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Comparison of Mechanical and Fracture Stratigraphy between Failed Seal Analogues
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INTRODUCTION
The presence of discontinuities in seal lithologies affects their mechanical and hydro-geologic properties. We examine the mechanical and fracture stratigraphy of failed Paleozoic and Mesozoic seal analogues in south-east Utah to understand the nature and distribution of fluid flow pathways in various seal lithologies. Outcrop surveys provide data for comparison between each locality to identify relationships between depositional composition, diagenesis, and loading history. These data characterize the distribution and morphology of open mode fractures, with changes in lithology and provide input for accurate quantitative subsurface mechanical and fluid flow models.

METHODS

Outcrop
- Measured stratigraphic sections -- detailed rock descriptions, identification of lithologic changes including grain size, bed thickness, & mineralogy
- Strainmeter - measure stress distribution throughout the outcrop
- XRD (N-type Schmidt hammer) and permeability (TinyPermII).

Thinsection
- Petrography
- XRD

Burnout History & Stress Evolution
- Burial histories merged with simple Mohr-Coulomb
- Tensiometer

Burial History & Stress Evolution - burial histories merged with simple Mohr-Coulomb analysis to constrain stress, St, and Sf burnout models through time.

Mohr-Coulomb - stress changes & failure modeled through time where:

\[
\sigma = C + P \sin \phi + P \cos \phi \tan \phi
\]

Mohr-Coulomb analysis includes:
1. Increase of effective stress \( \Delta \sigma \) due to external loading (lithostatic overpressure)
2. Increase of effective stress \( \Delta \sigma \) due to tectonic stress
3. Increase of effective stress \( \Delta \sigma \) due to tectonic stress

Fracture Scanline
- Fracture scanlines
- Control scanlines

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OUTCROP OBSERVATIONS
- All localities show:
  - evidence for mineralization and fluid flow in the subsurface
  - mineralogic differences between host rock and fracture fill
  - meso-scale fault and fracture orientations which follow regional structural trends
  - fracture spacing <0.25-0.5 fractures/meter
  - fracture densities and morphology which vary with lithology and bed thickness

OUTCROP MECHANICAL STRATIGRAPHY: CARMEL FORMATION

Using a modified rock mass rating, we identified mechanical stratigraphic units.

Mechanical stratigraphic units have similar:
- bed thickness
- fracture density
- field-derived permeability
- field-derived compressive strength

INPUT DATA FOR GEOMECHANICAL MODELING
- Estimates of dynamic Young's modulus
- Field-based fracture density and compressive strength data
- Variability in elastic moduli will be used in future geomechanical modeling

CONCLUSIONS
Stratigraphic variability and resulting changes in mechanical properties influence the variability of fracture morphology and density over the cm to mscale.

Understanding fracture morphology in different seal types, across interfaces, and in various structural settings is key to understanding how seals respond to hydraulic failure.

Calculated variability in elastic moduli correlates to the mechano-stratigraphic variability observed in outcrop --- the variations in elastic moduli will be modeled to quantify their effects.

Overpressure during burial (lithostatic loading) can induce open-mode tensile failure that can effect future seal integrity: Are most seals fractured then re-cemented/re-sealed in some way?

REFERENCES

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