GreenFire-LLNL Small Business Vouchers Pilot

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Methods

LLNL has developed a range of methods for predicting dynamic loading of rocks and soils. Applications include defense and energy:
- Containment of underground explosions
- Effects on underground structures
- Stimulation of geological resources
- Geothermal
- Petroleum

Material models for hot granite have been calibrated against experimental data (Morris et al., 2017).

Results of Dynamic Stimulation Models

First series of stimulation scenarios using the calibrated “hot granite” material model considered:
- Single well
- Influence of stress and temperature

A second series of stimulation scenarios addressed the interaction of two charges in neighboring wells:
- Spacing varied from 6 m to 16 m
- Stress state:
  \[\sigma_{xx} = 100 \text{ MPa}\]
  \[\sigma_{yy} = 120 \text{ MPa}\]
  \[\sigma_{zz} = 80 \text{ MPa}\]
- Temperature of 400°C

The final series of models considered the influence of inclination upon well-to-well interactions:
- Stress state:
  \[\sigma_{xx} = 100 \text{ MPa}\]
  \[\sigma_{yy} = 120 \text{ MPa}\]
  \[\sigma_{zz} = 80 \text{ MPa}\]
- Temperature of 400°C
- HF tops separated by 16 m

Summary and Conclusions

Parametric studies using a calibrated material model for hot granite demonstrated that:
- Brittle fracturing is possible even at high pressure and temperature
- Wellbores separated by 10 m or less are likely to be connected by a brittle-fractured zone
- It is preferred to have the wells within 6 m separation for some portion of their length

A mapping from porosity to permeability was developed using data from the literature:
\[k = 5 \times 10^{-15}(\phi_{w} + 0.65)\text{m}^2\]

Stimulated permeability increase is several orders of magnitude:
- We observe a region between the wells with ~10^2 Darcy
- This is unlikely to be sufficient permeability to sustain flow

In reality deformation will likely localize into a number of individual cracks:
- This process is very sensitive to the heterogeneity and any preexisting flaws
- In this instance the flow rate will be much higher

We conclude that the successful connection of the two wells will likely require one of two scenarios:
1) higher initial permeability of the formation, or
2) localization of the rock deformation upon individual fractures

Both mechanisms are sensitive to the geological setting

References


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