SPE Workshop: Managed Pressure Drilling (MPD) and Underbalanced Drilling (UBD)

8 – 9 JULY 2025 | KUALA LUMPUR, MALAYSIA

Managing Pressures in High-Enthalpy Geothermal Wells

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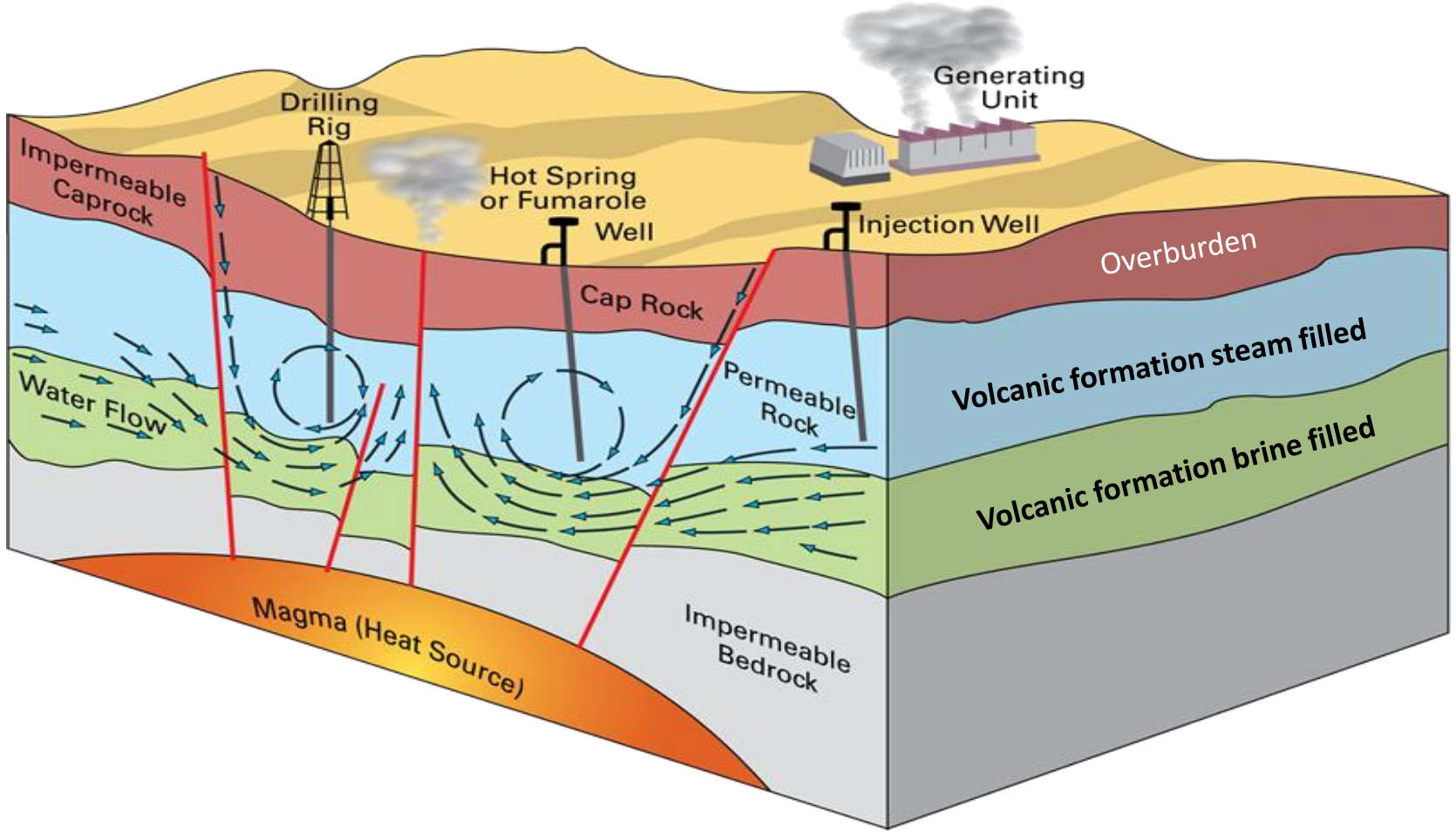
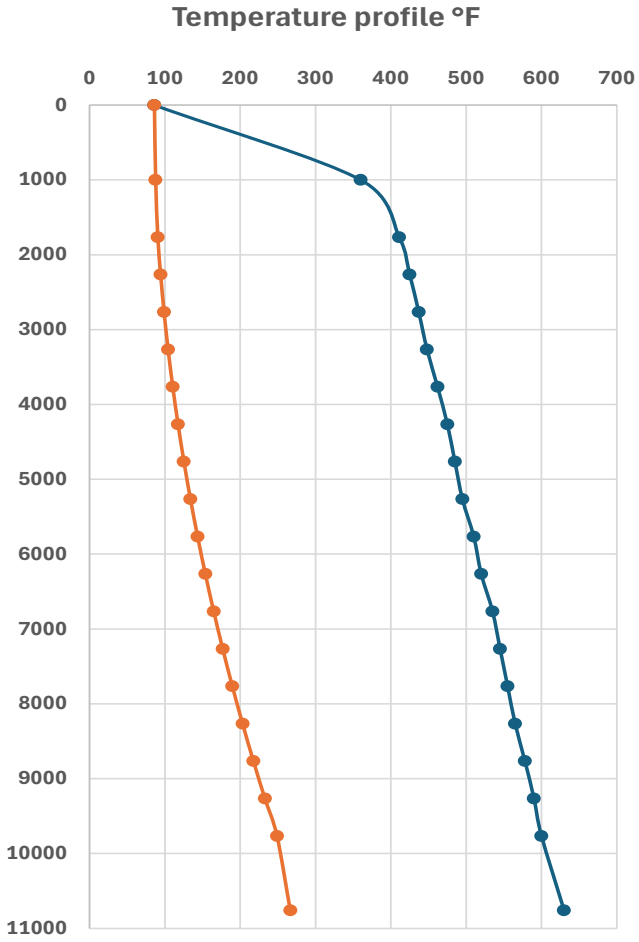
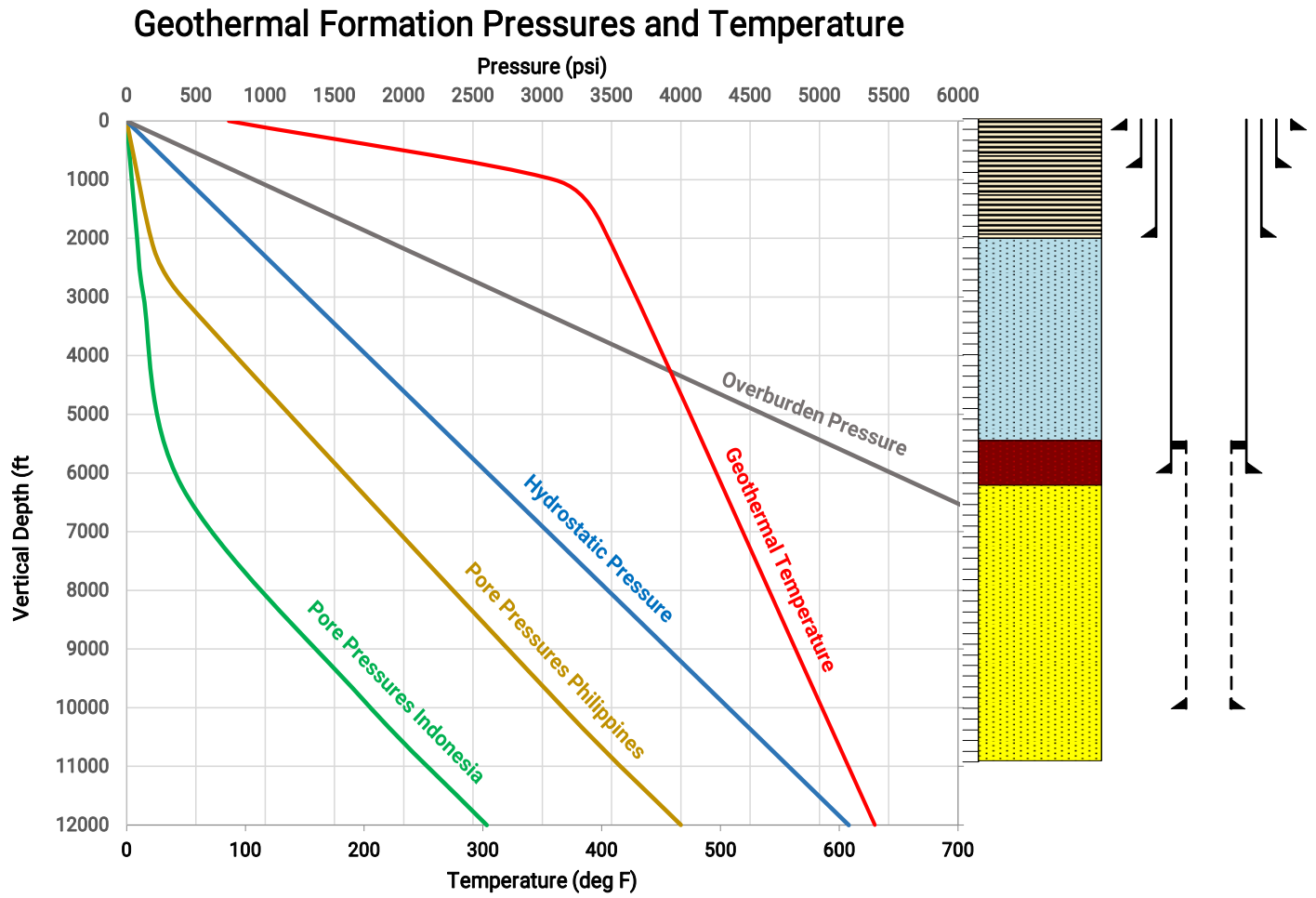
Well Examined

Geothermal Reservoirs (Liquid dominated High Temp)





Drilling Challenges



Sub hydrostatic pore pressures.

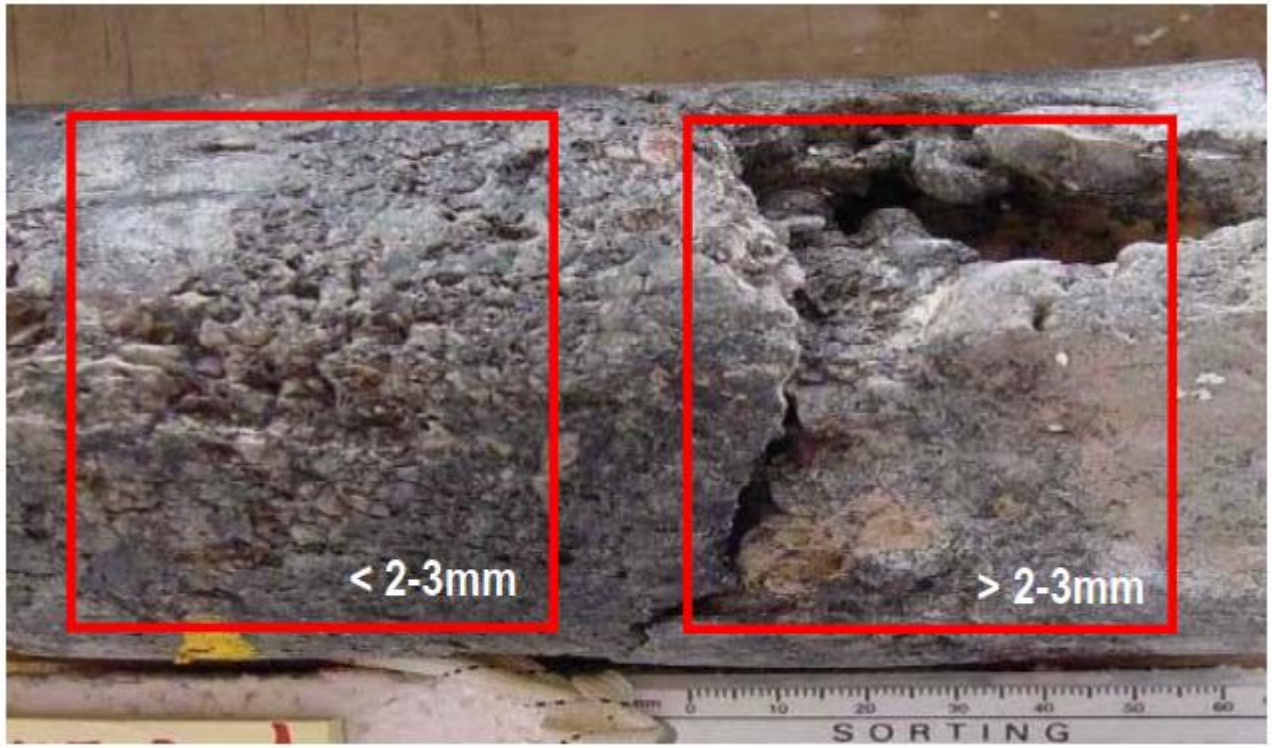
Water level is at 2000 to 4000 ft below surface.

Upper steam filled volcanic reservoir

Lower brine filled volcanic reservoir (Target reservoir)

High Temperature 610°F (325°C)

Why use Aerated Fluids ?



Smaller fractures < 2- 3 mm cause fluid losses when drilled overbalanced.

These small fractures can be plugged with LCM to regain circulation.

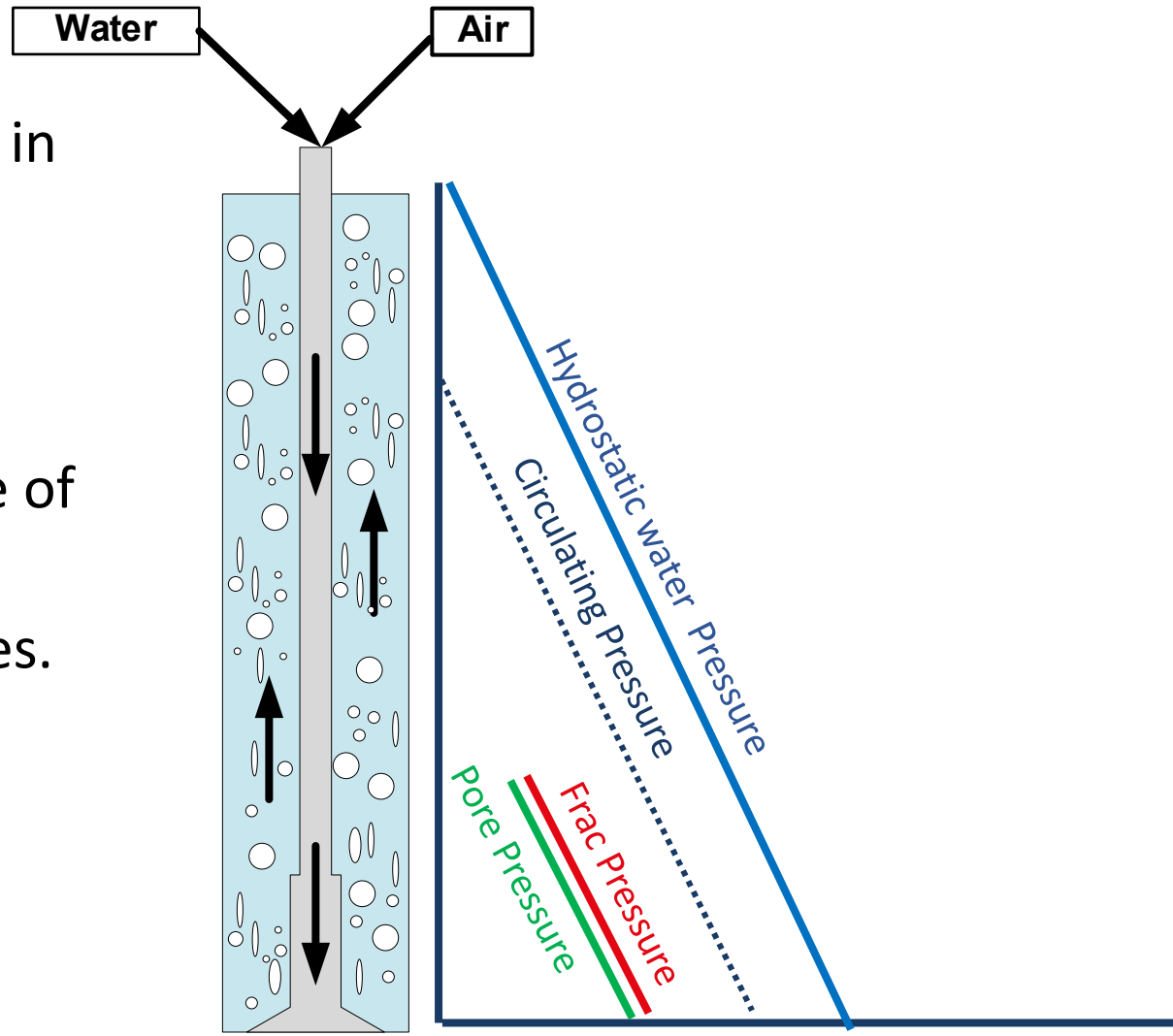
Bigger fractures impossible to seal with LCM

Why use Aerated Fluids ?

Aerated drilling was first used in the Philippines in 1982.

Pore pressure ≈ fracture pressure

- Reducing formation damage by avoiding use of LCM or cement.
- Reducing water consumption minimize losses.
- Control hole stability and hole cleaning.



Drilling Equipment

Water

Pumped with mud pumps from mud pits

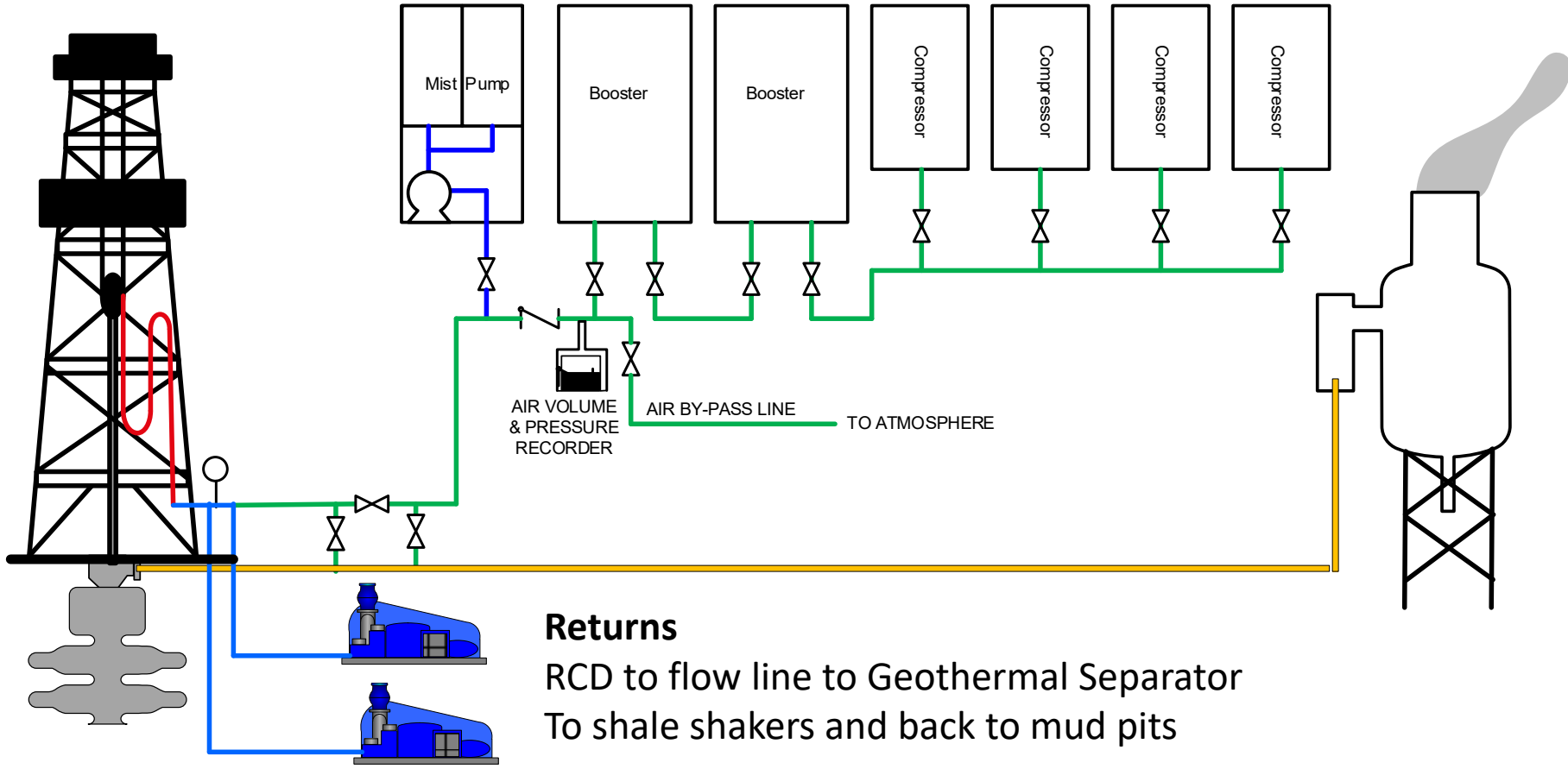
Air

Compressors

Boosters

Mist pump

Air & water mixed at standpipe and injected into the drillstring

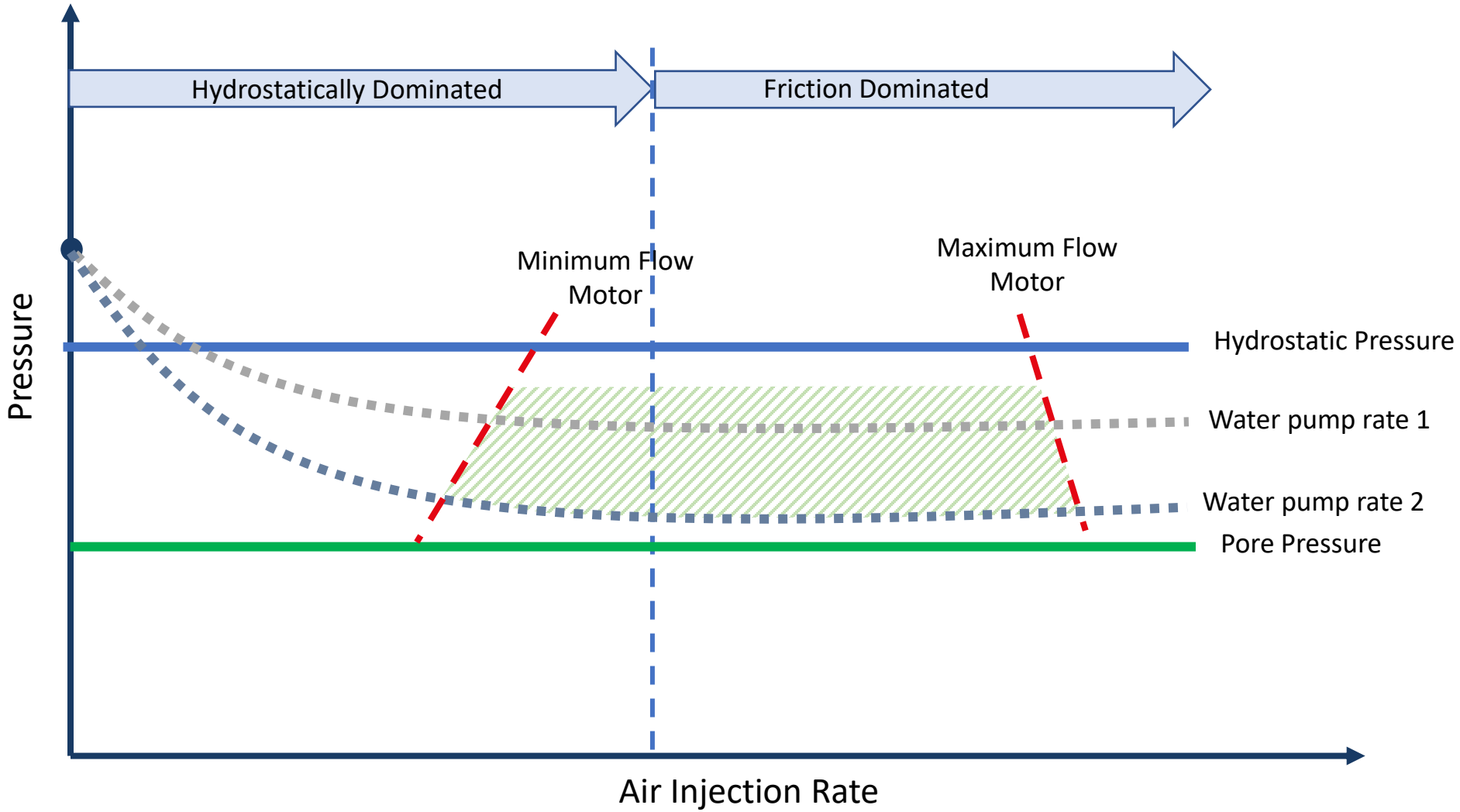


Returns

RCD to flow line to Geothermal Separator

To shale shakers and back to mud pits

Aerated flow modelling used from Underbalanced Drilling

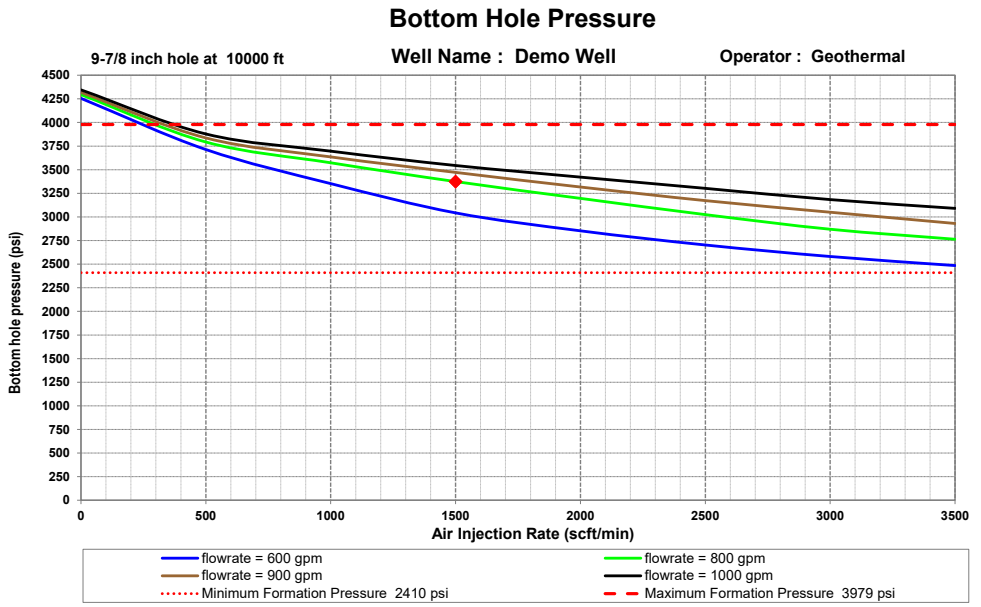


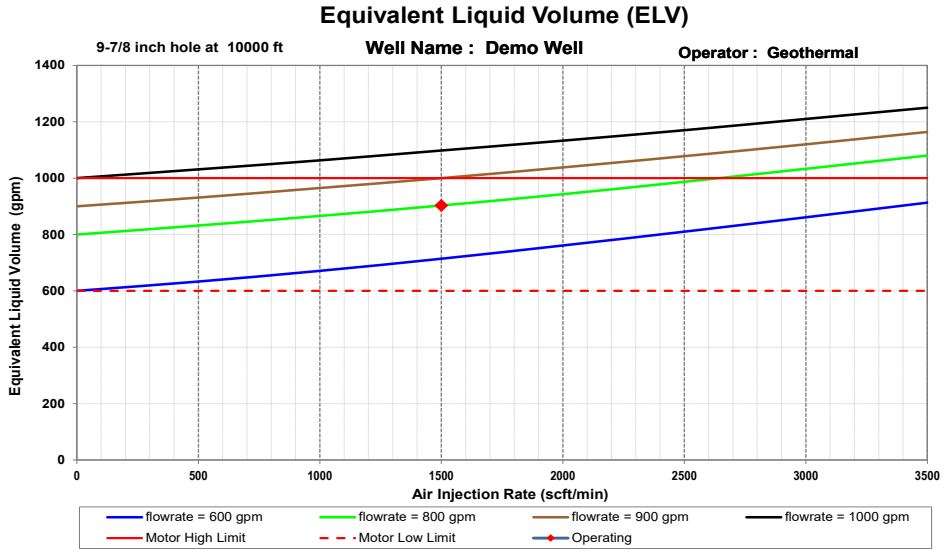
Flow modelling

- Bottom hole pressure
- Equivalent Liquid rates
- Hole cleaning (cuttings transport)
- Velocities
- Liquid hold up
- Injection Pressures

Software used

- Neotec Wellflo
- UBDPro
- Drillsoft

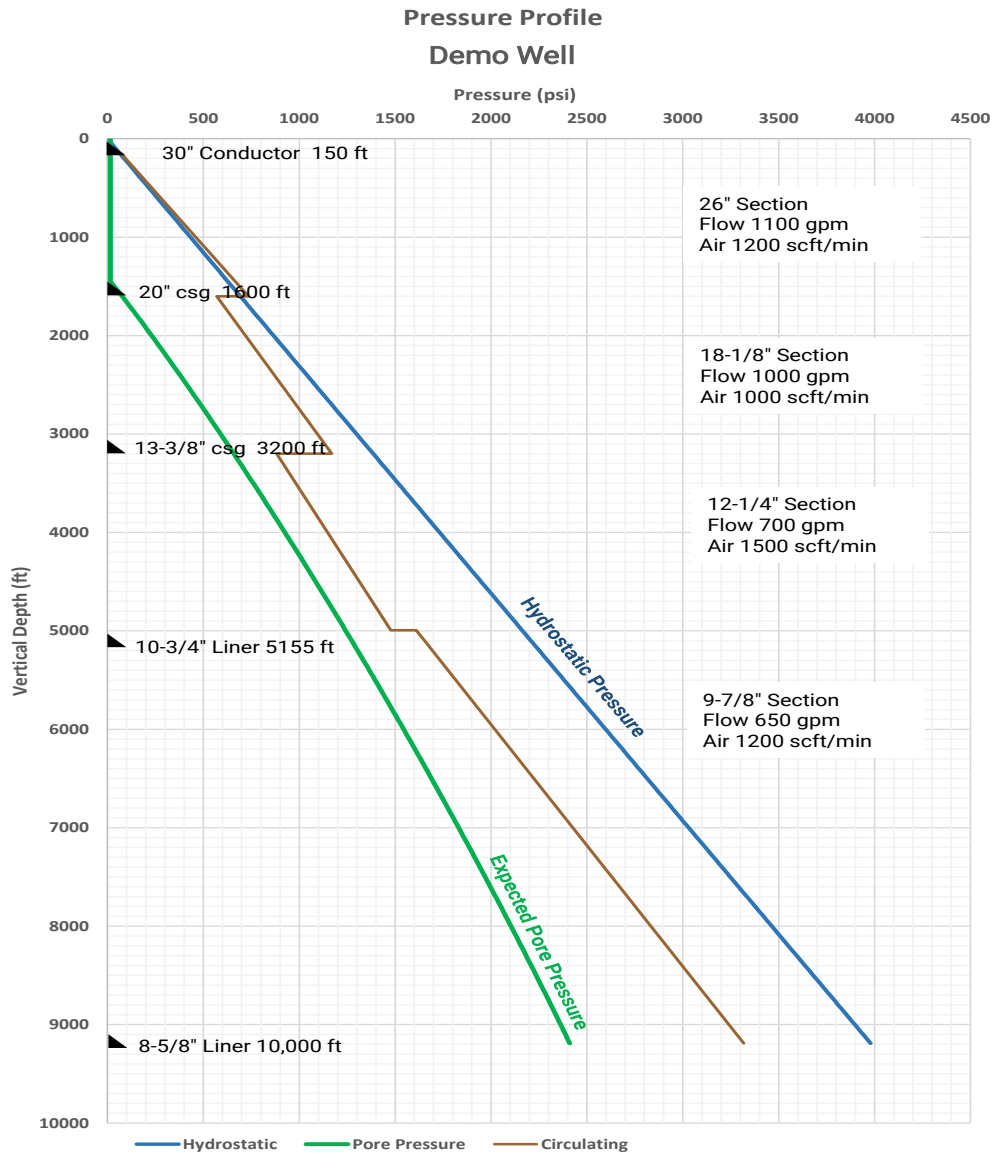




Aerated system design

Designing a hydraulic system using air and water to:

- Control wellbore pressures
- Minimize losses
- Avoid influxes
- Ensure hole cleaning and cuttings transport
- Maintain injection pressures to below booster capability
- Avoid hole collapse
- Efficiently drive the down hole motor
- Ensure hole cleaning



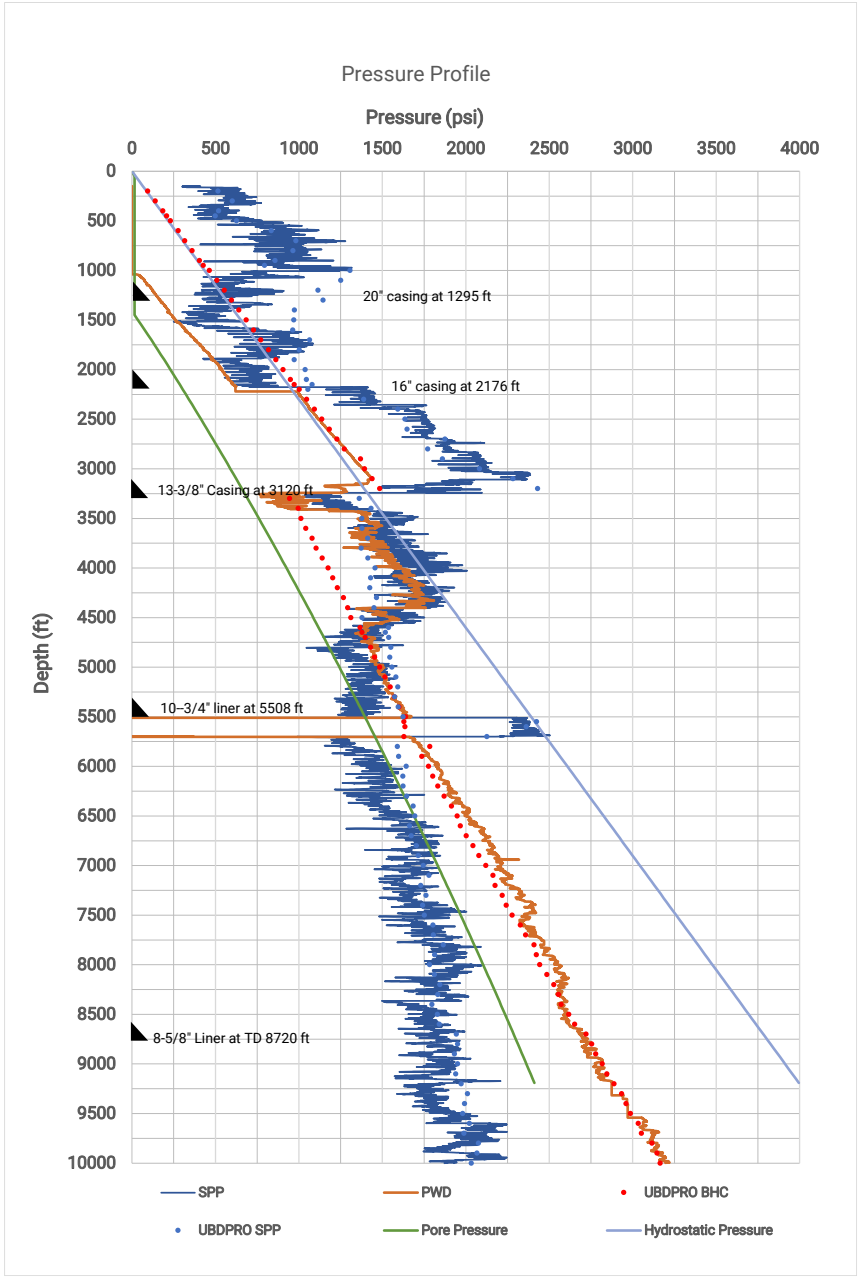
PWD data (EM tools)

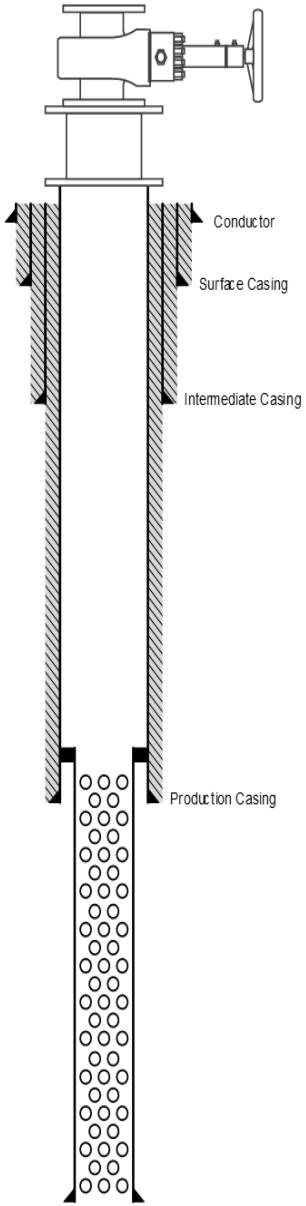
Standpipe pressure, bottom hole pressures are plotted,

Model results are compared with measured pressures (SPP & BHP)

To avoid possible steam kicks water is injected into the annulus as soon as total losses are encountered.

Top hole sections drilled without air.





Conclusion

- Combining technologies from underbalanced drilling and mud cap drilling
- Aerated drilling in porous and fractured volcanic formations allows drilling to continue with total losses. (10000 ft well 3 x csg, 1 x liner, drilled and completed in 30 days)
- Avoiding cement plugs and LCM maintains productivity of formations.
- Maintaining air and liquid parameters constant irrespective of loss rate avoids stuck pipe. (Stuck pipe incidents reduced from 3 per well to 1 in 5 wells.)
- Drilling with cold water and no returns to surface maintains downhole tool temperatures. EM MWD tools allow good downhole data (GR-PWD-Directional).
- Down hole data allows software model correlations.

Questions ?