

Geothermal Energy

Why do we need it?
Where do we get it?

Ashley Johnson

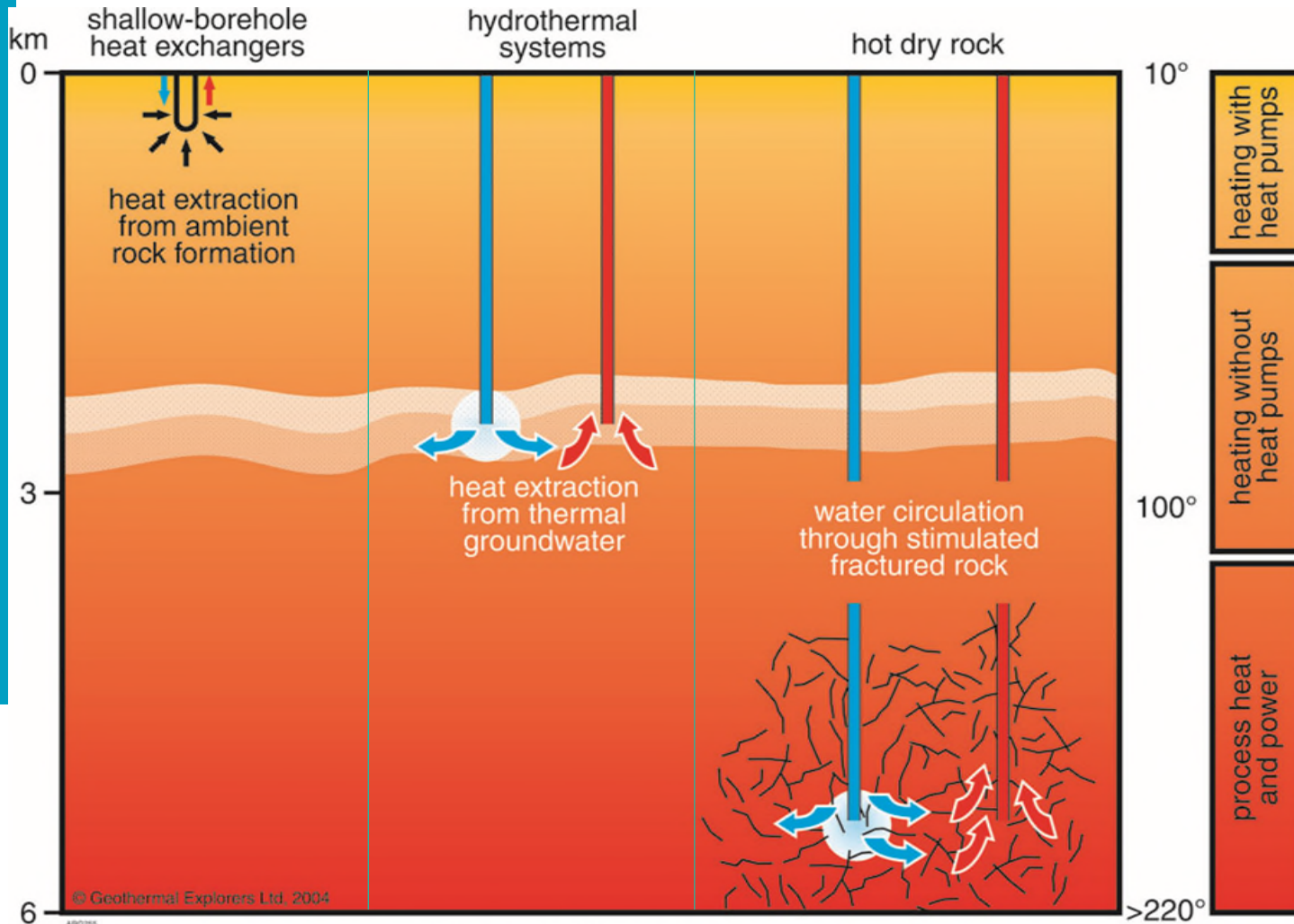
Geothermal Energy

- ❑ What is Geothermal Sourced Energy?
- ❑ Why Geothermal Power
- ❑ Drilling for Geothermal Power
- ❑ Research Challenges
 - ❑ Elastomers
 - ❑ Bits and Materials
- ❑ Conclusion



Geothermal sources and applications

Shallow Sources Intermediate Sources Deep Sources



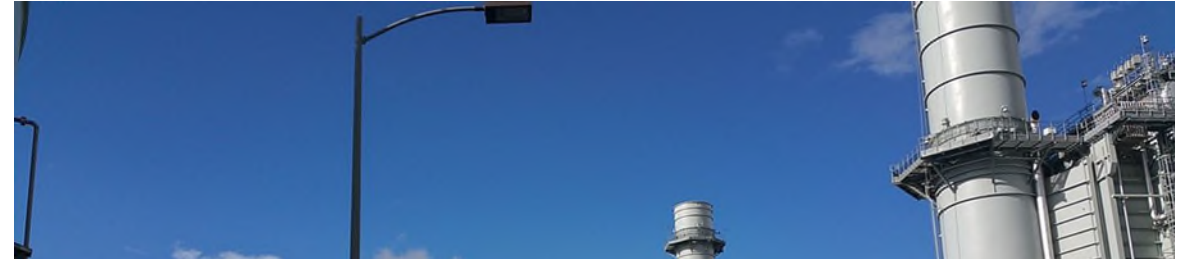
Type of geothermal resources from Earth's heat, (courtesy of Geothermal Explorers Ltd).

Application	Product
District heating, closed/open loop Vertical borehole arrays or aquifer – seasonal thermal storage Solar influx or active recharge	Hot fluid <50 degC
Direct heating -domestic, industrial Low grade heat Produced water, abandoned wells	Hot fluid <100 degC Soluble minerals
Power generation -Direct steam -Binary cycle	Electricity Soluble minerals

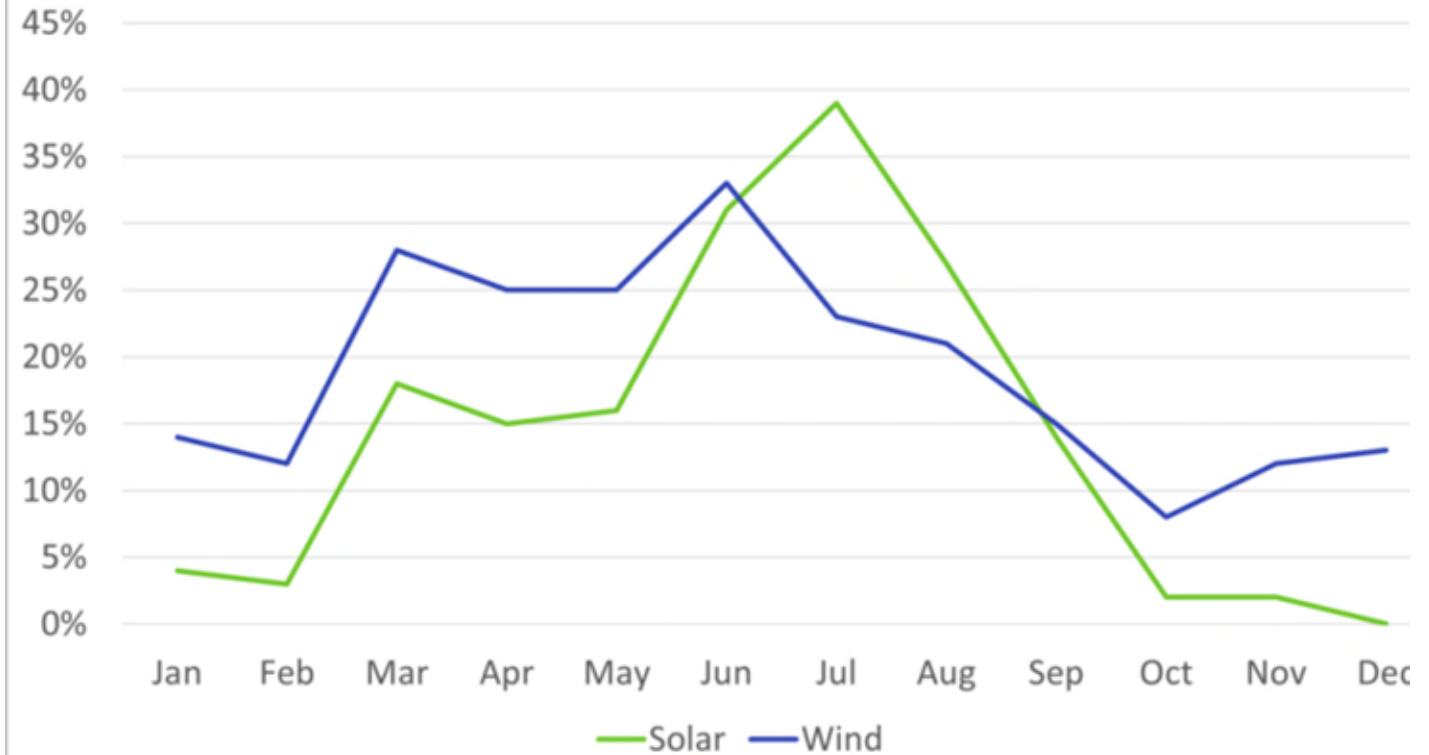


Why Geothermal Power

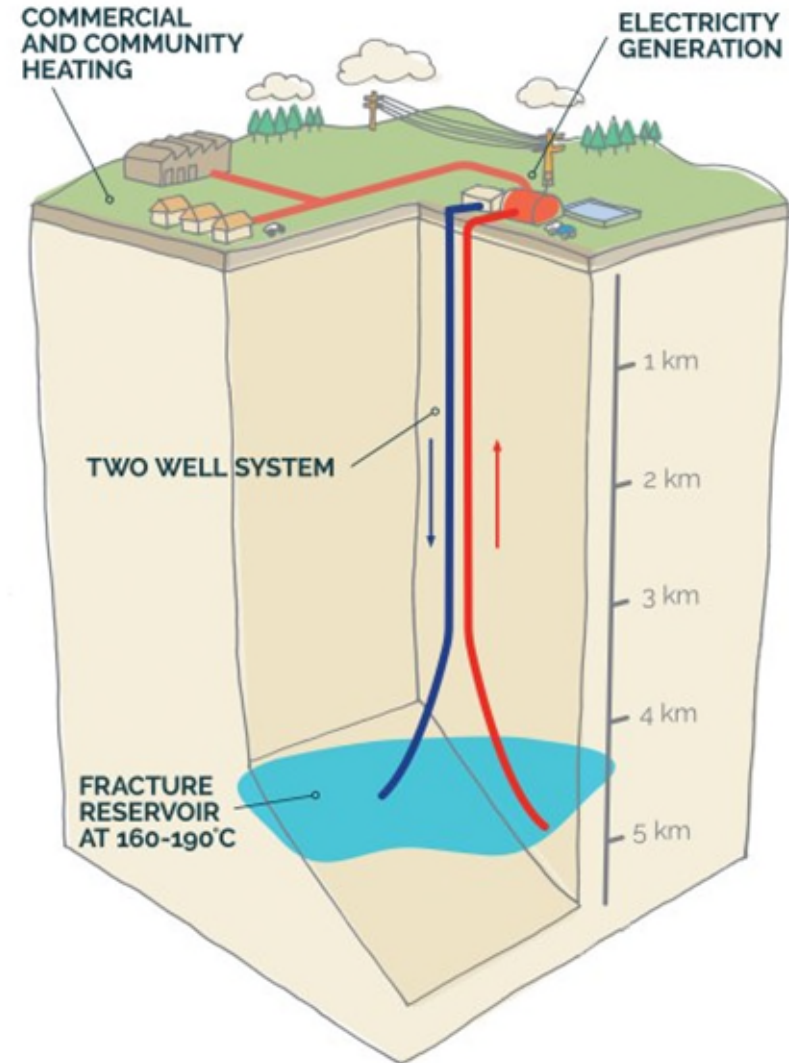
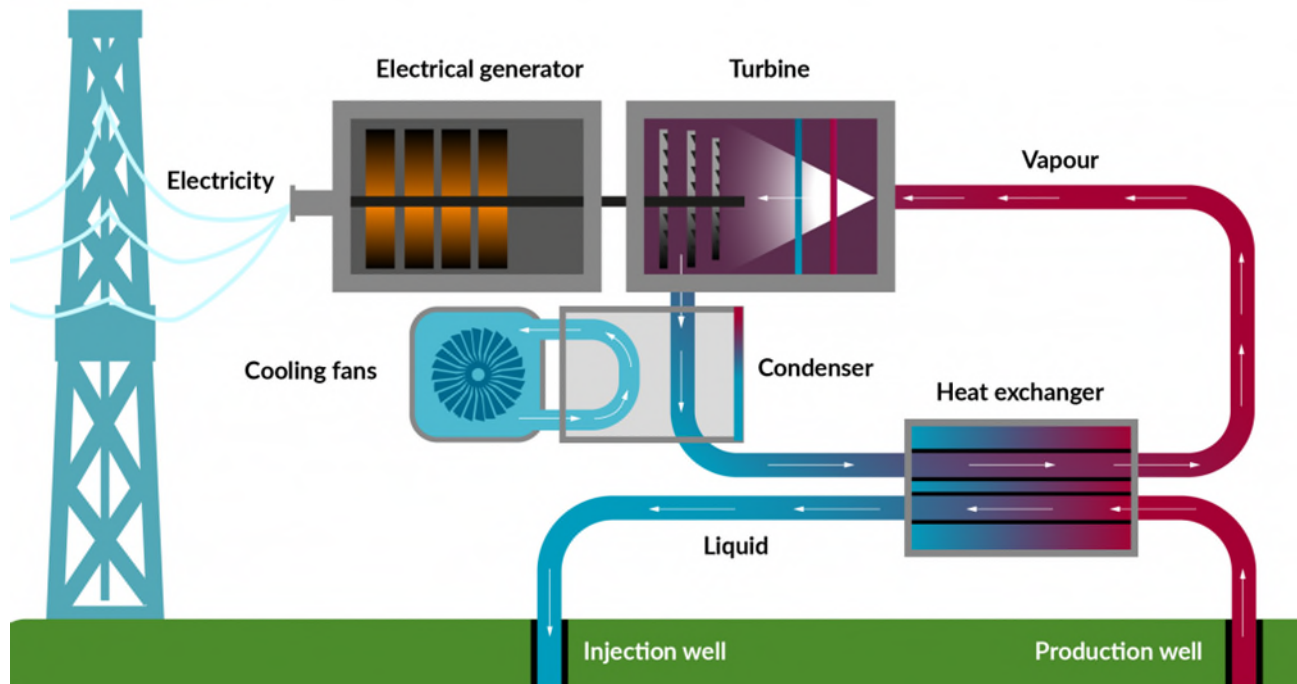
- ❑ Renewable Energy vs Reactive Power
- ❑ Inland Empire Energy Centre - Closure
- ❑ Effective Load Carrying Capacity
- ❑ Durable Base Load
 - ❑ Critical for Grid Stability



ELCC of Solar and Wind by Month

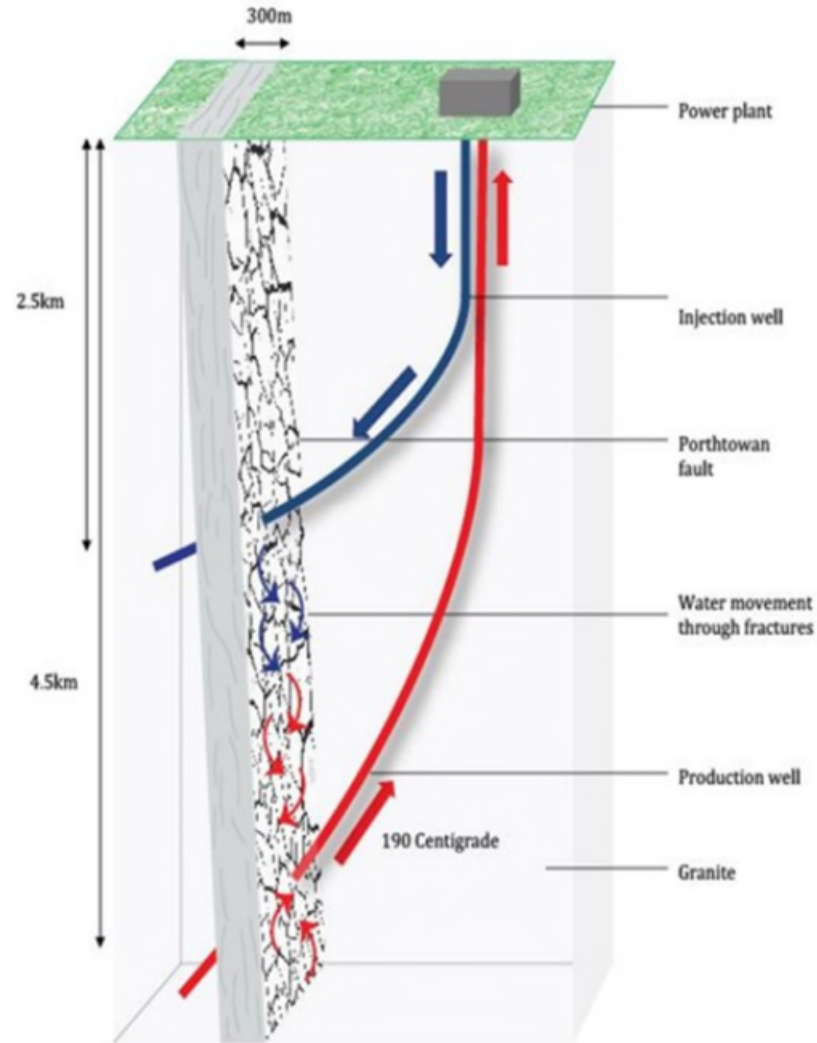


Geothermal Power – Heat to Electricity



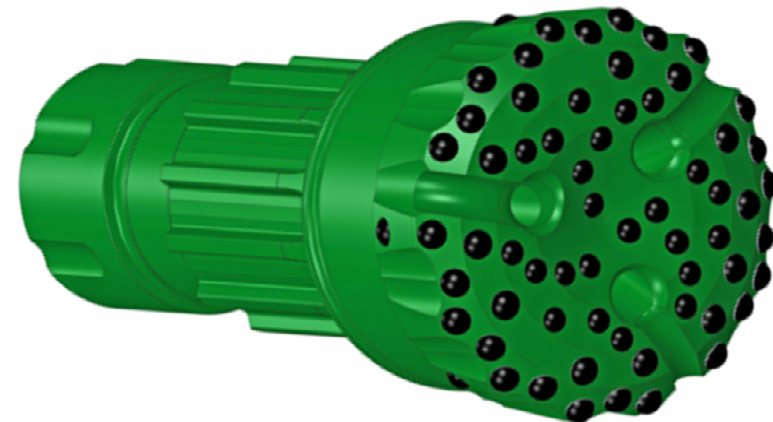
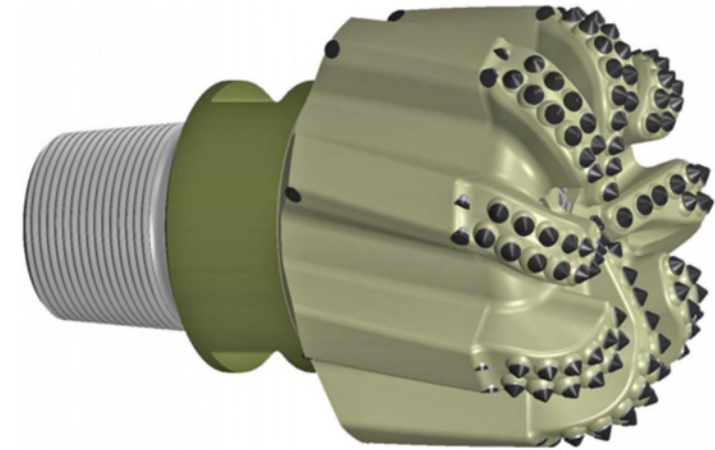
Conductive Lode

- ❑ Identify the Conductive Path
 - ❑ Penetrate the Lode
 - ❑ Granite – Challenging drilling
 - ❑ Drill to Target
 - ❑ Break Rock (not tools)
 - ❑ Deliver Power
 - ❑ Steered Hole
 - ❑ Map Permeability
 - ❑ Characterise formation
 - ❑ Temperature 220 °C

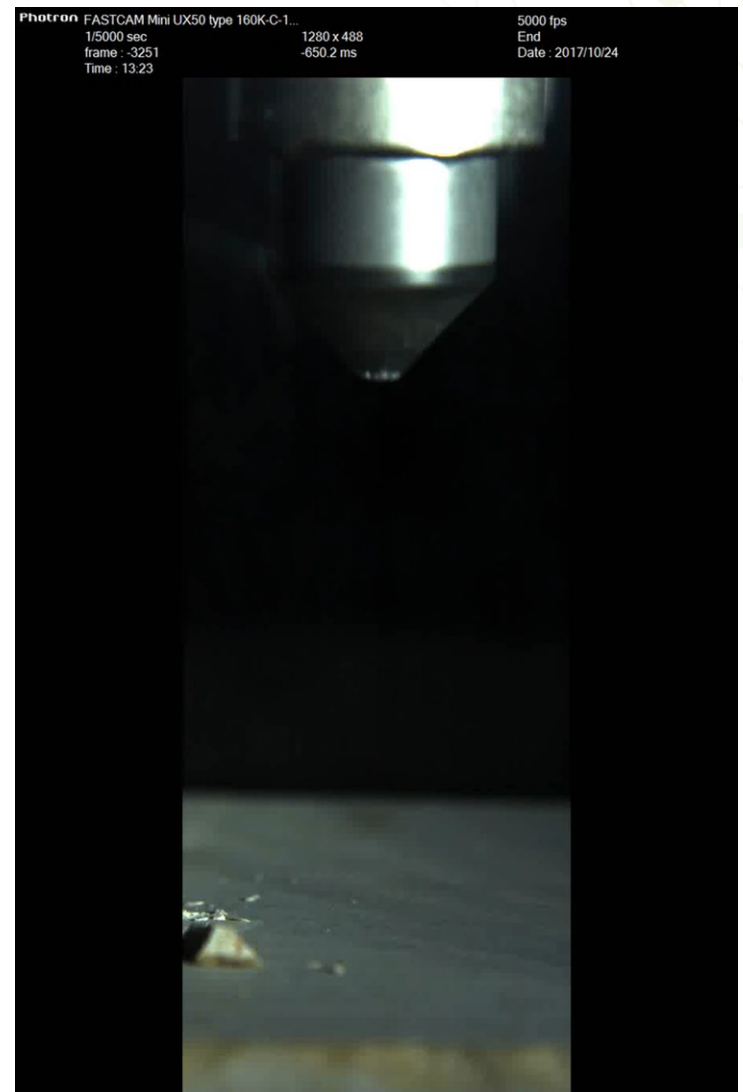
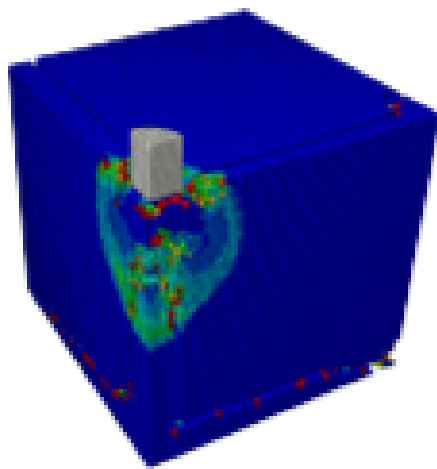
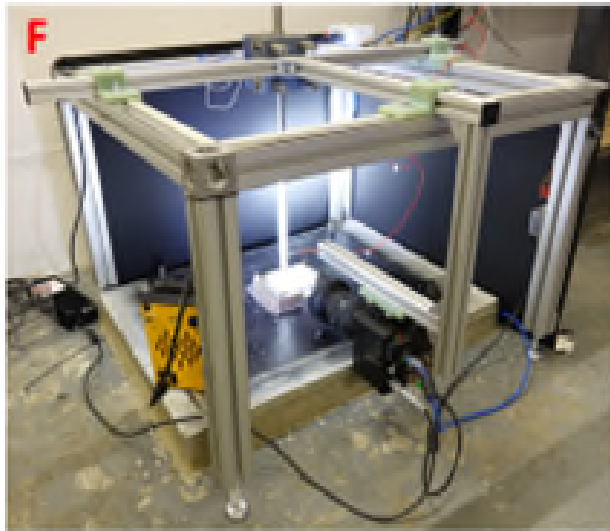


Drilling – Cutting Rock

- Shear Cutter Cutting
 - Unconventional Shale – 150 m/hr, 5 km
 - Granite 1 m/hr, 20 m
- Impact Hammer Drilling
 - Efficiency
 - Failure Mechanism

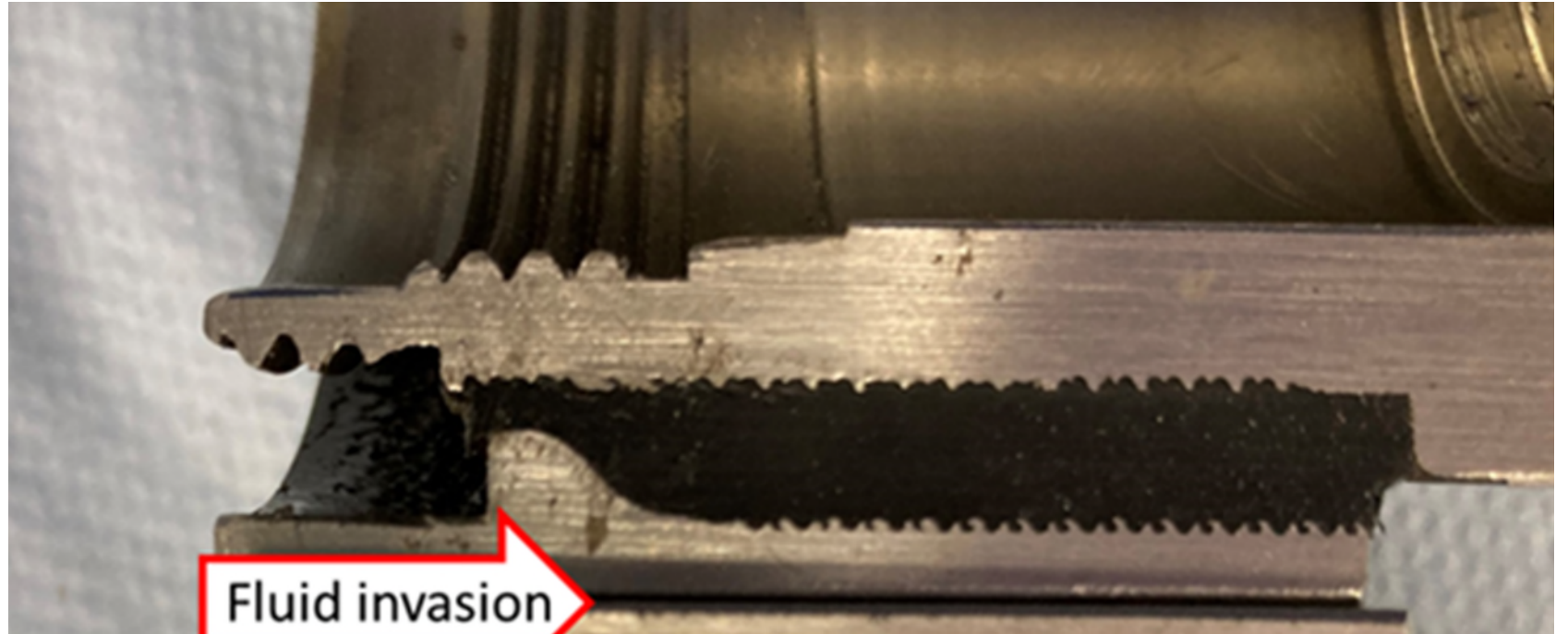


Fundamental Cutting Performance



Steering the Bit

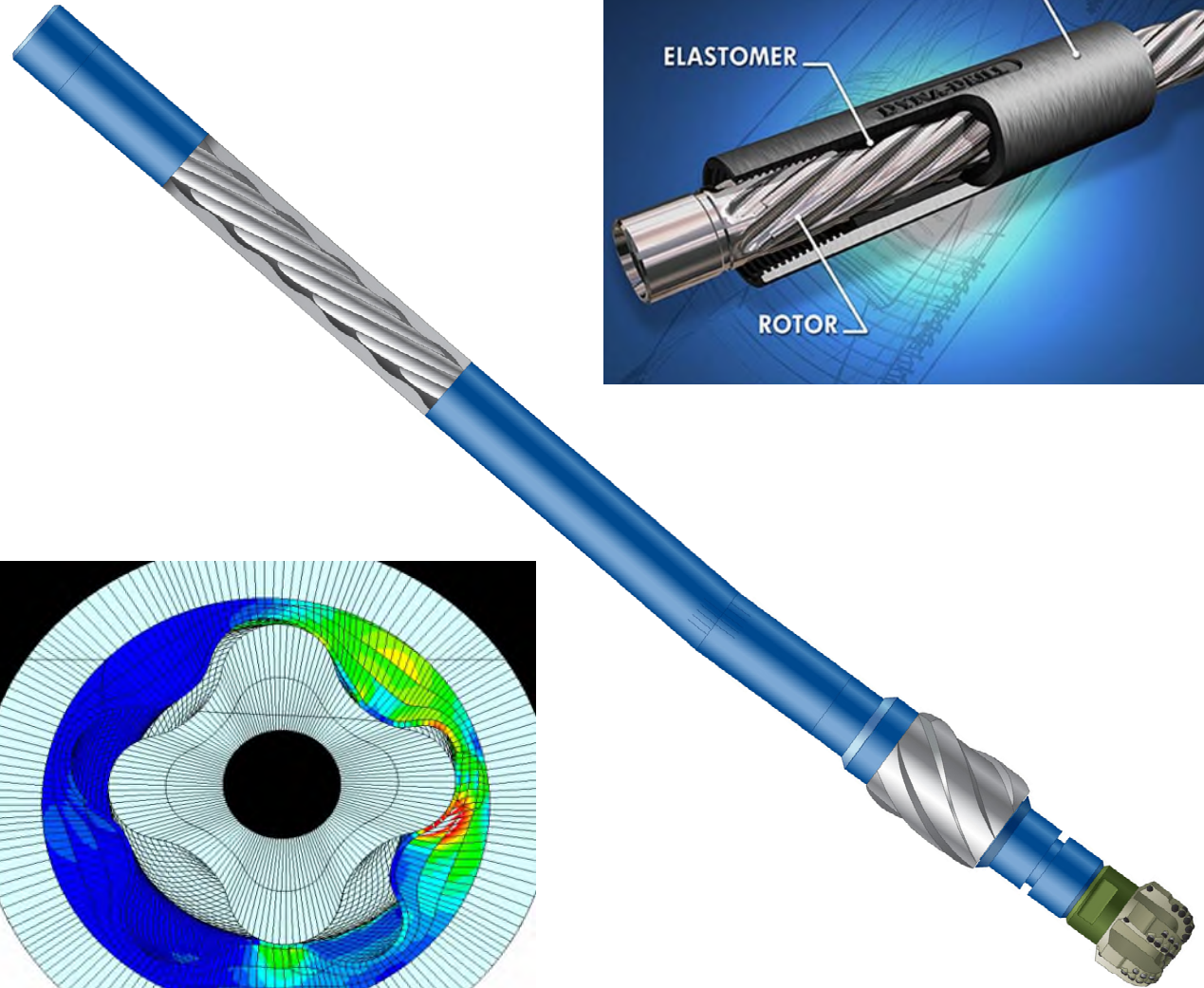
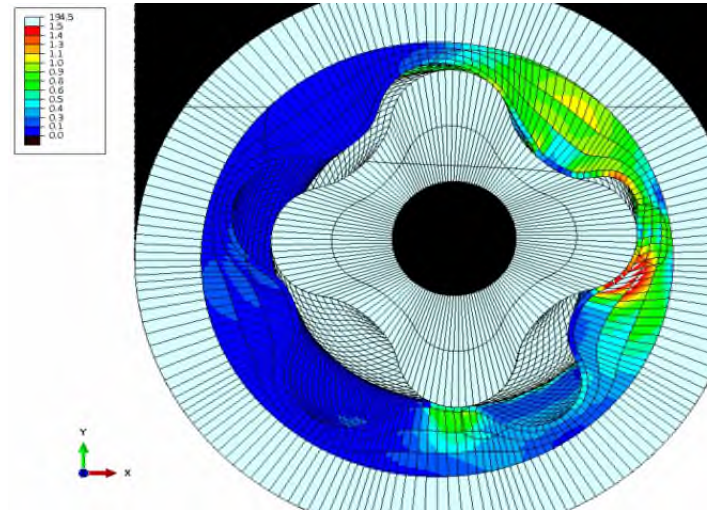
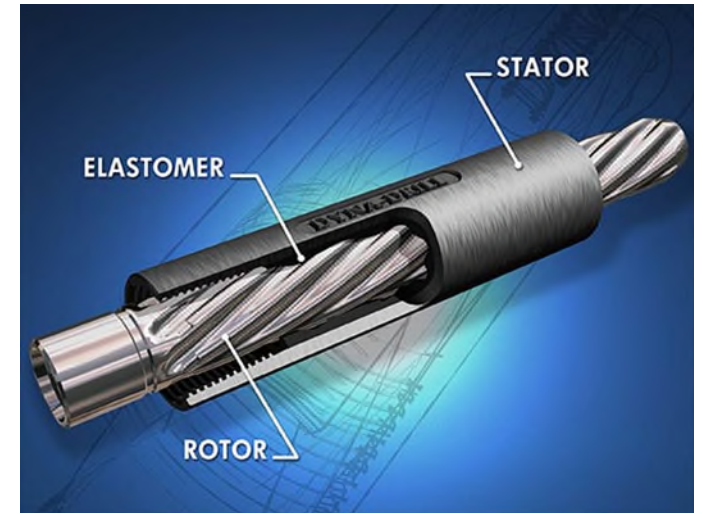
- ❑ Selectively Push the Bit
 - ❑ Hydraulically driven
 - ❑ Moving Pistons
- ❑ Environment
 - ❑ 220 + °C
 - ❑ 70 MPa
 - ❑ 10 MPa (Differential)
 - ❑ Water, Oil, Solids



Mechanical Power at Bit

- Mechanical Power Transmission
 - Torque through 5,000 m rotating pipe
- Hydraulic Power + Motor
- Mono Motor

- Elastomer Challenge
 - Chemical Stability
 - Thermal Stability
 - Mechanical Deformation
 - Abrasion



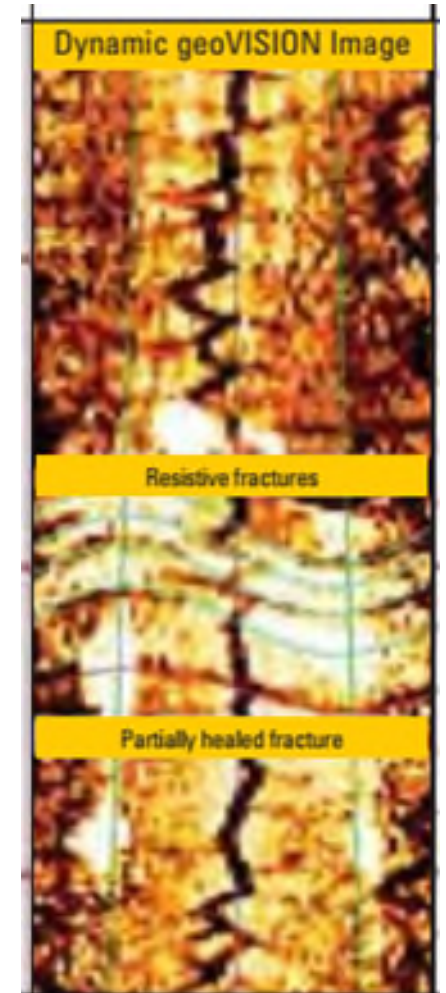
Characterise Formation

- Lithology
- Permeability
- Resistivity

- Electrical Isolation
- Abrasion Resistant

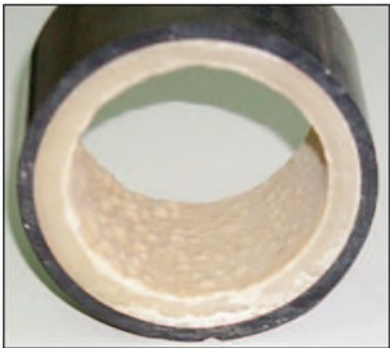
- Temperature, Pressure

- Electronic Board Stability



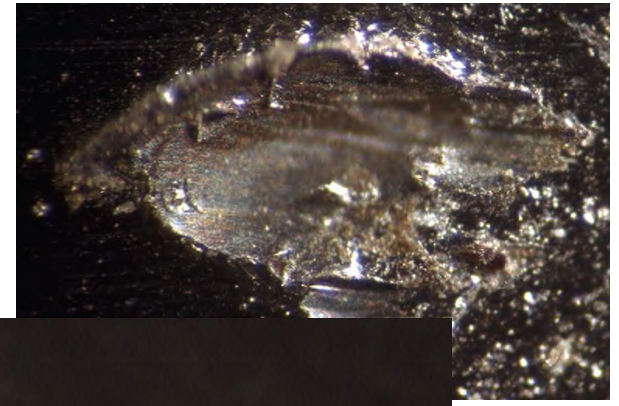
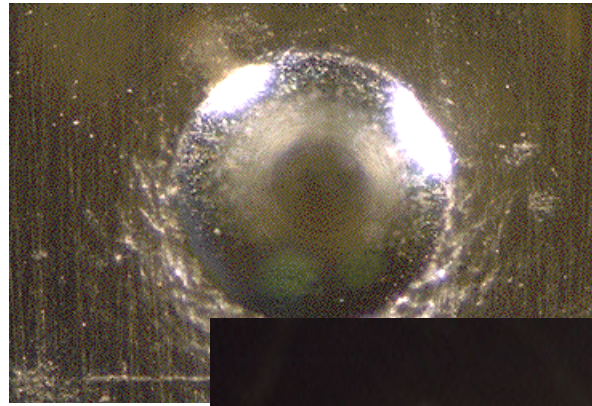
Common problems requiring well intervention

- High to Ultra-high reservoir temperature
- Typically within the 200-300+ °C range
- Corrosion (reservoir and occasionally top hole)
- CO₂ and H₂S corrosion
- Pitting, galvanic, crevice
- Scaling
- Silica, Calcium carbonate, and heavy metal Sulphide salts



Scale Removal

- ❑ Mineral Scale Removal – No Ductile Steel Damage
- ❑ Abrasive Jetting
 - ❑ Shape, Hardness, Density, Fracture Toughness, Toxicity
- ❑ Sterling Beads



Geothermal Power

- ❑ Critical Enabler for Sustainable Power Systems
- ❑ High Temp Fluid Flow
- ❑ High Permeability Formation Conduit
- ❑ Challenging Environment
 - ❑ 220 °C, 60 MPa, Water, Oil, Solids, Corrosive
- ❑ Hydraulic, Electronics, Mechanical, Materials Systems

