Assessment of Fault Zone Properties for Groundwater Models

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What are the mechanisms by which faults transmit fluids (or not)?

1. Up-fault flow where the fault is in dilatant conditions usually assessed through a combination of fault zone architect
2. Up-fault
This can
tectonis
accumu
fluids th
3. Across f
stratigra
4. Across f
assessed
cataclasis
5. Lastly can we assess sub-seismic strain?

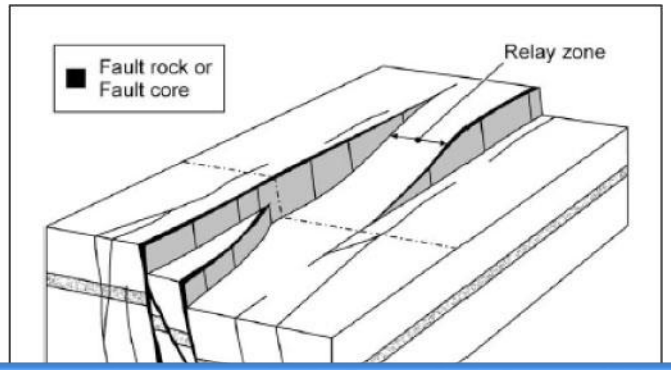
J.R. Underschultz. (2016). Linking Capillary and Mechanical Seal Capacity Mechanisms. Petroleum Geoscience. 22 (3). DOI: 10.1144/petgeo2016-032.

Jim Underschultz and Julian Strand, (2016). Capillary seal capacity of faults under hydrodynamic conditions. Geofluids Journal special edition on Fault Zone Hydrogeology. Geofluids Journal, 16, 464-475.

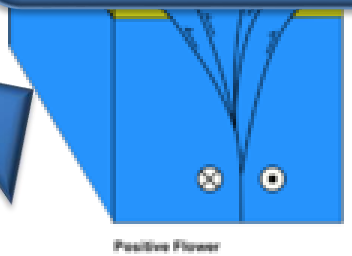
+ many other publications

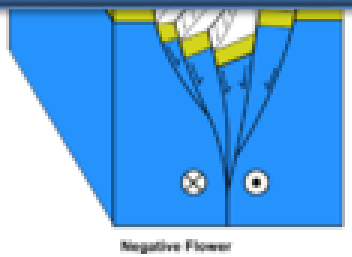
Up-Fault Leakage (hydraulic communication) Potential

- Fault Zone Architecture
- In-Situu Stress



Portions of fault out of plane with stress field tend to show up-fault migration potential often via focused flow paths



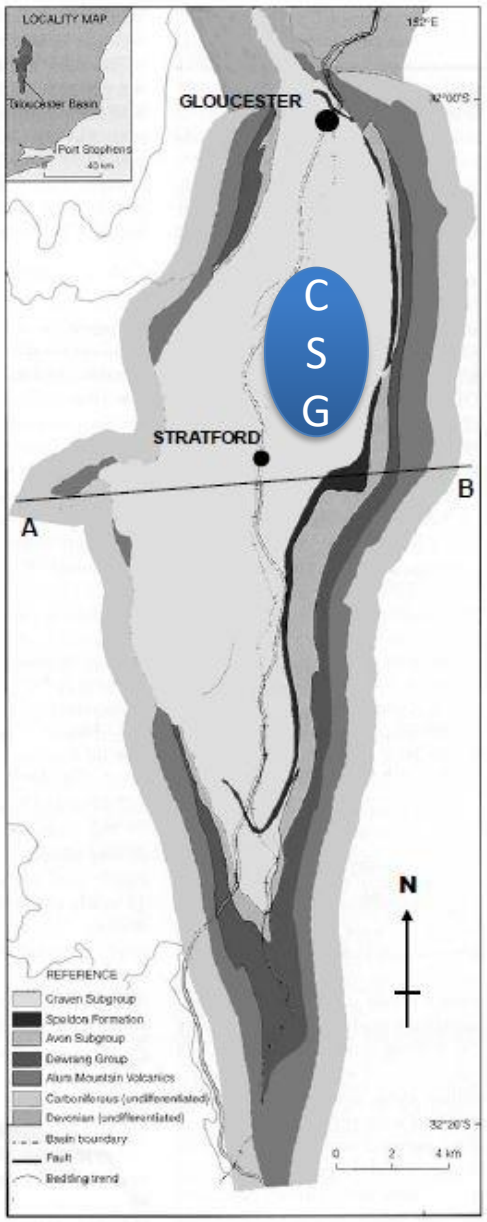


Study Area

after Ward et al., 2001; Ogier-Halim, 2010

10 km

38 km



Group	Subgroup	Formation	Approx Thickness	Coal seams
Gloucester Coal Measures	Craven Subgroup	Crowthers Road Conglomerate	350 m	
		Leloma or Woods Road Formation	585 m	Linden Bindaboo Deards
		Jilleon or Bucketts Way Formation	175 m	Cloverdale Roseville Fairbairns Lane
		Wards River Conglomerate	Variable	**L8**
		Wenham Formation	24 m	Bowens Road
	Speldon Formation		77 m	
	Avon Subgroup	Dog Trap Creek Formation	126 m	Glenview
		Waukivory Creek Formation	326 m	Avon Triple Rombo Glen Road Valley View Parkers Road
Dewrang Group	Mammy Johnsons Formation		300 m	Mammy Johnsons
	Weismantel Formation		20 m	Weismantel
	Duralie Road Formation		250 m	
Alum Mountain Volcanics			2000m	Clareval Basal coal seam

Devonian and Carb volcanics and sed

Alluvium **~100's mD**

Weathered Bedrock **~10's mD**

L1-6

~1's mD or less

Permian Age Strata

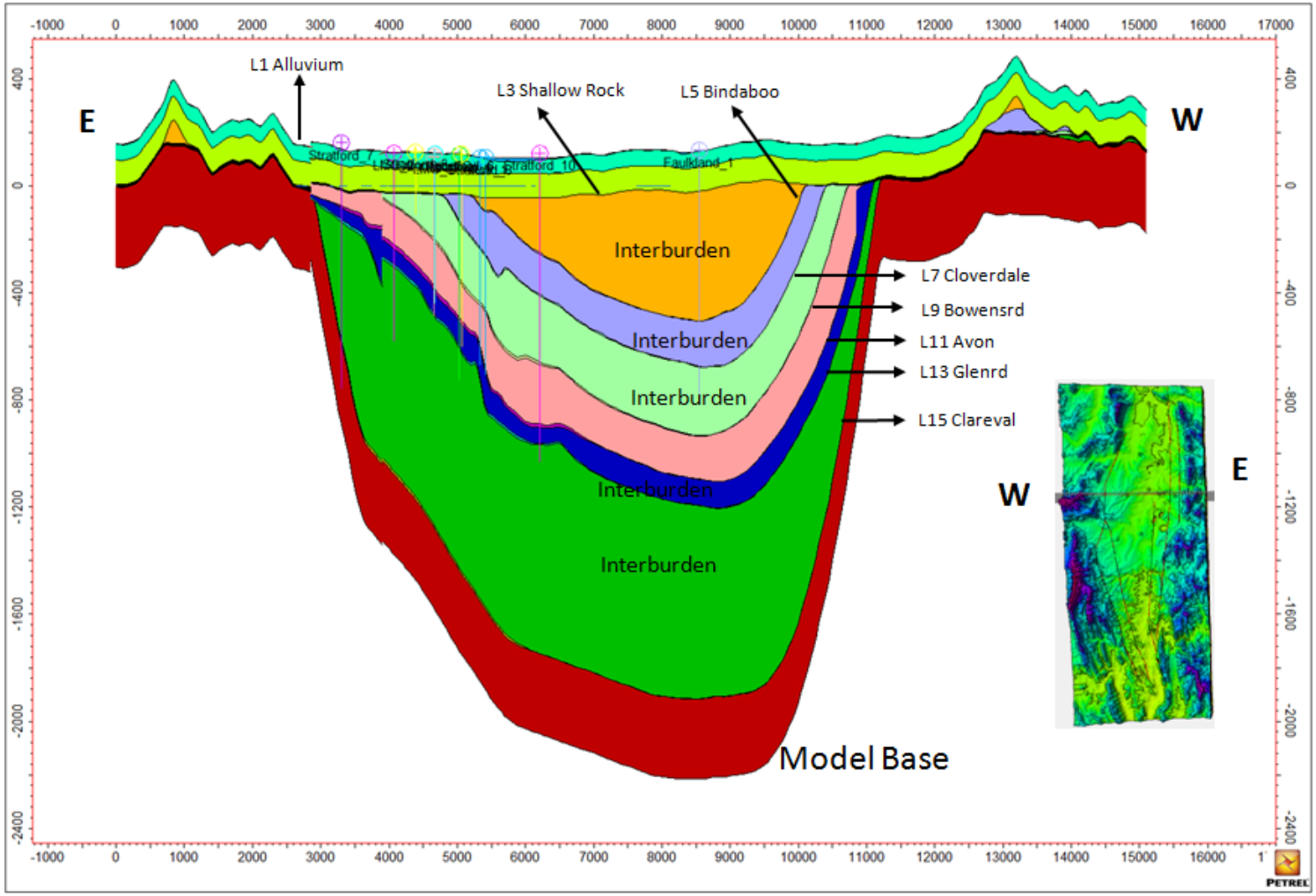
250m CSG

Marine SSt & Mdst

200m CSG

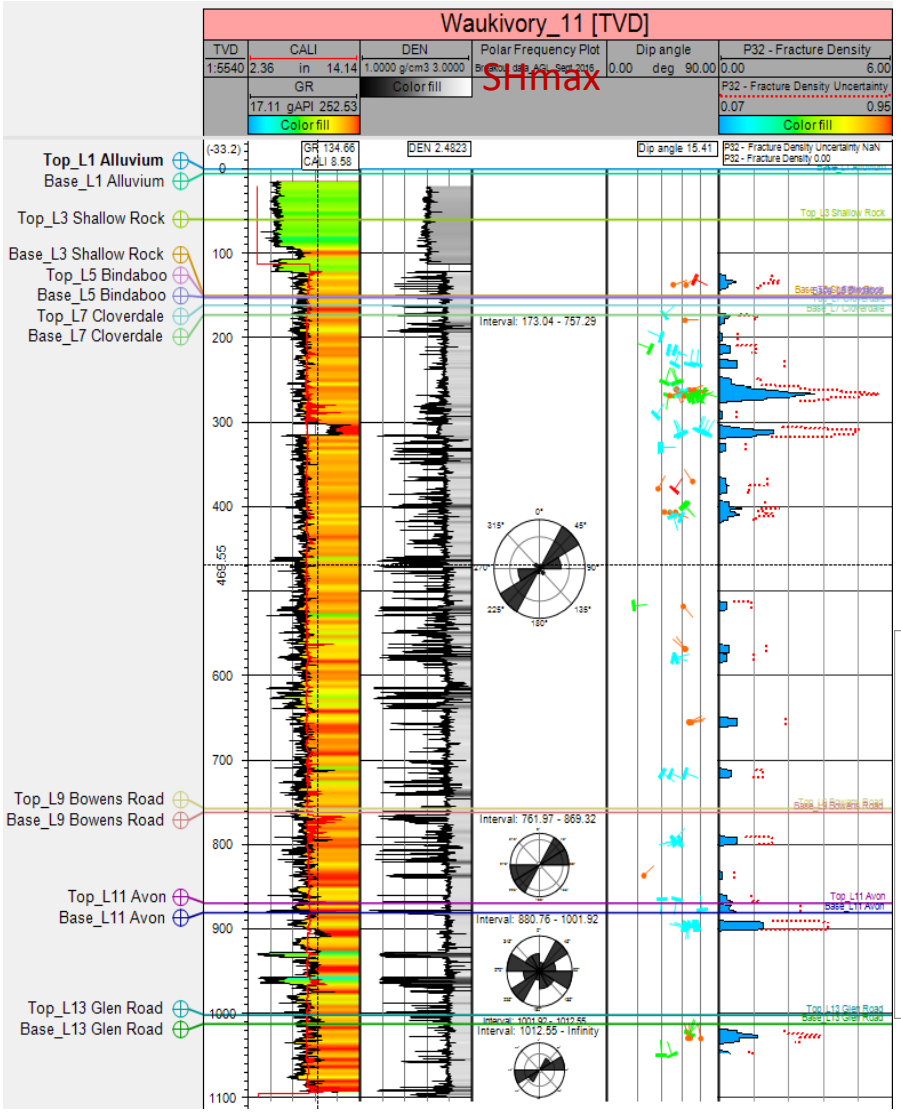
~1's mD or less

East - West Cross Section

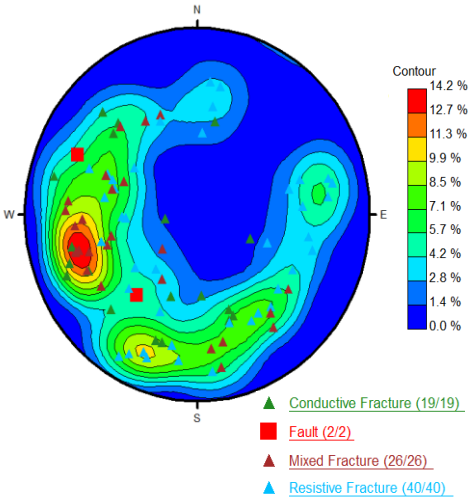


Gloucester Basin East West Cross Section

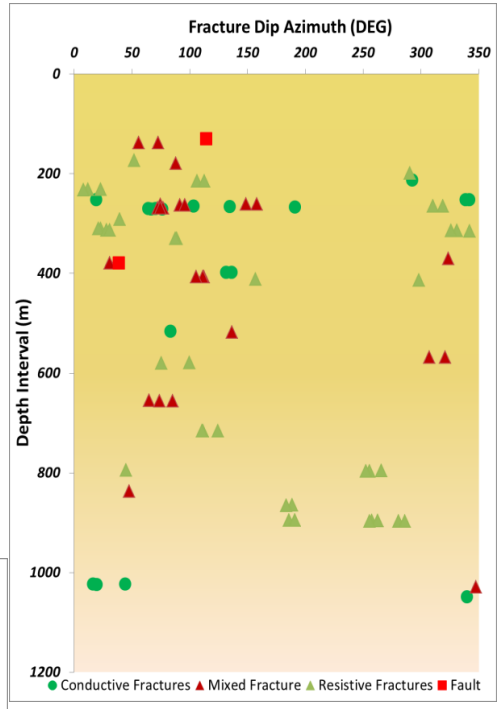
Fracture Data Analysis – Waukivory 11



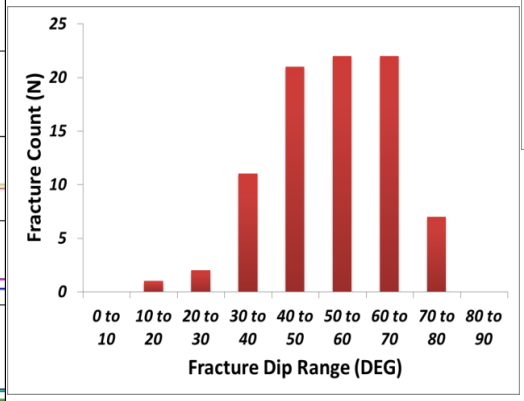
Waukivory11 Shmax and fracture distribution along depth



Stereonet contour of faults and fractures dip azimuth in Waukivory11 well



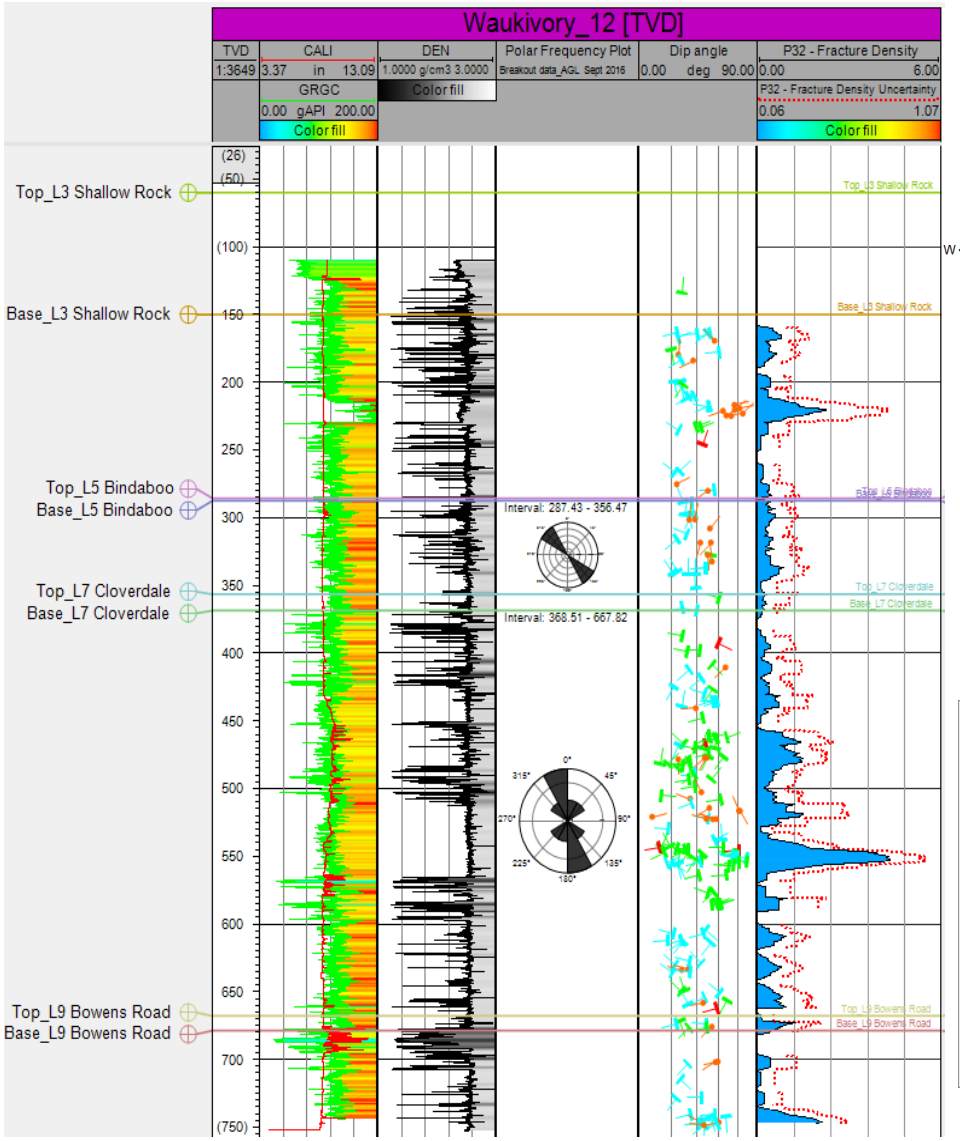
Waukivory11 fracture distribution vs depth



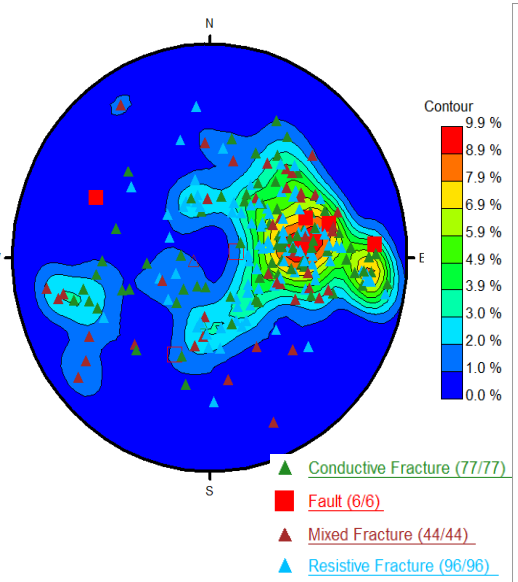
Waukivory11 fracture dip range vs fracture count

Compression and Low Fracture Density

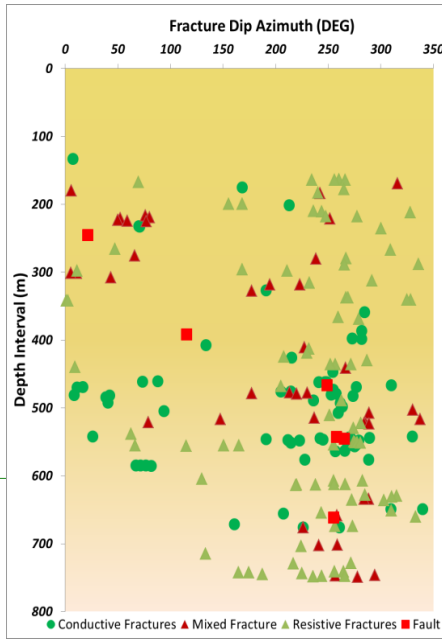
Fracture Data Analysis – Waukivory 12



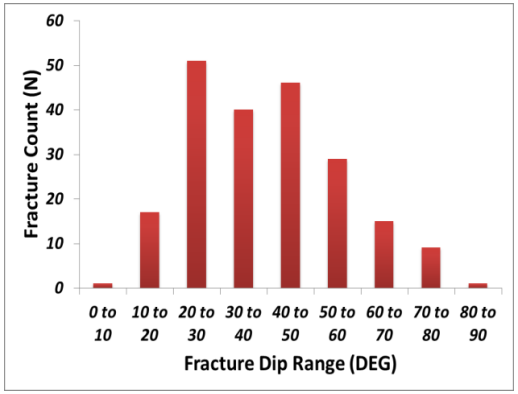
Waukivory12 Shmax and fracture distribution along depth



Stereonet contour of faults and fractures dip azimuth in Waukivory12 well



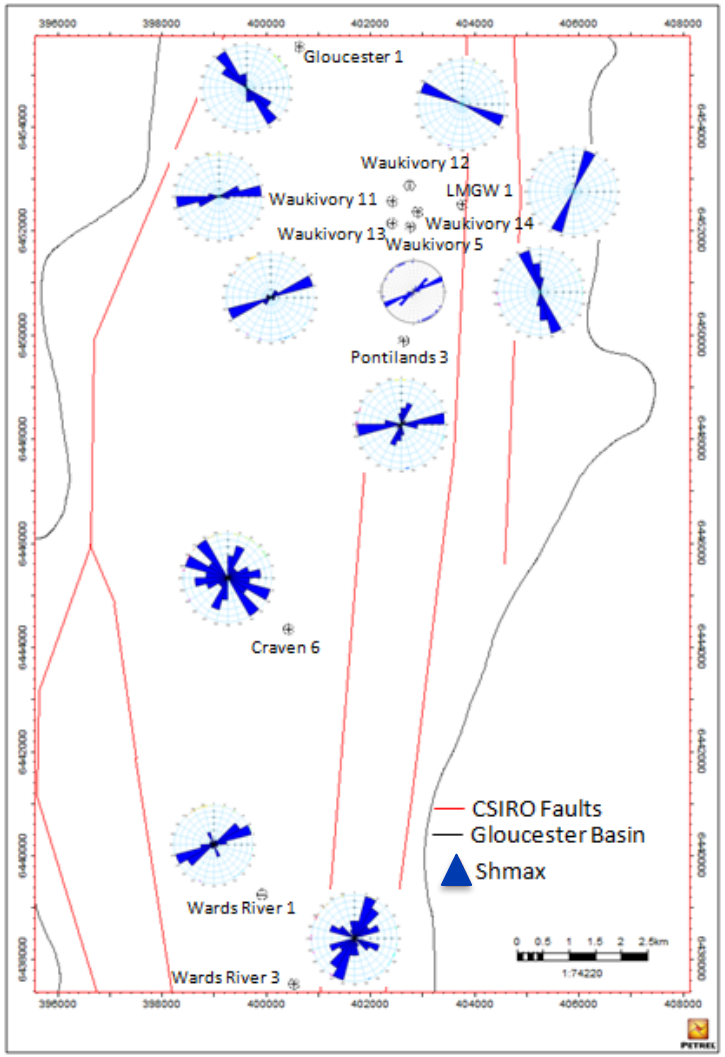
Waukivory12 fracture distribution vs depth



Waukivory12 fracture dip range vs fracture count

Dilatant and High Fracture Density

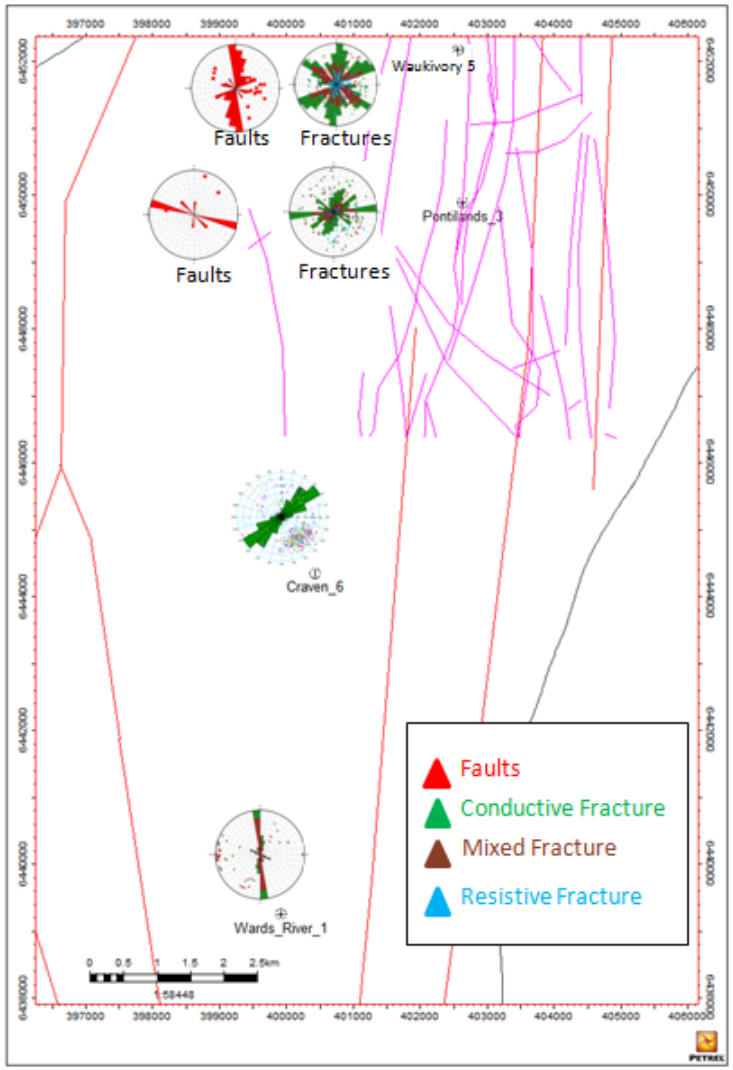
Gloucester Basin Shmax Distribution Map



Gloucester Basin Shmax Distribution Plot

- Large geographic variation in Shmax orientation
- Some Locations where Shmax varies substantially up the well

Gloucester Basin Faults, Fractures & Stress Distributions Map



Gloucester Basin Fault & Fractures Distribution Map

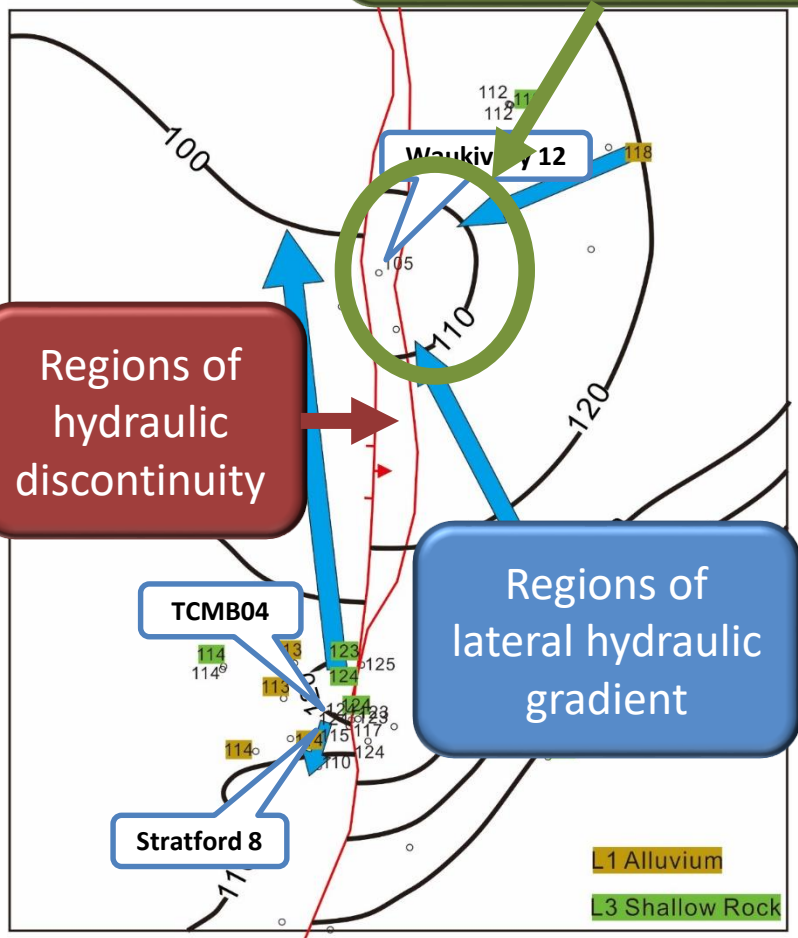
- Large geographic variation in fault plane orientation
- Some Locations have multiple fracture set orientations

Hydraulic Head Data per Layer

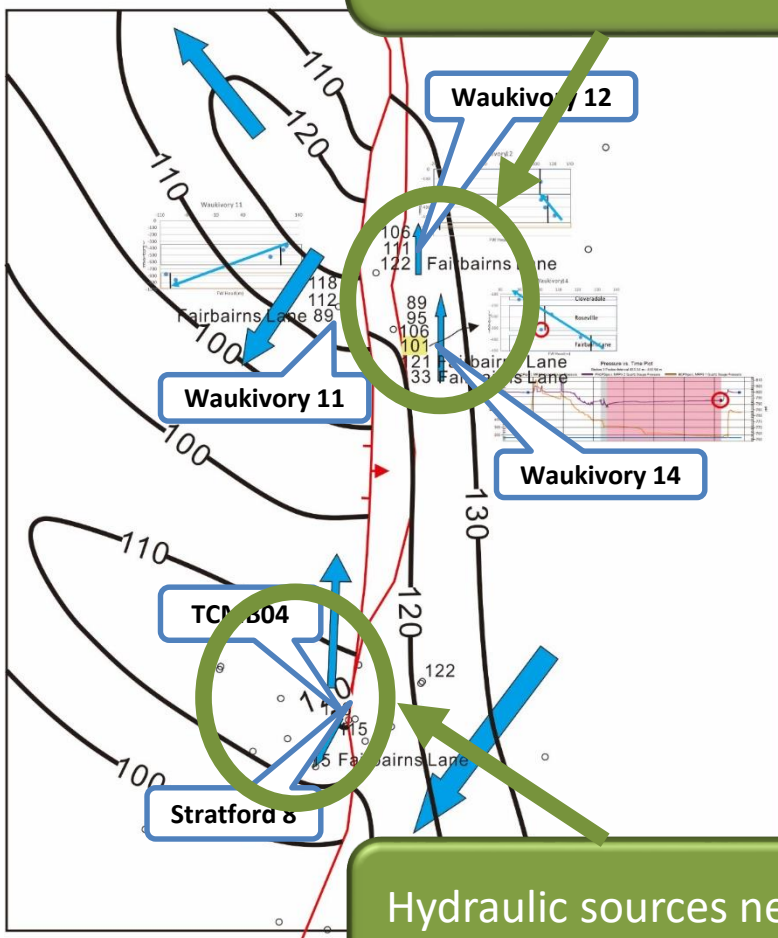
Hydraulic sinks next to fault zones

Regions of hydraulic discontinuity

Regions of lateral hydraulic gradient



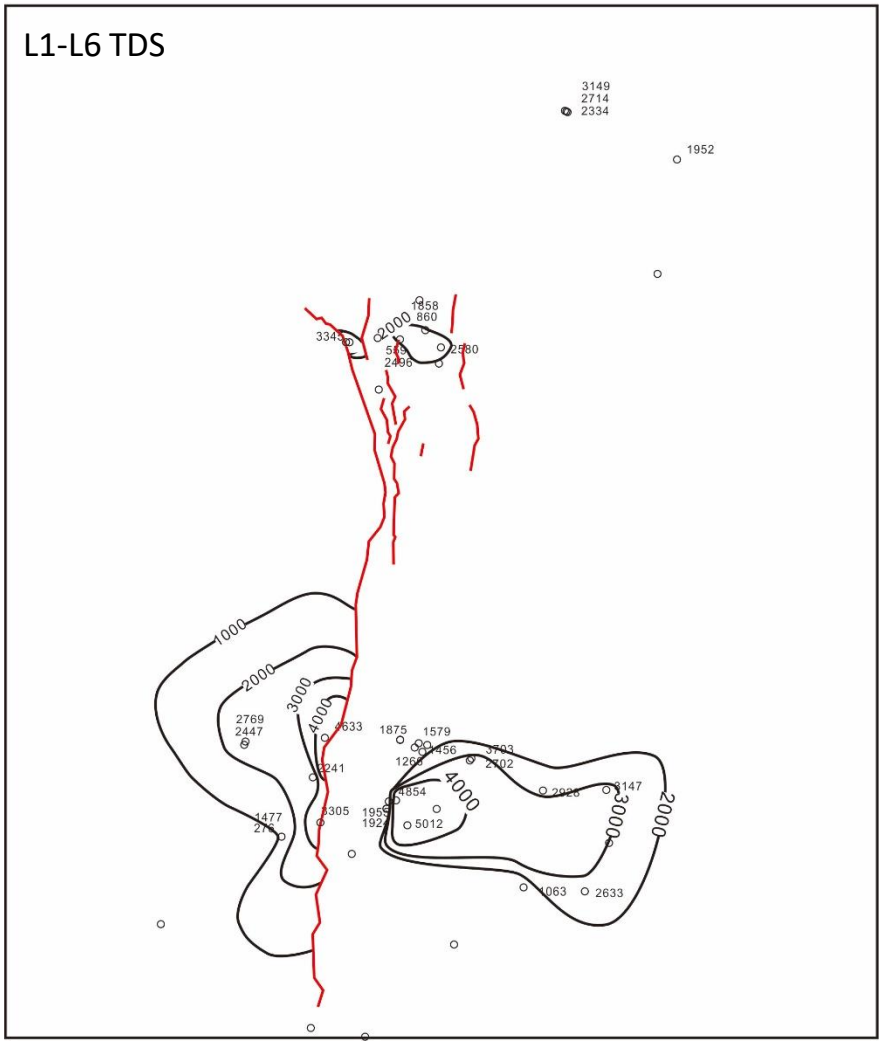
Wells that show a consistent vertical hydraulic gradient



Hydraulic sources next to fault zones

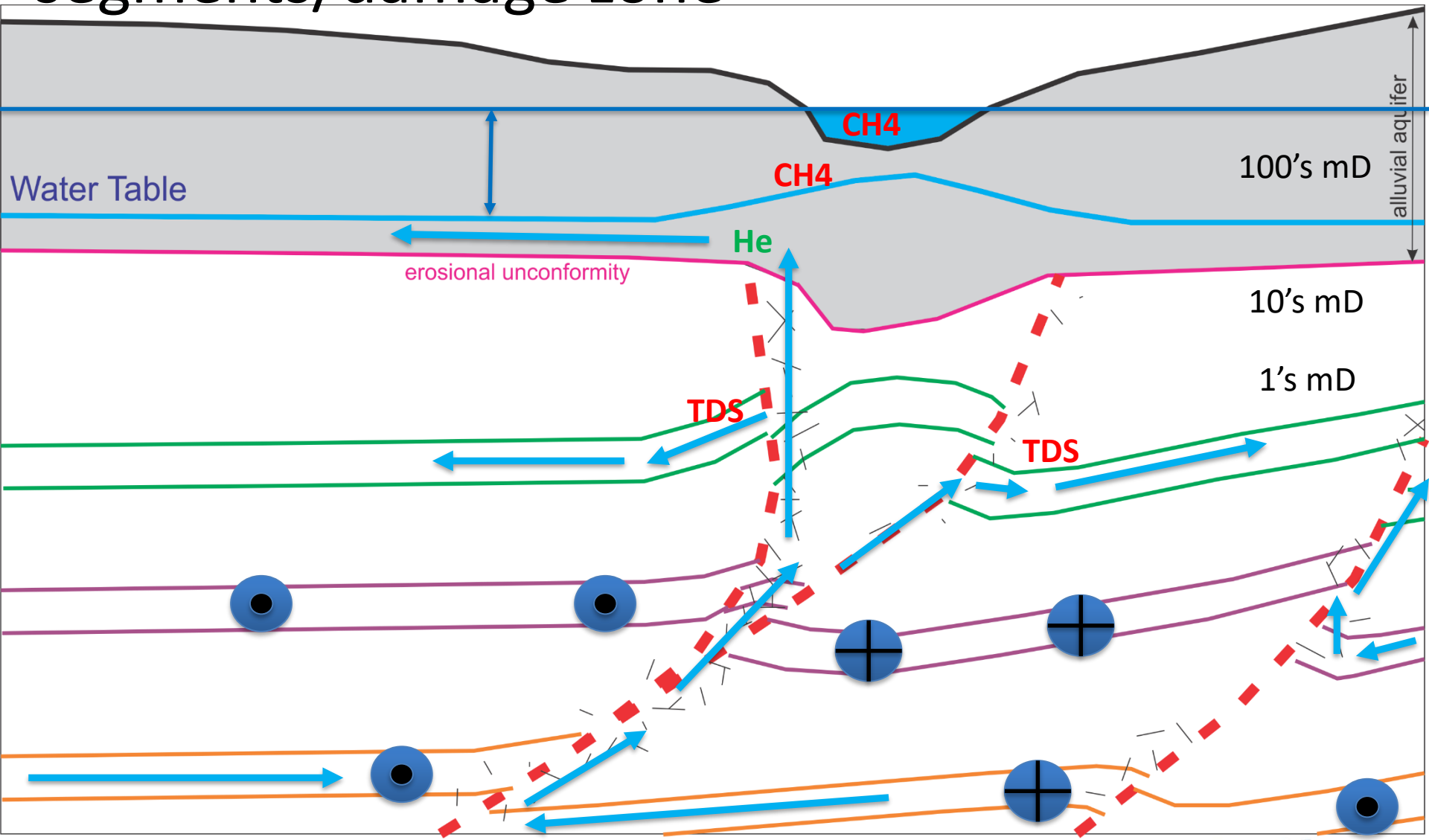
Upwards flow and discharge is reality checked with DEM

L1-6 salinity contour and hydraulic head reminder

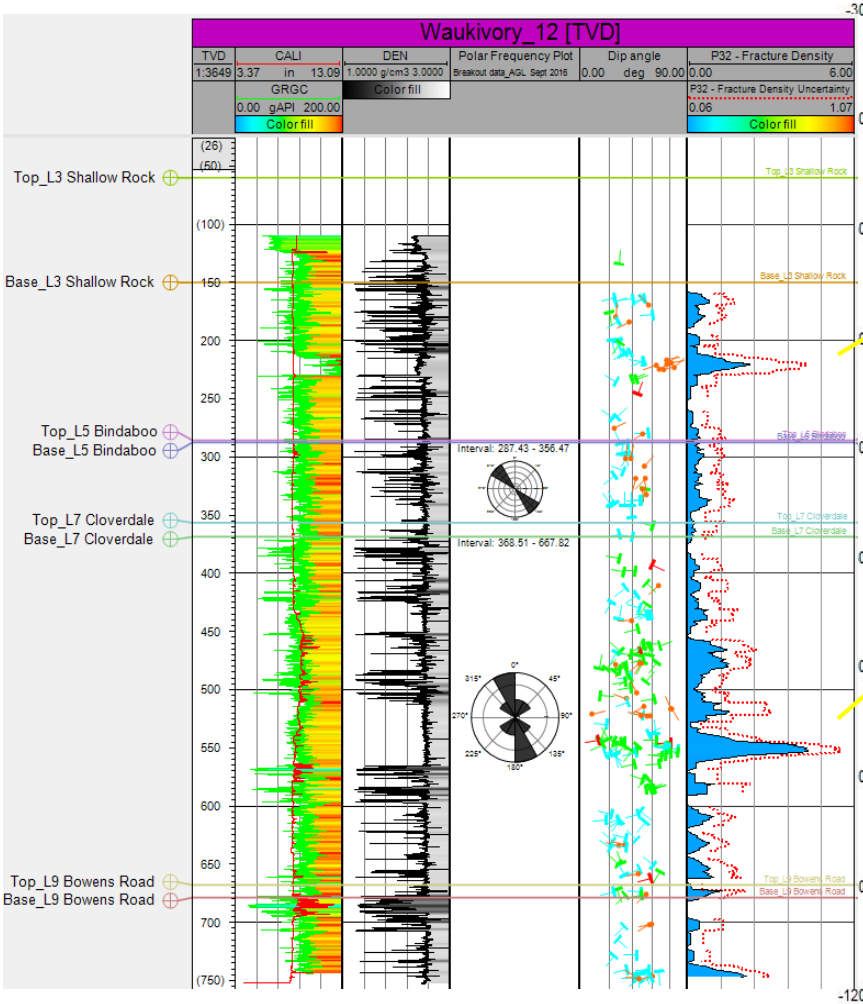


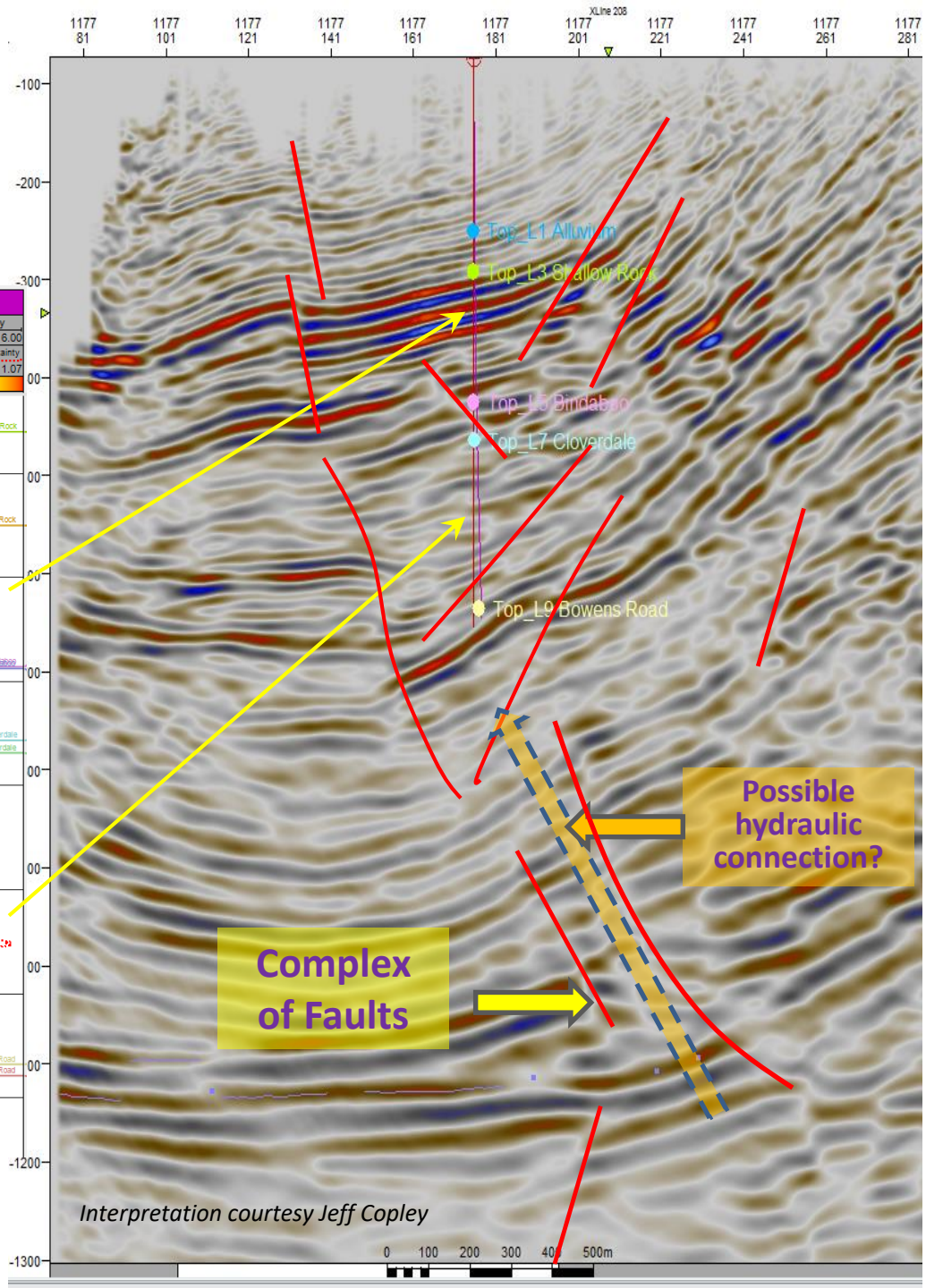
- Multivariate cluster analysis was not so informative
- Elevated salinity anomalies at shallow depth were most instructive

Conceptual Model: for certain dilatant fault segments/damage zone



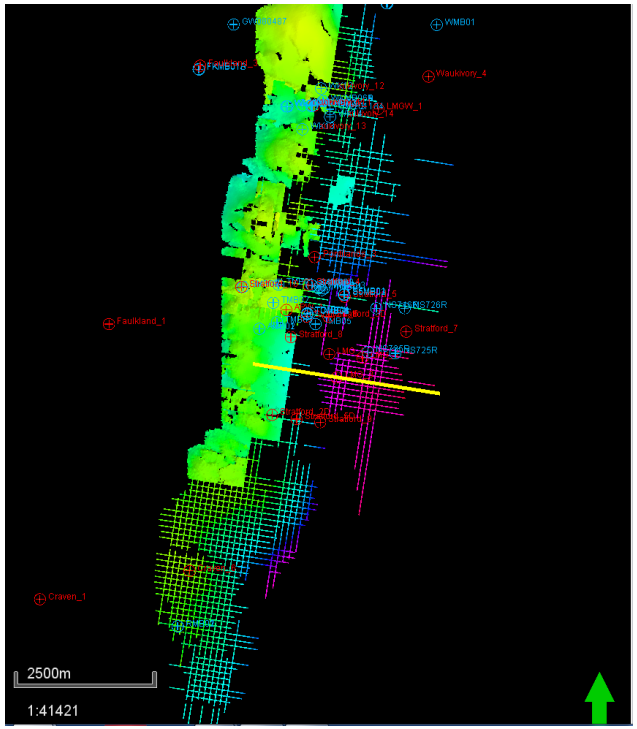
Waukivory 12 on Seismic Section

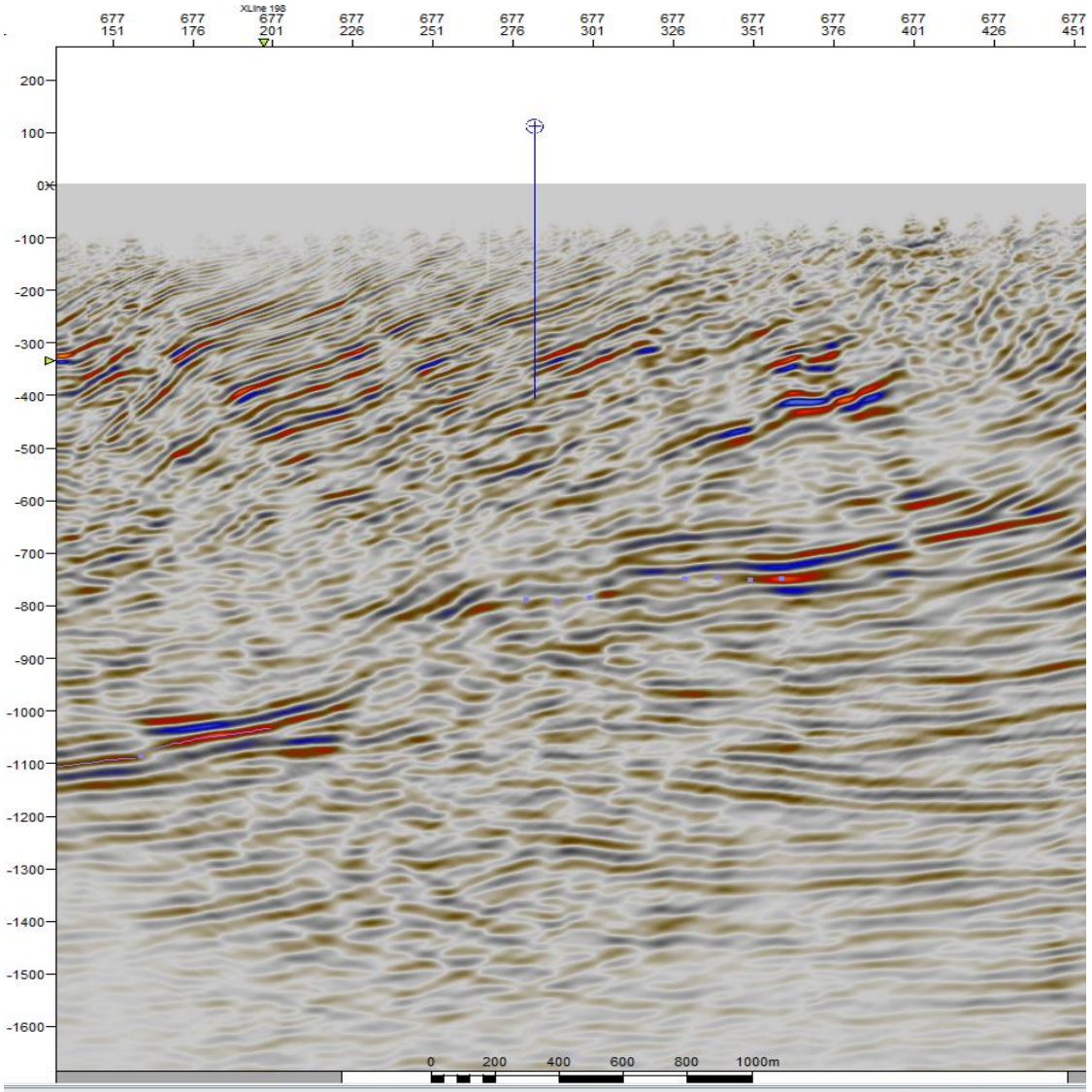




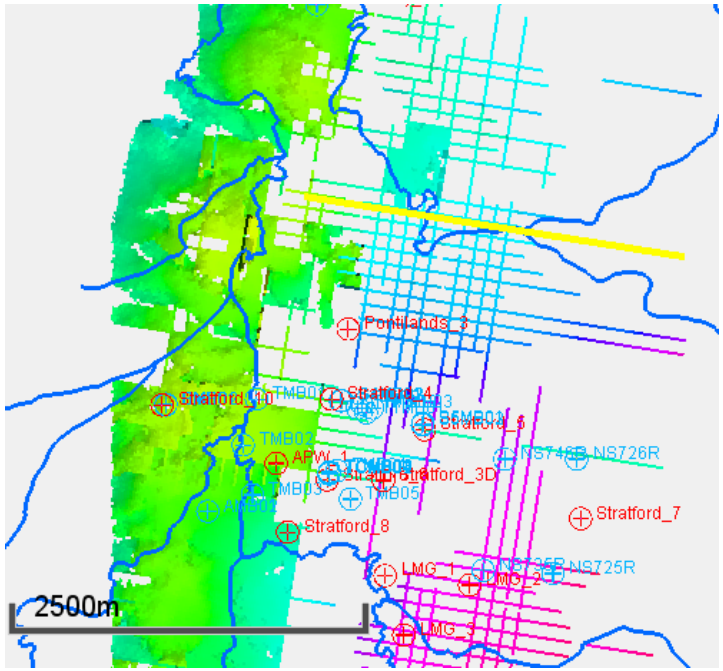
Seismic and well section showing structural complexity, in-situ stress and fracture character variation along depth

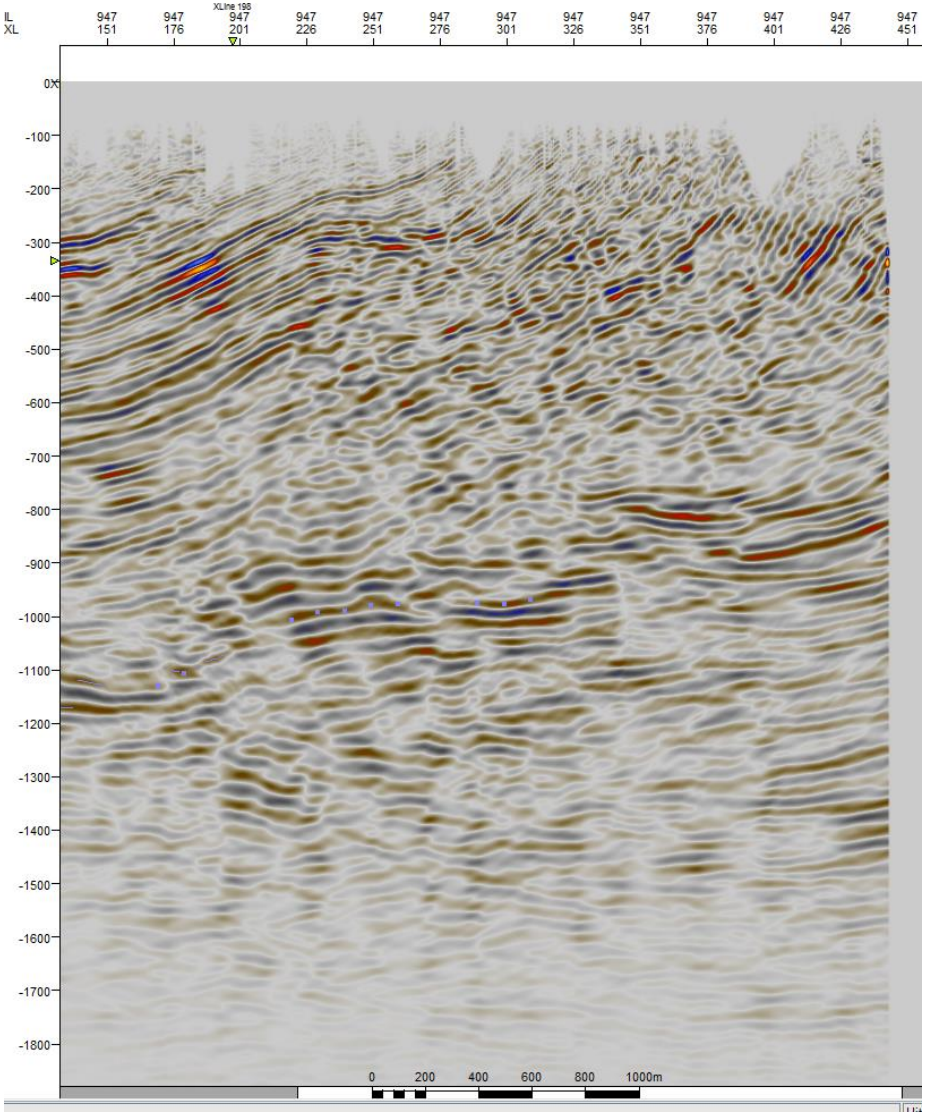
Region of sealing faults





Region of leaking faults





Takeaway messages

- Changes in water chemistry are subtle
- There is some indication that TDS can help characterise the flow systems near faults e.g. previous slide.
- Damage zone permeability appears to be key to up fault fluid flow in a block of 1 mD permeability rock volume
- Needs more detailed zooms for fault zone architecture at more key locations

Thank you

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