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Lamination Effects on Borehole Breakout, Laboratory Experiments on Mancos Shale

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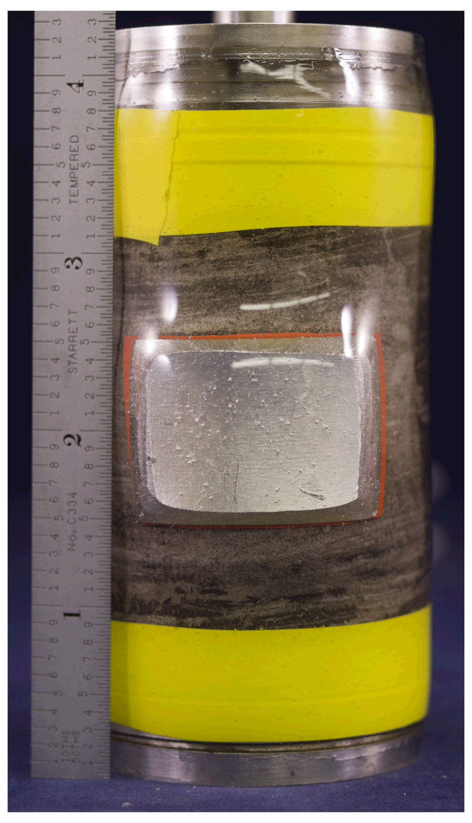
Introduction:

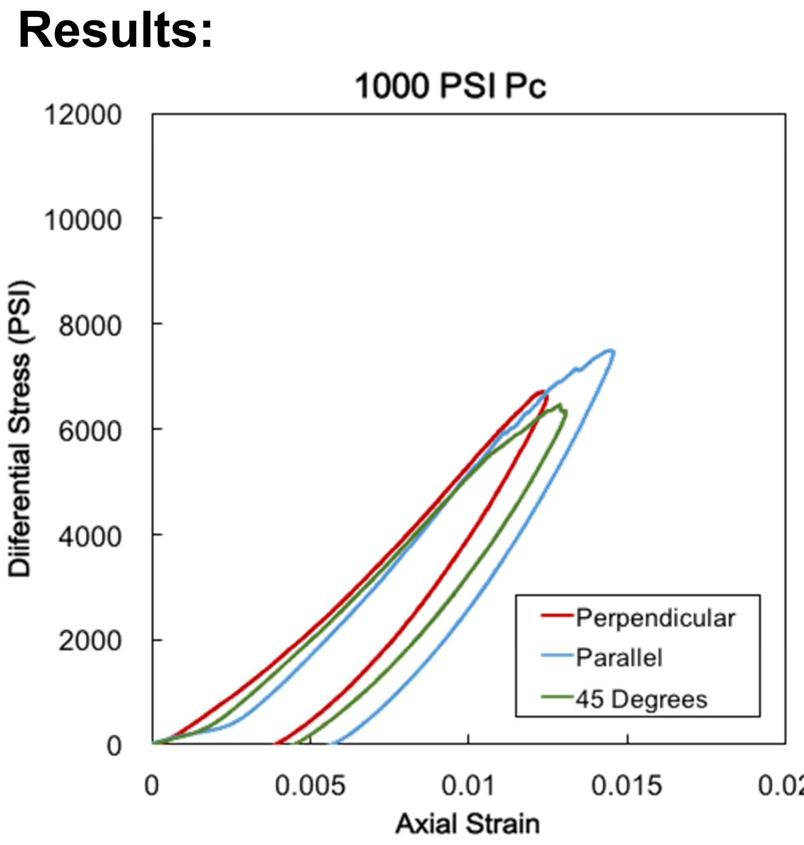
- Emplacement of wellbores and structures in the subsurface create stress concentrations that can trigger a variety of failure phenomena, potentially triggering instability and collapse.
- Borehole breakouts, dog eared fractures induced in wellbores, are a common tool in determining subsurface stress magnitudes and orientations.
  - Based on basic assumptions about rock failure, errors in stress calculations can be as high as 30-40% in complicated geologic terranes.
  - Shales increasingly important, lack of experimental data
- This study utilizes a novel experimental geometry to investigate the effect of bedding plane orientations on borehole breakout initiation.

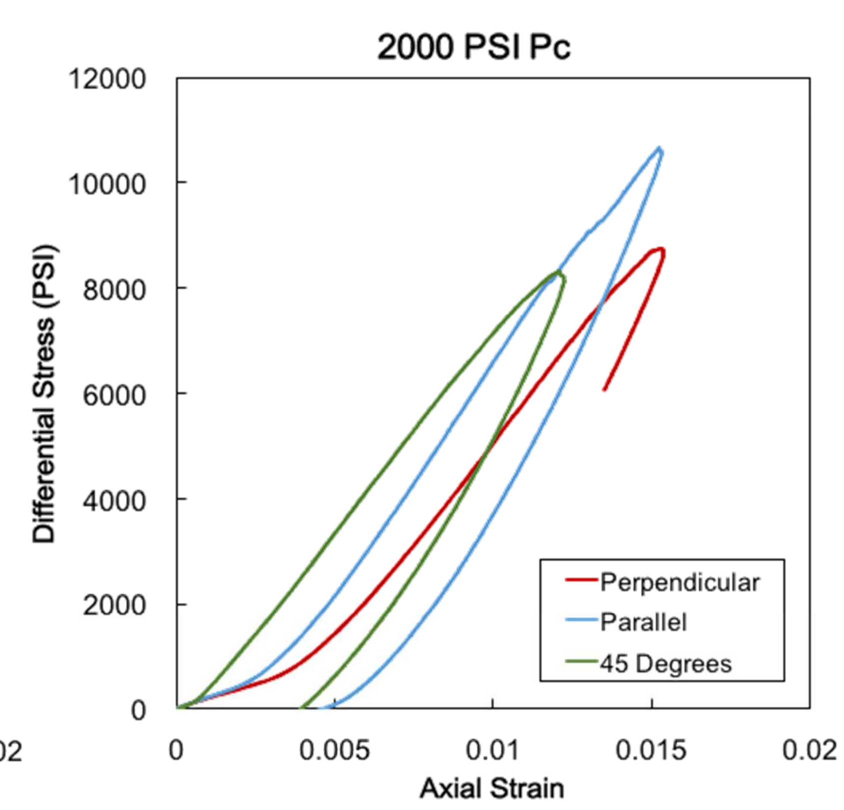


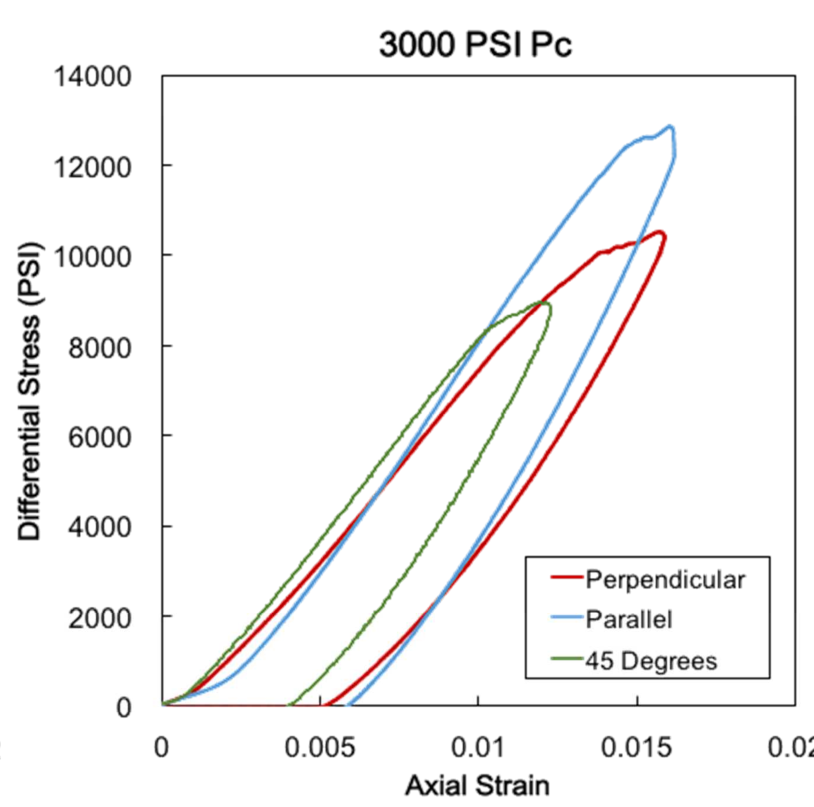
Methods:

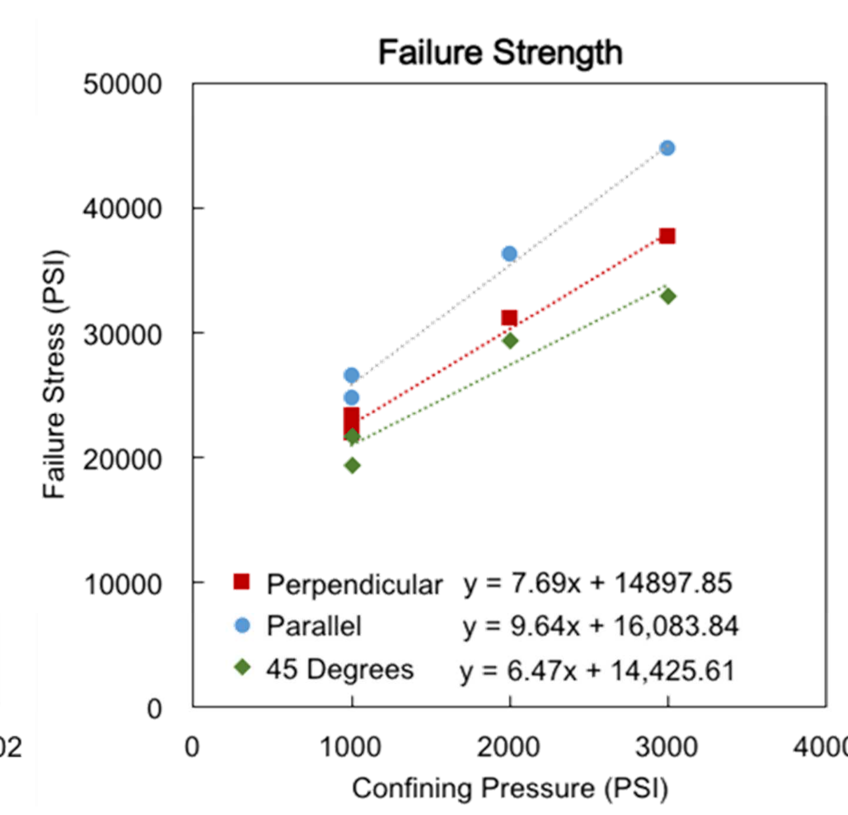
- Experiments were conducted on Mancos shale, a thinly laminated, transversely isotropic rock.
- Samples were 2” diameter, 3” long, and had three different bedding orientations to the axis: perpendicular, 45°, and parallel
- Following Kirsch’s hole in a plate problem, 0.445” hole simulated a borehole, an aluminum cover and UV epoxy isolated the sample from the confining medium
- Samples were deformed at 1000, 2000, and 3000 PSI confining pressure (Pc)
- Samples were axially compressed to induced failure.

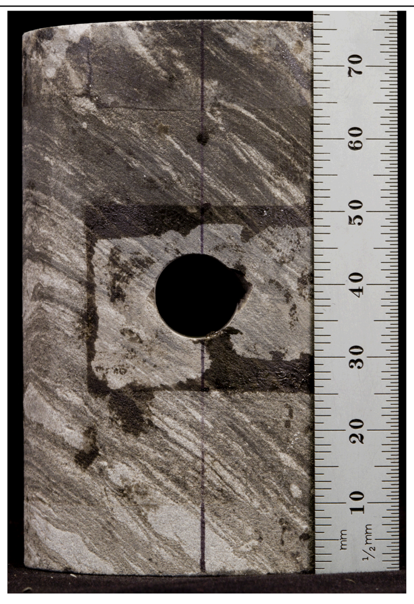
Results:

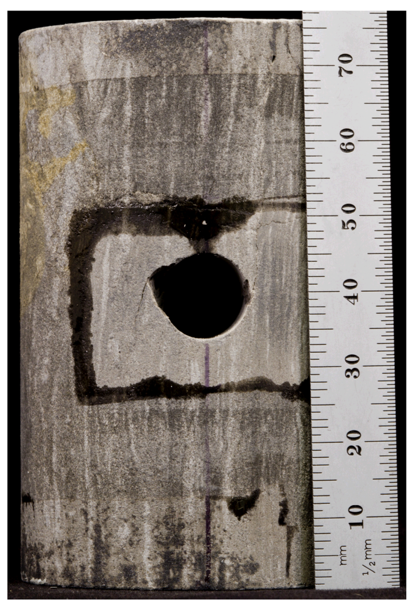












- Experimental geometry successfully recreated borehole breakout
  - First test of this geometry
  - Much simpler, more practical than previous experimental geometries
- Fractures evenly distributed along wellbore
  - Even stress distribution
- Visual observations indicate laminations affect fracture growth
- Clear differences in strength for the bedding orientations
  - Parallel strongest, then perpendicular, then 45 degrees
- Failure strength calculated using Kirsch equations
- Failure strength increases with increasing confining pressure
- Trend depends on bedding orientation
  - Parallel stiffest, followed by perpendicular, then 45 degrees

Applications:

- Borehole breakouts are commonly used for in situ stress determination, experiments presented here can help refine bedding effects
  - Geohazards assessment, induced versus natural seismicity
  - Completions planning for unconventional petroleum reservoirs
  - Subsurface engineering for storage and disposal projects
- Experimental geometry shows great potential as a tool to investigate a range of wellbore issues
  - Different load paths and stress states to investigate different failure mechanisms
  - Extend to include pore pressure, temperature for more realistic downhole conditions
  - Coupling with chemistry to address wellbore stability issues

Conclusions:

- Experimental geometry successfully recreated borehole breakout phenomena
- Difference in strength between different bedding orientations
- Failure strength increases with increasing confining pressure
- Fracture growth affected by laminations

Future Work:

- Microstructural investigations of near wellbore fractures using CT, thin sections
- Chemical effects using high salinity brines, wellbore stabilizers
- Pore pressure effects
- Strain rate effects, creep tests
- Extend experiments to different materials, granite

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NNSA National Nuclear Security Administration

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