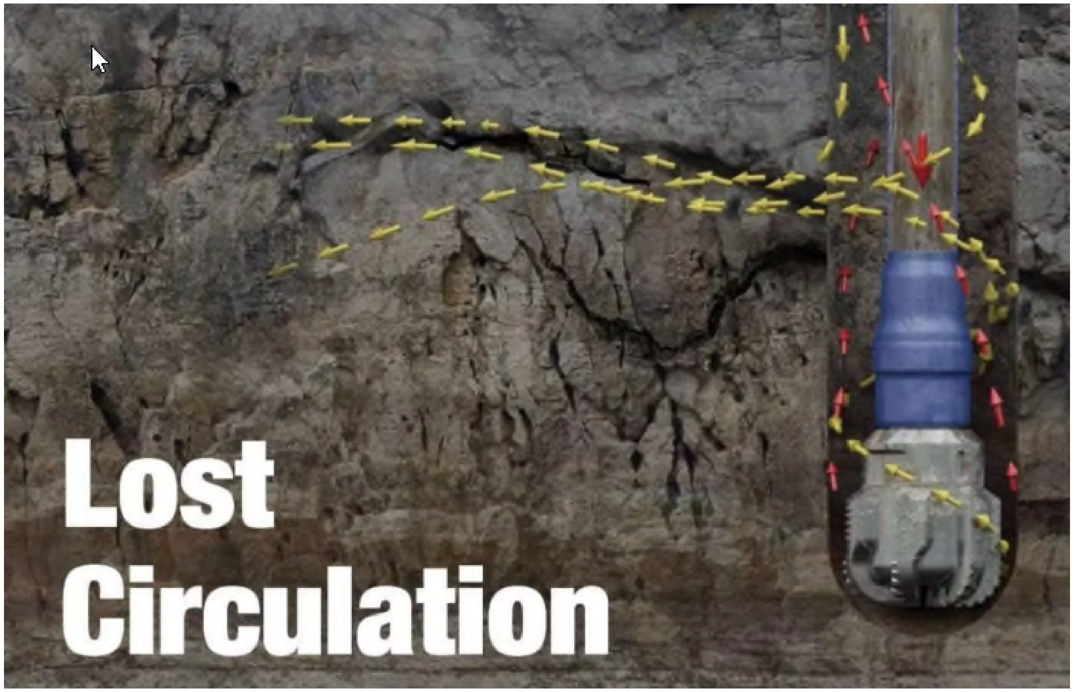
Geomechanics Considerations for Lost Circulation



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Reasons for Mud Loss

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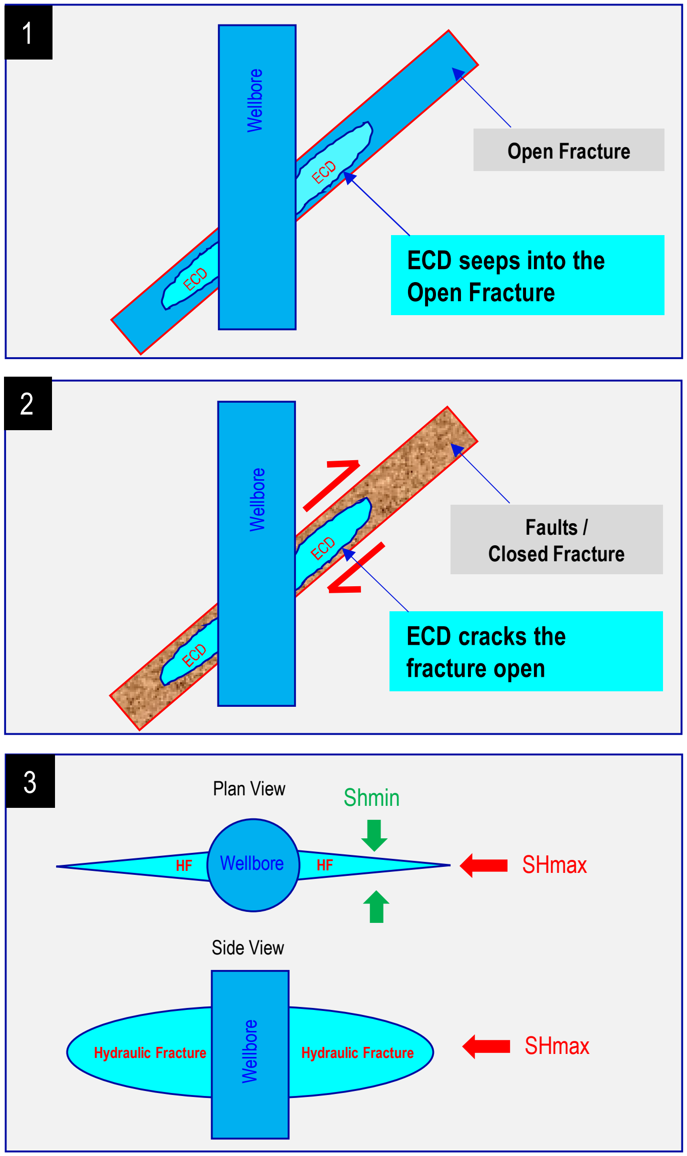
1. Natural Fractures
Seepage

2. Existing Faults:
Slippage of existing fault

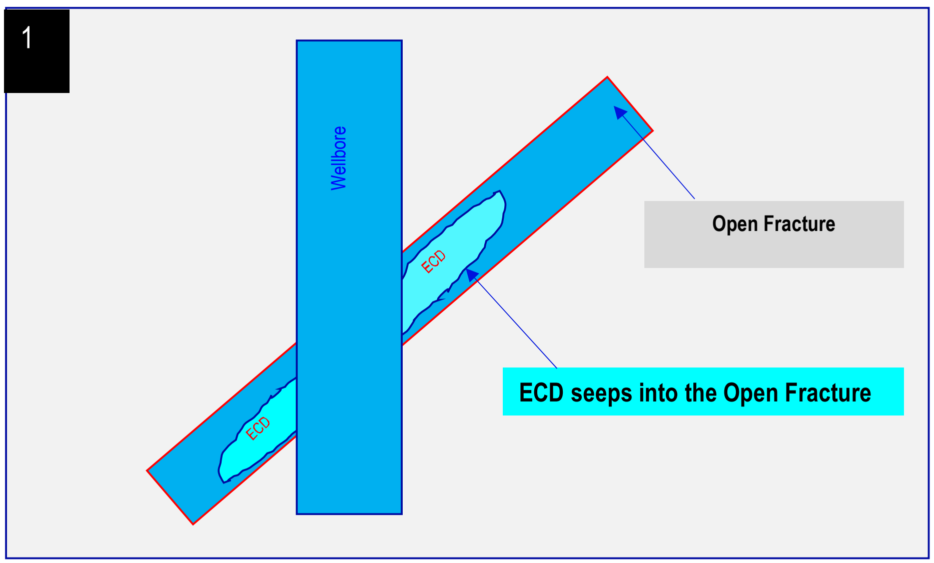
3. Hydraulic Fracture (Tearing)
a. Tearing existing fracture
b. Tearing intact rock



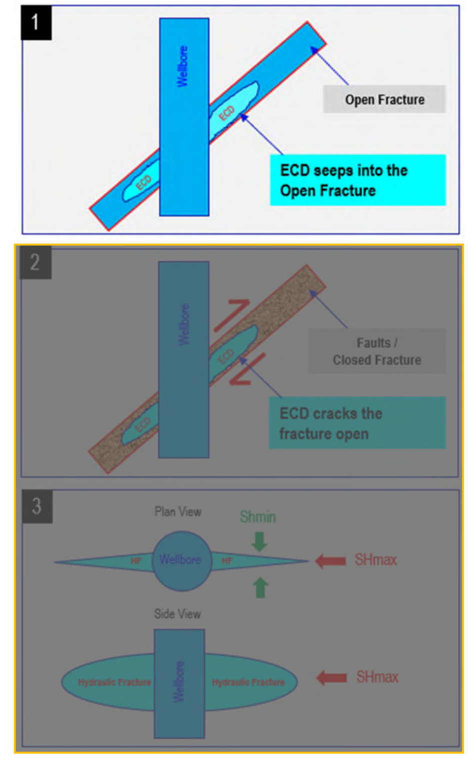
Reasons for Mud Loss (1)

1. Natural Fractures / High Permeability Zone

MW (Mud Weight) > PP (Pore Pressure)



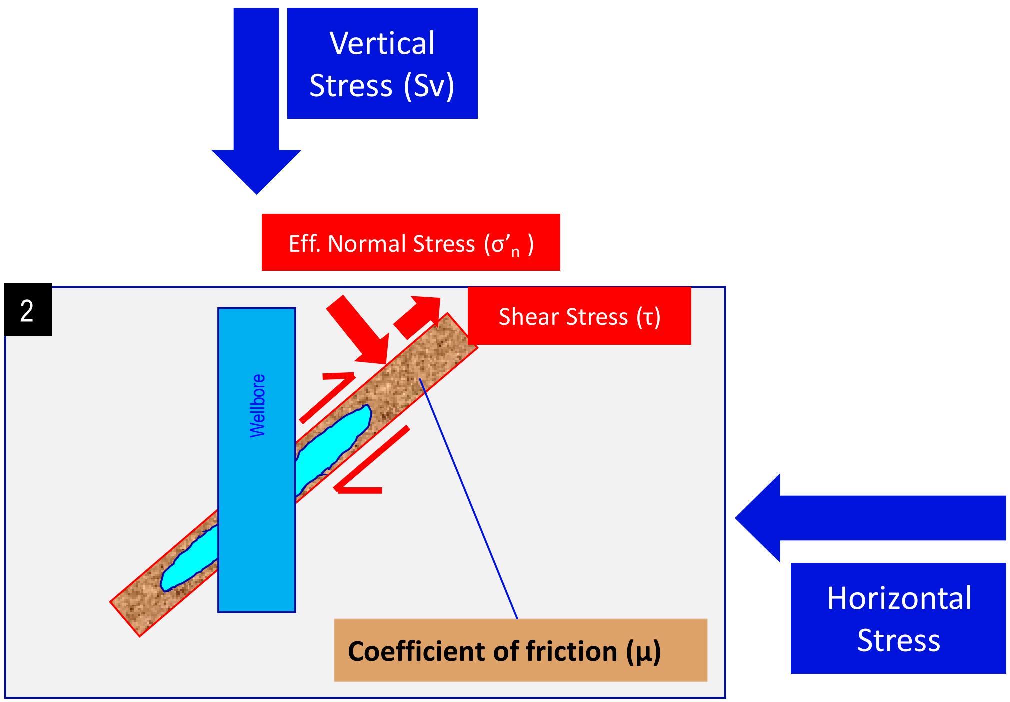
Equivalent Circulating Density (ECD) is the pertinent MW for mud losses during drilling

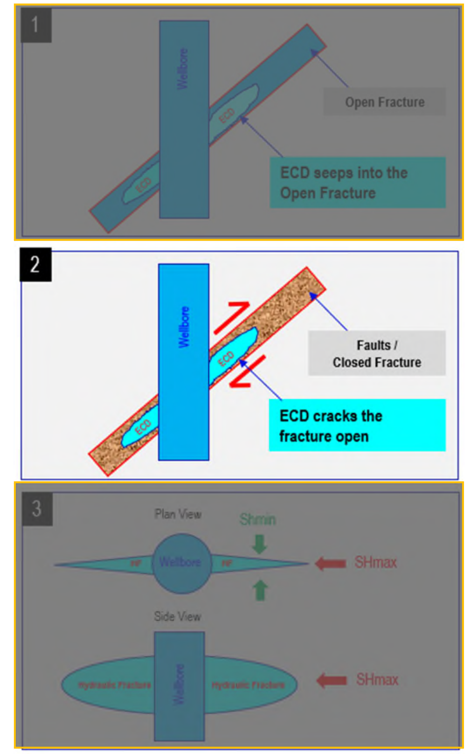


Reasons for Mud Loss (2)

2. Existing Faults / Closed Fractures:

Slippage of existing fault





$$CFF_{\text{(Coulomb Failure)}} = \tau - \mu\,(\sigma_n - ECD)$$
$$= \tau - \mu\,\sigma_n + \mu\,ECD$$

If CFF >0 , then fault will slip

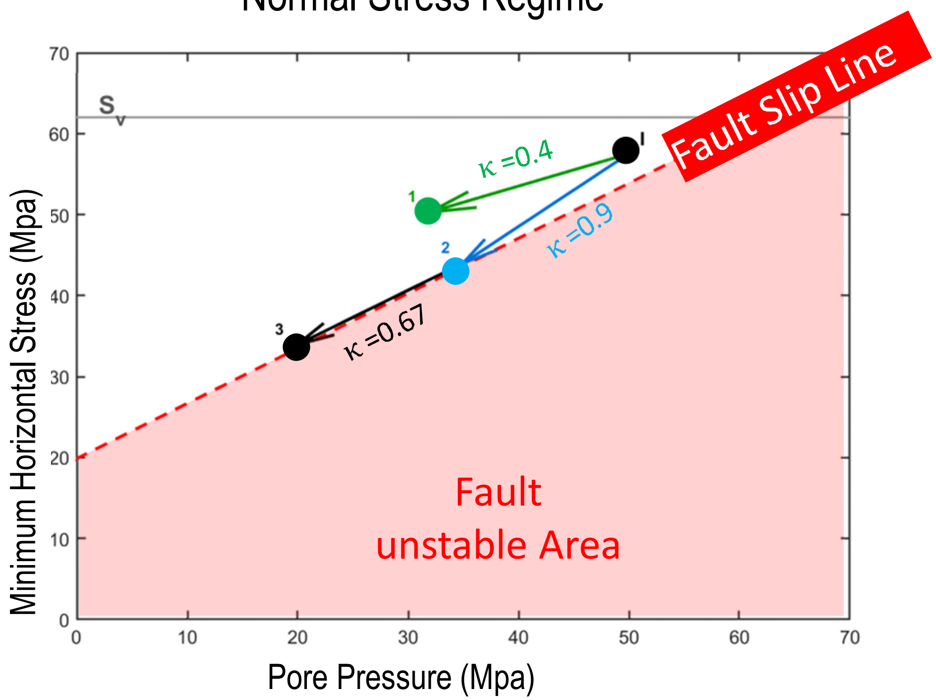
Depletion Effects on Fault Stability

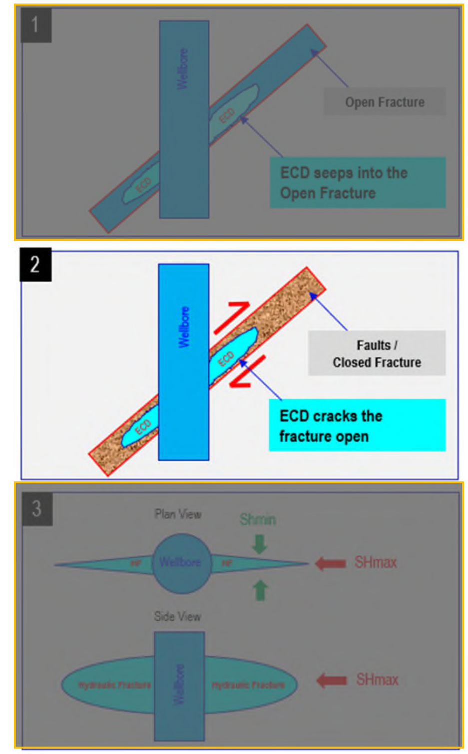
Stress Path

$$\kappa = \frac{\Delta S_h}{\Delta P_p}$$

Stress path (or depletion factor κ) is defined as the ratio of change of horizontal stress **Sh** with change in Pore Pressure **Pp**.

Normal Stress Regime



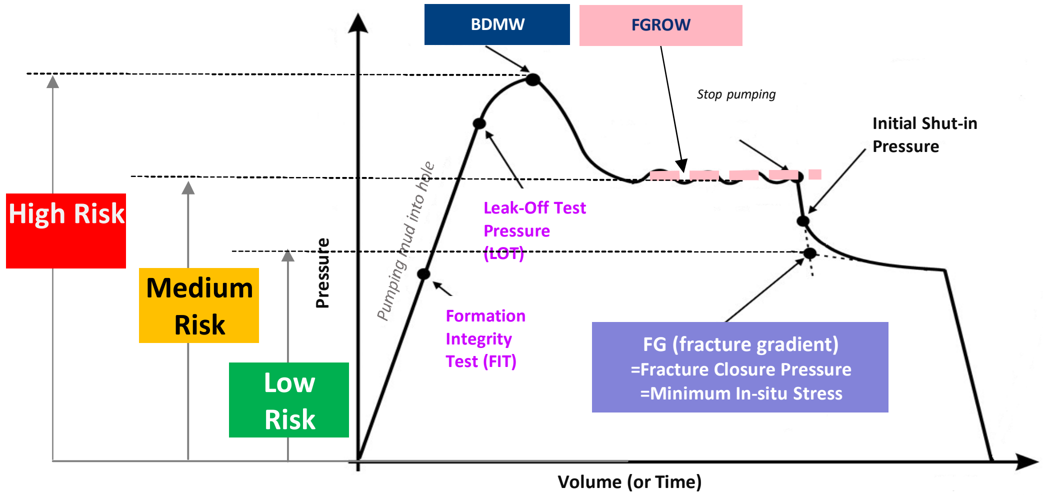


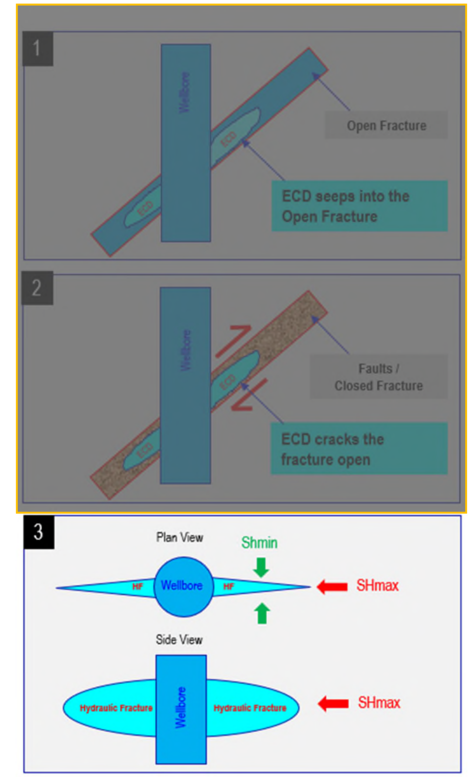
Reasons for Mud Losses (3)

3. Hydraulic Fracture (Tearing)

a. Tearing existing fracture

b. Tearing intact rock





- Conceptual Illustration of Extended LOT (XLOT)
- Fracture Gradient (FG) is the minimum in-situ stress

Case Example: Mud Loss in Depleted Reservoir

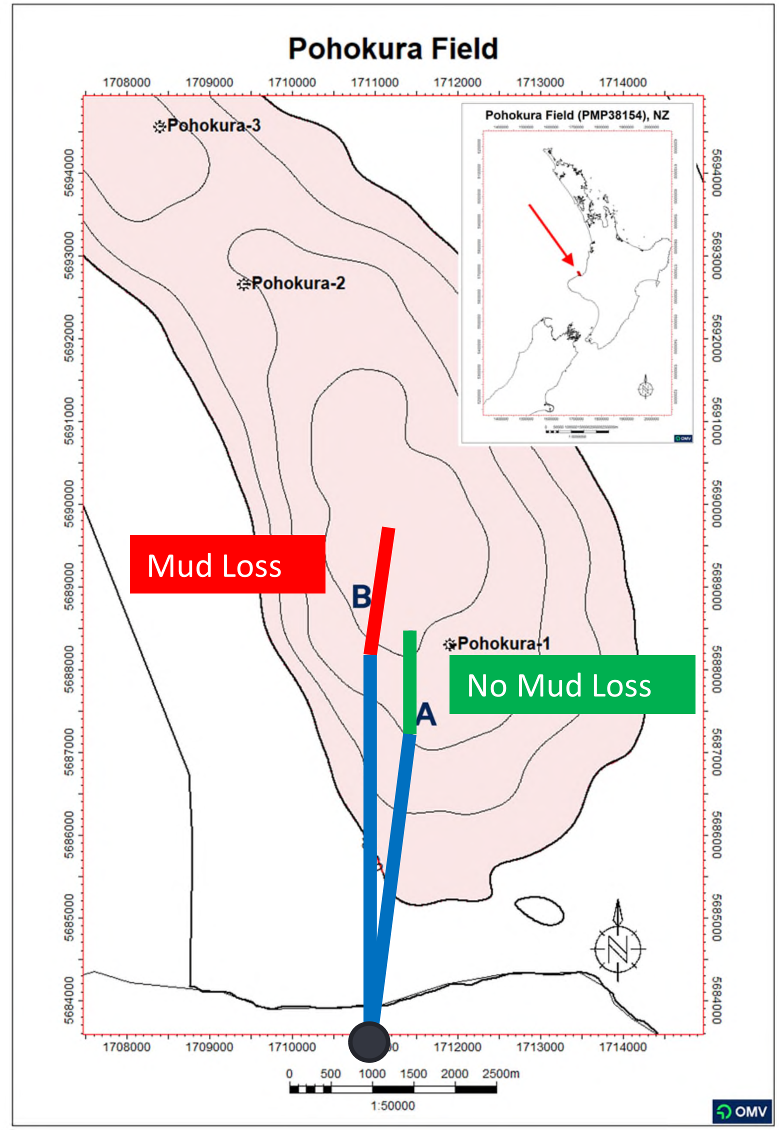
Unexpected Mud Losses

The Challenge

- Earlier wells including WELL-A had no major mud loss issues
- WELL-B had significant mud losses in depleted zone

Key questions:

- **Why did the mud losses happen?**
- **How to prevent it in future wells?**



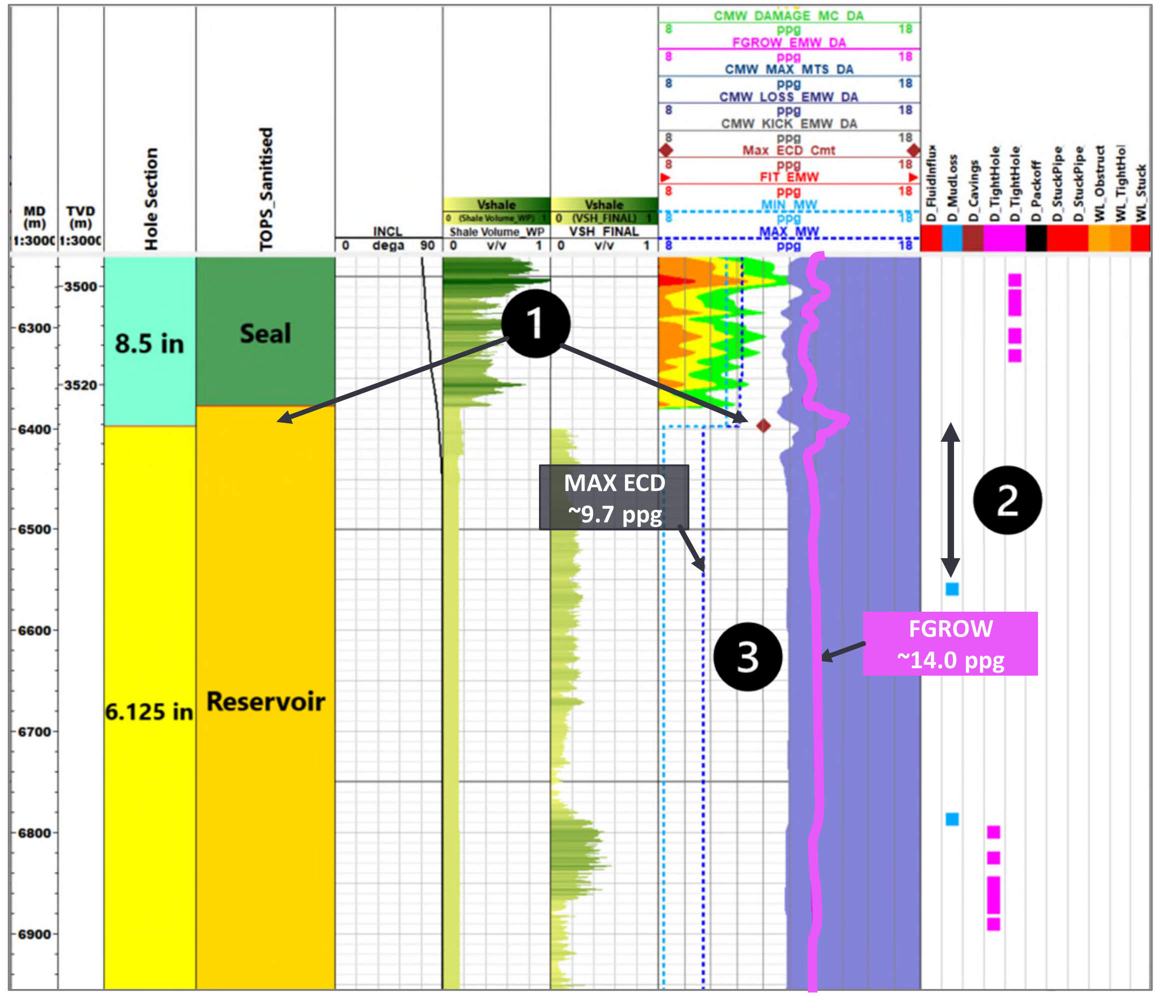
1D MEM Analysis & Observed Mud Losses

No Intact Rock Failure

1. **8.5" hole**: ~20 m in depleted reservoir with maximum Cementing ECD = 12 ppg; no losses.
2. **Mud losses** after ~150 m horizontal drilling in reservoir
3. **6.125" hole**: FGROW ~14 ppg, while maximum ECD 9.7 ppg.

➢ **Earlier Hypothesis:**
ECD > FGROW not the case. Losses remain unexplained

➢ **New Hypothesis:**
Losses are due to presence of faults / natural fractures



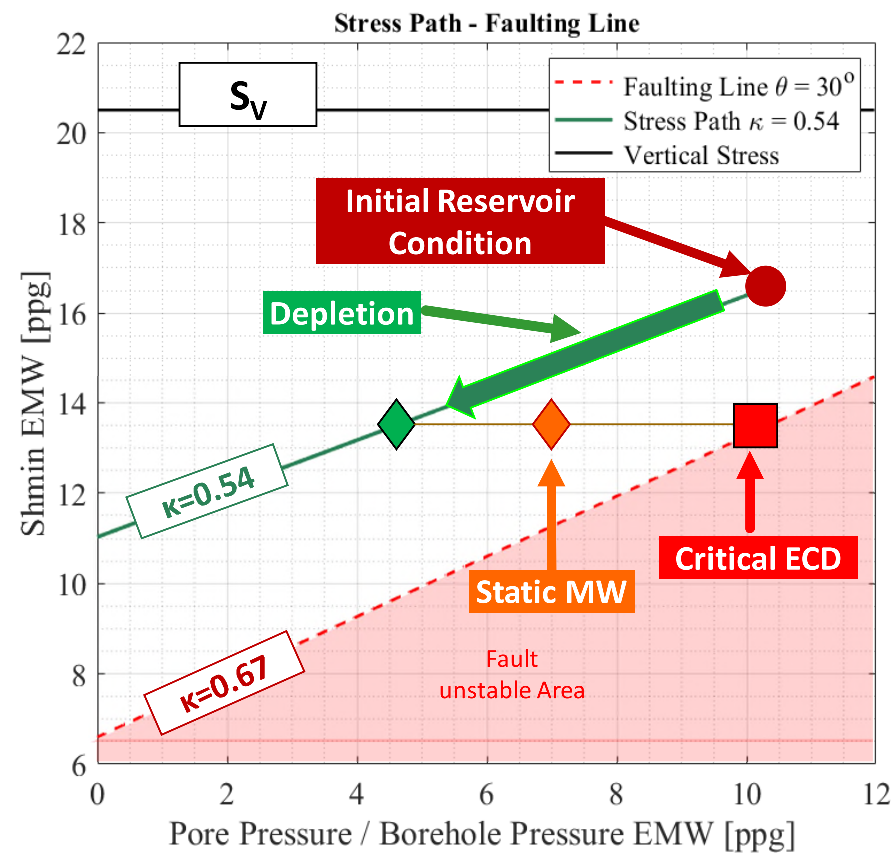
Easy Display for Mud Weight Planning

What to Display

- Evaluate horizontal stress **Sh** change with depletion on a reservoir scale

Read the Display

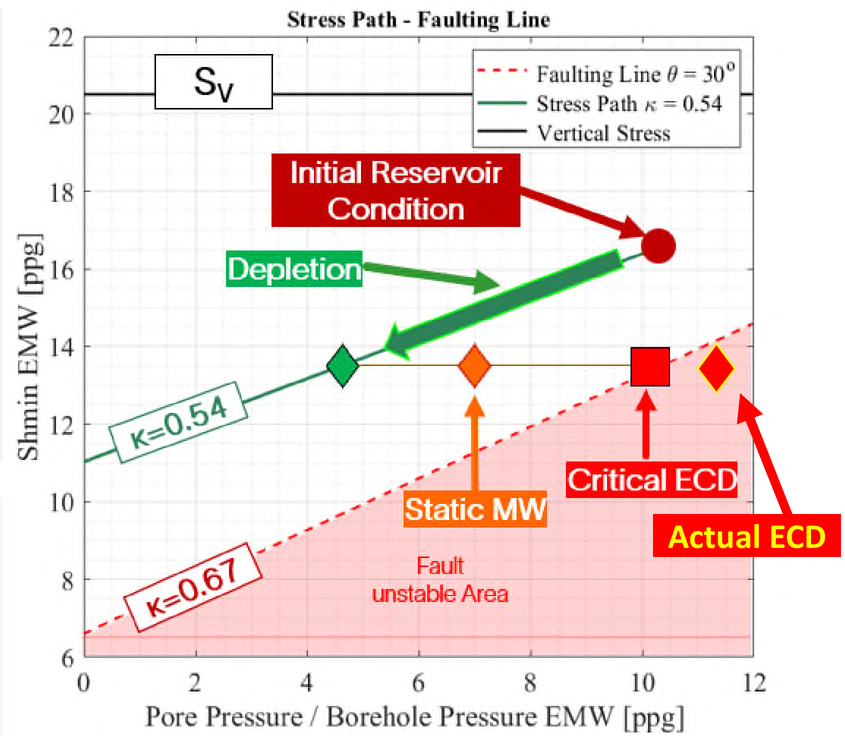
- Determine Critical ECD



Gaede, O., Hearn, M., Van Koughnet, R., Pallikathekathil, Z., & Altaf, I. (2026). Mitigating the mud-loss challenge when drilling in a depleted field–A case study from New Zealand. *Australian Energy Producers Journal*, EP25211.

Results

- **Losses due to Hydraulic Fracturing:**
  Ruled out (ECD < FGROW)
- **Fault Reactivation:**
  Ruled out (Stress path diverges from faulting line)
- **Losses related to near wellbore fault slip:**
  Yes! ECD > Critical ECD limit for Well B



Practical take aways:

1. **Drill laterally through undepleted seal formation, before entering reservoir**
2. **Keep ECD < Critical ECD**
   (Use diagram for easy visualization of Critical ECD in depleted field before drilling well)

Conclusions

Mud loss investigation should consider two (geomechanical) mechanisms:

1. **FGROW PLOT:** Intact rock failure with emphasis on FGROW
2. **CRITICAL ECD PLOT:** wellbore fault criticality

- New upper limit for safe mud weight window (Critical ECD) in depleted reservoirs with faults or natural fractures.
- Enhanced reservoir space plot integrates mud weight considerations with fault stability assessment.

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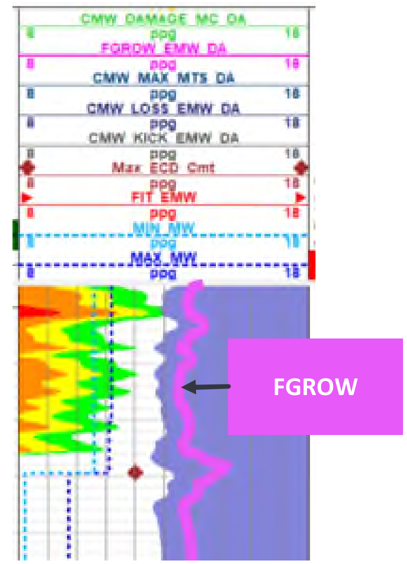

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