Geothermal Well Logging Opportunities & Challenges

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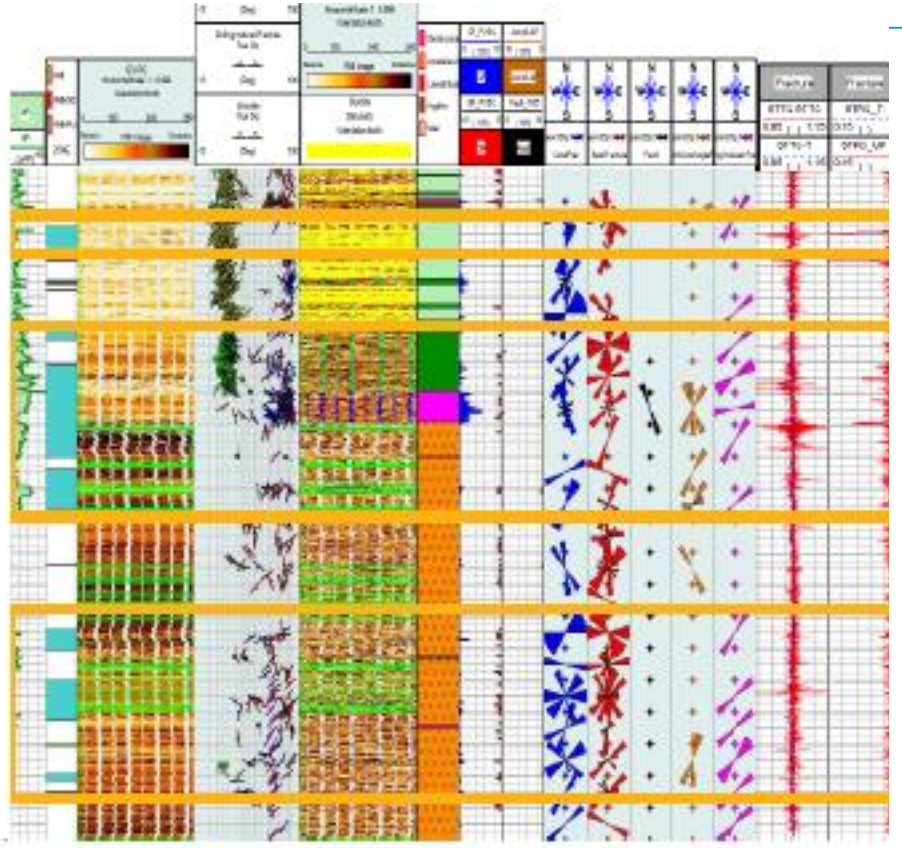

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Topics

- Objectives
- Geothermal environments
- Opportunities
- Limitations & challenges

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Objectives

Geothermal exploration and development are fundamentally a search for subsurface **temperature** and **permeability**, adequate to support **productive wells** for heat-energy extraction

- Temperature can be “mapped” adequately with the limited surface and subsurface data that are typically available
- **Permeability has proved much more difficult to “map” and predict**
  - Useful new developments in logging & analysis techniques are likely to be aimed at understanding and mapping permeability (directly or indirectly)

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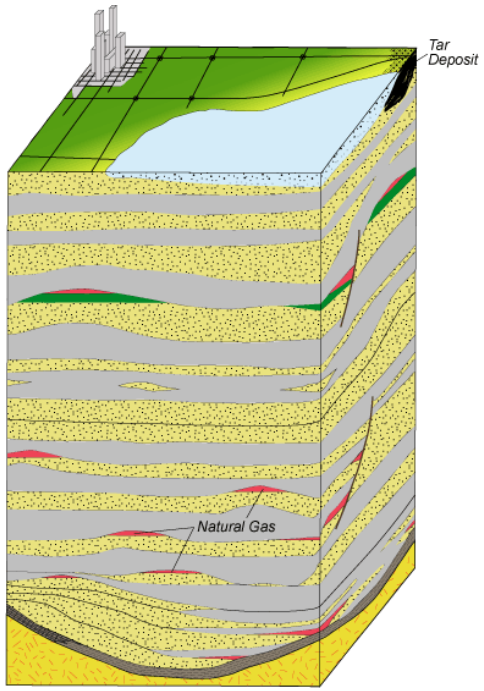
Geothermal Environments

Sedimentary Basin



Extensional (Basin & Range)

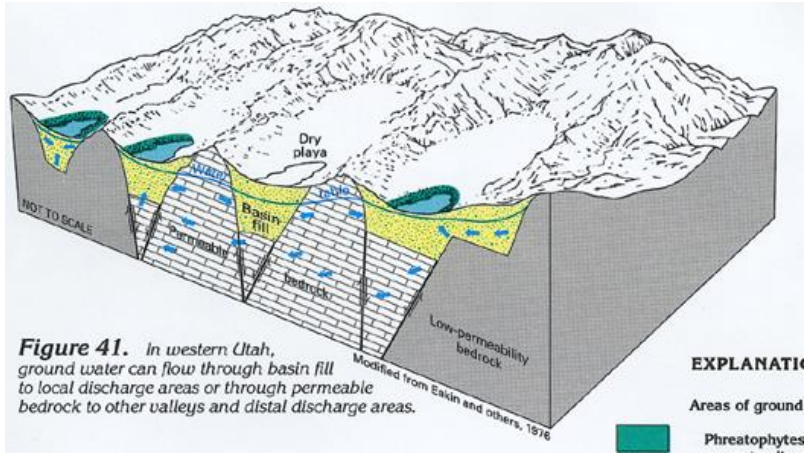
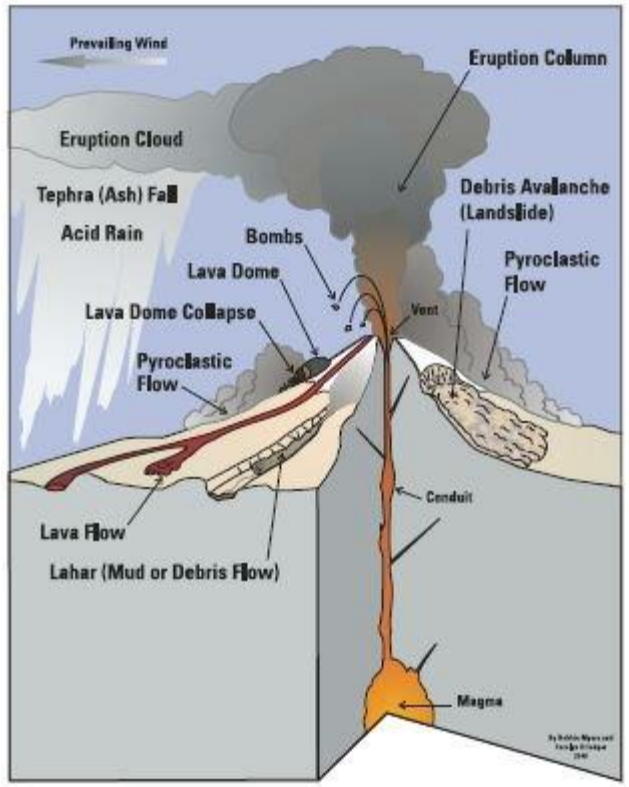


Figure 41. In western Utah, ground water can flow through basin fill to local discharge areas or through permeable bedrock to other valleys and distal discharge areas.

Volcanic



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Geothermal Environments

- Higher-temperature geothermal systems are likely to be in environments that are more:
  - Structurally and lithologically complex
  - Dominated by fracture permeability
  - Changed by hydrothermal activity

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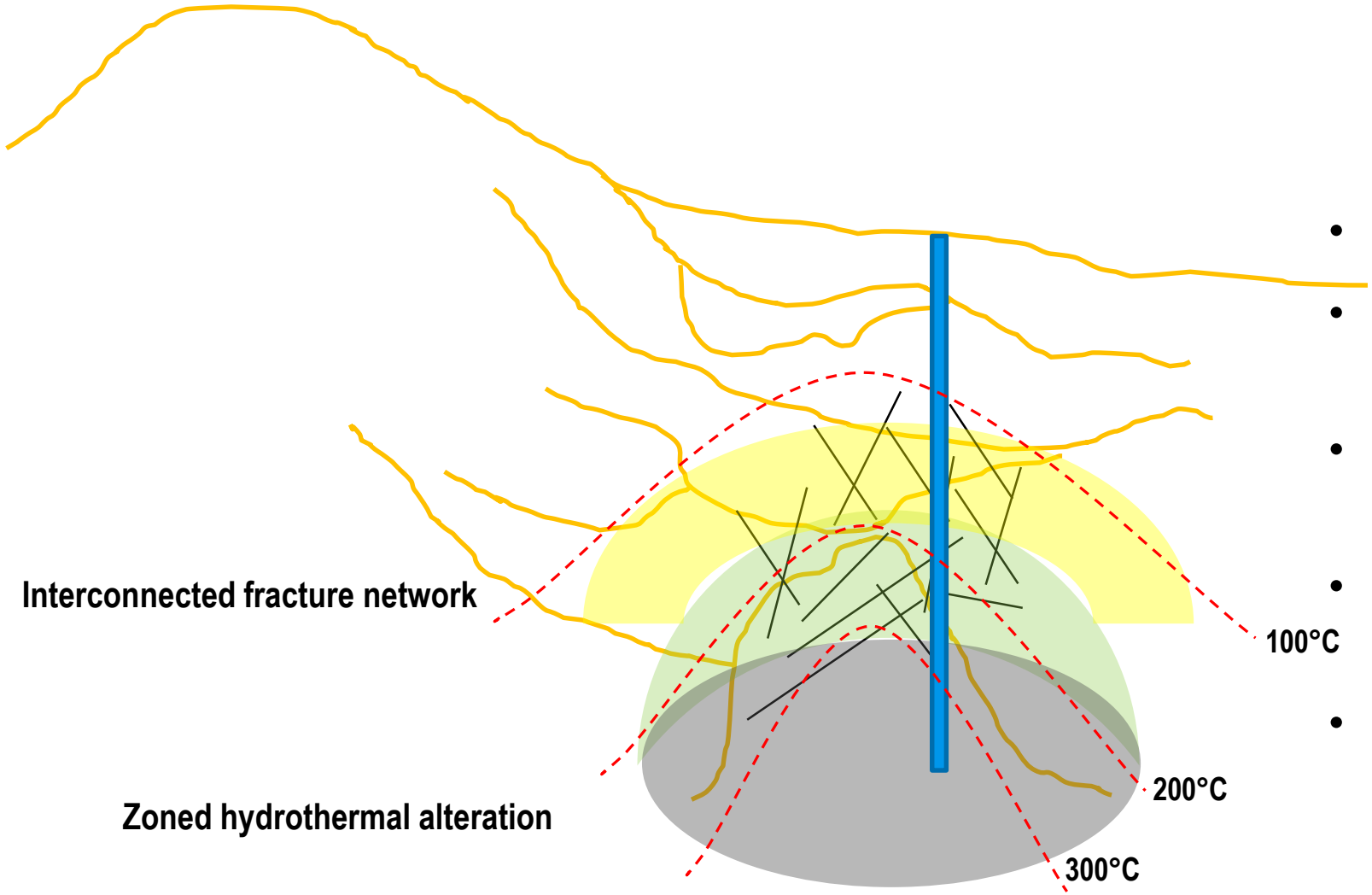
Volcanic Environments



- Young, dynamic environment
- Discontinuous and irregular rock units (lavas, pyroclastics, debris flows)
- Complex (tectonic + volcanic) stresses & structures
- Few or no reliable indicators of structural deformation
- Hydrothermal alteration changing original rock properties

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Volcanic Environments

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Opportunities

- Logging to better characterize lithologies and fracture conditions
- Objective characterization of stratigraphy for correlation
- Better integration of downhole data with surface data (electromagnetic, passive seismic; active seismic in sedimentary environments)
- Assessment and prediction of fracture permeability at reservoir scale (improved well placement strategy)
- Reservoir “mapping” by means other than delineation drilling

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Limitations & Challenges

- High temperatures (often >250°C) in zones of greatest interest
  - *Logging-while-drilling tools might be effective in avoiding high-temperature problems*
- Unstable wellbore conditions in reservoir zone
- Data sets are small (often just a few wells)
- Lack of detailed “map” of rock properties
  - *Conventional geomechanical analysis is difficult, if possible at all*
- Uncertainty in projecting conditions away from wellbore
  - *Can more sophisticated logging data be used to characterize and predict permeability over greater volumes, away from the wellbore?*

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Challenges

- Developing case histories with demonstrably better commercial results than would have been achieved if the technique had not been applied

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