Geothermal Well Drilling, the differences between Geothermal Drilling and Oil and Gas Drilling. The challenges of drilling and producing hot, volcanic resources from fractured formations.

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Different types of Geothermal Resources

Resource Type

- Liquid-dominated.
- Vapor-dominated
- Geopressed - Geothermal
- Engineered Geothermal System (EGS)
Field and Lithology Information
Differences between Oil/Gas and Geothermal Drilling

- Temperature
- Hard-Rock Formations
- Large Wellbore
- Low Reservoir Pressure
- Completion Methods
Temperature

- Normal Geothermal Gradient is 1° to 1.5° per 100’. Geothermal Gradient can be as high as 10° per 100’
- Reservoir Temperatures can be as low as 280° to 300° F to as high as 700° F plus.
- Changes will have to be made to all conventional drilling tools, materials and equipment to withstand temperature in the Reservoir.
Temperature

- Mud coolers
- High temperature electronics
- High temperature cements
- High temperature mud additives
Mud Coolers

• Needed to keep fluid cool to maintain mud properties.
  – Wall Cake
  – Gel Yield
  – Carrying Capacity

• High Temperatures can damage electronic drilling tools.

• Mud must be changed out prior to entering the productive reservoir.
High Temperature Electronics

- Directional tools are very temperature sensitive
- Wireline electronic logging tools are also very temperature sensitive
- Bit program design must take temperature and circulating media into consideration
High Temperature Cement and Cementing Procedures

- Cements will need to be retarded to withstand reservoir conditions.
- Unlike Oil and Gas wells, casing in Geothermal wells need to be cemented across entire length.
- Uncemented voids in casing annuli will result in casing failures (One of the primary important factor of a good geothermal well is a good cement job on all casing strings).
High Temperature Mud Additives

- Gel (Bentonite) Muds can cause formation damage in production sections.
- High temperature polymers are needed to clean the hole and stabilize the wellbore.
- Air or Aerated Fluids can be used due to low pressure formations.
- Air / Aerated Drilling can cause hole integrity problems.
Hard Rock Formation

- Volcanic hard rock may exist from spud to total depth.
- Permeability exists primarily in fracture systems.
- Fractures may exist throughout the entire wellbore.
- Lost Circulation due to fractures and low reservoir pressures is very common.
- PDC bits do not perform well due to air/aerated drilling, fractures and increased temperatures.
- Lost circulation zones make casing cementing difficult.
Large Diameter Well Completions

• Production rates are directly proportional to the diameter of the well
• Large diameter “hard-rock” bits are expensive and drill slow due to available weight on bit.
• Large diameter casing and hole sizes require large amounts of cement and the placement methods become critical
Low Reservoir Pressures

- High potential of loss circulation in drilling and cementing.
- Low pressure may require the wells to be pumped requiring large diameter down-hole pumps, therefore large diameter wells.
- Drilling media, mud, air or aerated water or mist must be used to penetrate reservoir.
Completion Methods

• Many geothermal wells are completed open hole and resource is produced through casing.
• Slotted or Perforated casing is utilized to filter large formation debris from entering flow stream.
• Wellhead completion are large diameter master valve through which the well was drilled
Major problems in Drilling Geothermal Wells

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- Hard-Rock Formations
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- Completion Methods