FACTORS AFFECTING GROWTH OF STIMULATED RESERVOIR VOLUME IN KAYBOB AREA

MARCH 20, 2019

Erfan Sarvaramini
CONVENTIONAL HYDRAULIC FRACTURING AND FRAC CONTAINMENTS

- High lateral stress “blunts” vertical growth
- Fracture grows in the zone of lower $\sigma_{h\text{min}}$

Key!!

This is the “ideal” fracture, only attained when a higher stress gradient in the overburden blunts rise

Ref: http://geologycafe.com

Courtesy of Maurice Dusseault, University of Waterloo
HYDRAULIC FRACTURING IN ORGANIC RICH FORMATIONS

Ref: http://geologycafe.com

Courtesy of Maurice Dusseault, University of Waterloo
MOTIVATION: AFFECTS OF GEOMECHANICAL HETEROGENEITY ON THE FRACTURE HEIGHT

Ref: Walter et al., Alberta Energy Regulator

Ref: T Dong et al. 2018
### MODEL-SET UP

<table>
<thead>
<tr>
<th>Formation</th>
<th>Young's Modulus (GPa)</th>
<th>Poisson's Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireton</td>
<td>E = 27.5</td>
<td>v = 0.28</td>
</tr>
<tr>
<td>U Duvernay</td>
<td>E = 42</td>
<td>v = 0.18</td>
</tr>
<tr>
<td>M Duvernay</td>
<td>E = 55</td>
<td>v = 0.25</td>
</tr>
<tr>
<td>L Duvernay</td>
<td>E = 42</td>
<td>v = 0.18</td>
</tr>
<tr>
<td>Majeau Lake</td>
<td>E = 27.5</td>
<td>v = 0.28</td>
</tr>
<tr>
<td>BHLK</td>
<td>E = 55</td>
<td>v = 0.23</td>
</tr>
</tbody>
</table>

### GEOMECHANICS

![Graph showing Young's Modulus and Poisson's Ratio](image-url)

Ref: T Dong et al. 2018
MODEL SET-UP (STRIKE-SLIP FAULTING REGIME)

\[ \sigma_v = 85 \text{MPa} \]

\[ \sigma_{\text{Min}} = 70 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]

Domain = 500m \( \times \) 250m \( \times \) 500m

Ireton (high clay content)

U Duv

M Duv

T Duv

MJLK

BHLK

Pressure and rate data (per one stage and one frac)
FORMULATION AND APPROACH

- SRV is represented by poro-elasto-plasto-damage continuum zone of enhanced permeability
- Details at the discrete level are translated to
  1. Degradation of rock cohesion and material stiffness
  2. Energy dissipation is controlled by characteristic length scales
  3. Permeability evolves as function of damage
SRV Evolution (volumetric strain)

\[ \sigma_V = 85 \text{MPa} \]

\[ \sigma_{Max} = 120 \text{MPa} \]
Ireton (high clay content)

SRV rise

SRV is breaking through Duv. carbonate unit

$\sigma_y = 85\text{MPa}$

$\sigma_{\text{Max}} = 120\text{MPa}$
SRV Evolution (volumetric strain)

\( \sigma_v = 85 \text{MPa} \)

Ireton is initially a seal

\( \sigma_{\text{Max}} = 120 \text{MPa} \)
SRV Evolution (volumetric strain)

\[ \sigma_y = 85 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]

Seal is partially breached
SRV Evolution (volumetric strain)

\[ \sigma_y = 85 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]

Ireton (high clay content)
SRV Evolution (volumetric strain)

\[ \sigma_V = 85 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]
SRV Evolution (volumetric strain)

\[ \sigma_y = 85 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]

Ireton (high clay content)
Ireton (high clay content)

\[ \sigma_y = 85 \text{MPa} \]

\[ \sigma_{\text{Max}} = 120 \text{MPa} \]
NON-UNIFORM STRESS EFFECTS

Depth

<table>
<thead>
<tr>
<th>Depth</th>
<th>Stress</th>
<th>Minimum Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>41 m</td>
<td></td>
<td>70 MPa</td>
</tr>
<tr>
<td>6 m</td>
<td></td>
<td>68 MPa</td>
</tr>
<tr>
<td>6 m</td>
<td></td>
<td>70 MPa</td>
</tr>
<tr>
<td>10 m</td>
<td></td>
<td>68 MPa</td>
</tr>
<tr>
<td>10 m</td>
<td></td>
<td>80 MPa</td>
</tr>
</tbody>
</table>

$\sigma_{\text{Min}} = 80 \text{ MPa}$
Ireton (high clay content)

U Duv
M Duv
L Duv
MJLK
BHLK

SRV Evolution

Stress

Ireton

U Duv
M Duv
L Duv
Majeau Lake
BHLK

\( q \)
SRV Evolution
SUMMARY

• Geomechanical heterogeneities affect the SRV shape and conductivity

• Stiffness and Poisson’s ratio are not alone sufficient for fracture containments

• Stress has overriding impact on the SRV containment and out-of-zone growth
THANK YOU

Contact: esarvaramini@gljpc.com
Phone: (403)-266-9431