



HALLIBURTON

Recovering reservoir connectivity and addressing scales; reliable solutions for Geothermal wells

Innovazione e Sostenibilità per la Geotermia del Futuro

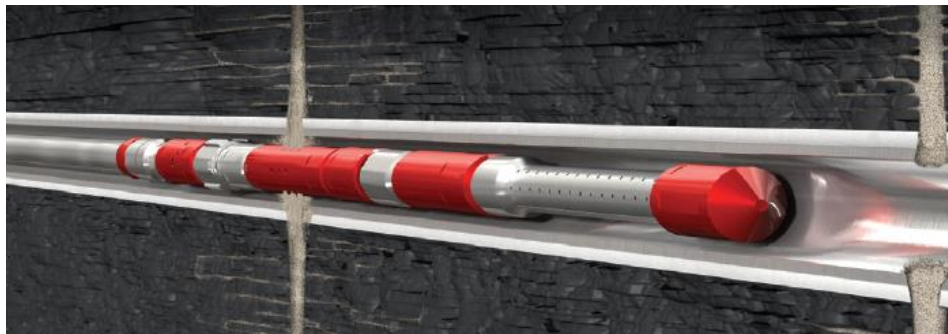
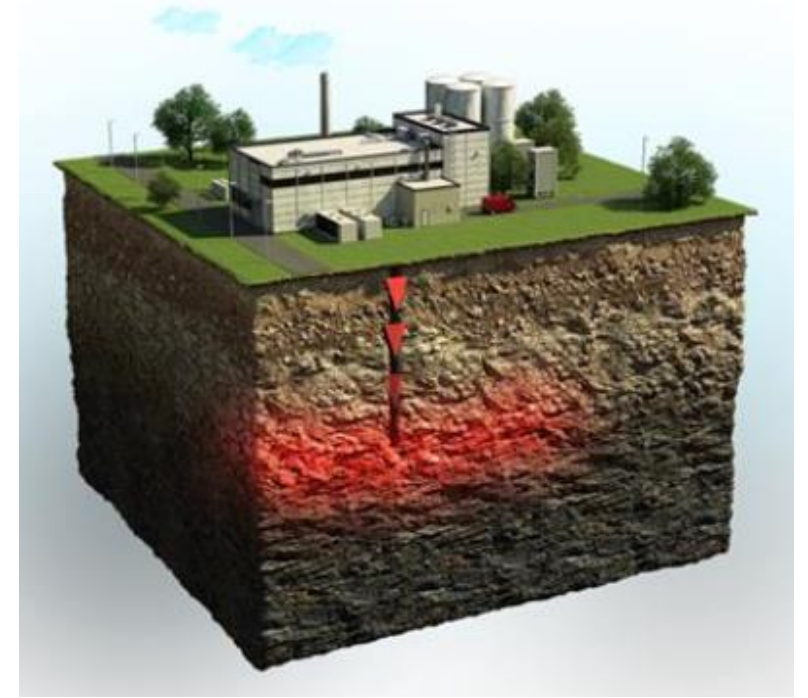
03 Marzo 2023

CNR, Auditorium dell'Area della Ricerca, Pisa

Via G. Moruzzi 1, Pisa

Project Overview: Ground Heat Storage

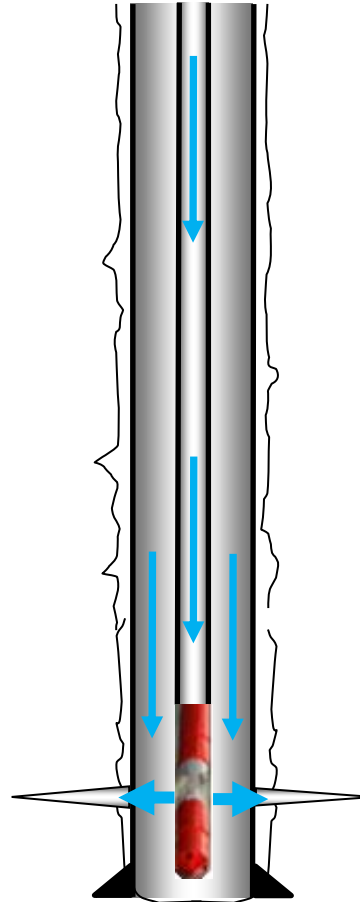
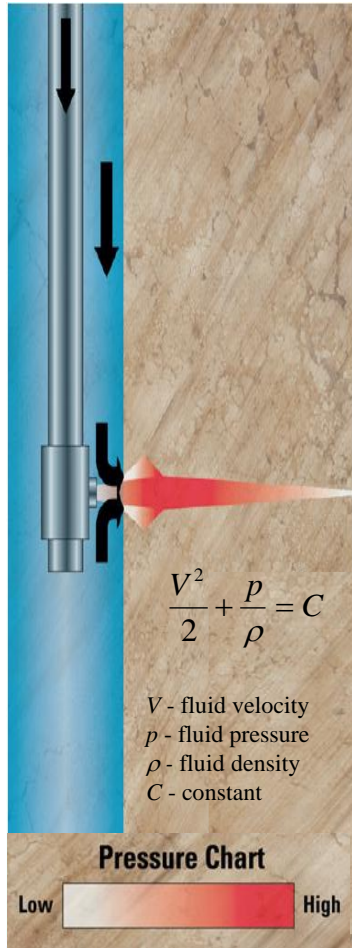
- Halliburton was awarded the task to implement High Enthalpy Aquifer Technology (HEAT) concept to store and recover seasonal waste heat from industrial processes.
- By turning bedrock into large-scale natural thermal batteries, the stored heat can be recovered whenever needed.
- The innovation-awarded heat-storage concept is to be piloted at the district heating facility in Northern Europe.
- Underground fracture system to be established between injector(s) and producer(s) to maximize contact area between circulating water and bedrock.



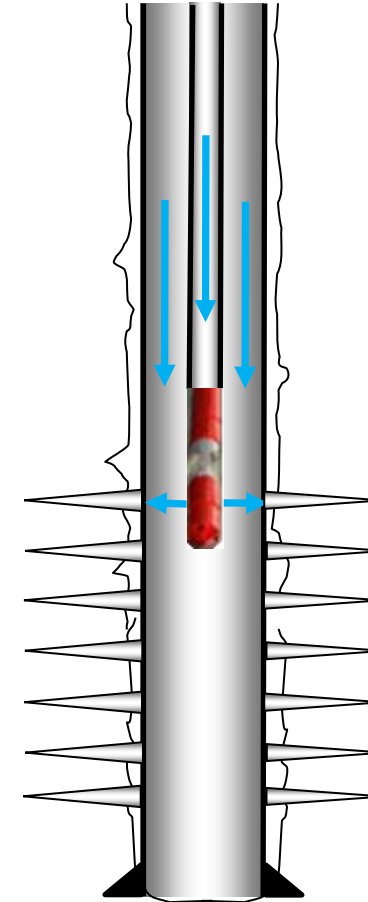
- Network of injector and production well(s) drilled into bedrock
- **Halliburton's SurgiFrac[®]** method is a key technology enabler for this concept.

SurgiFrac Method Overview

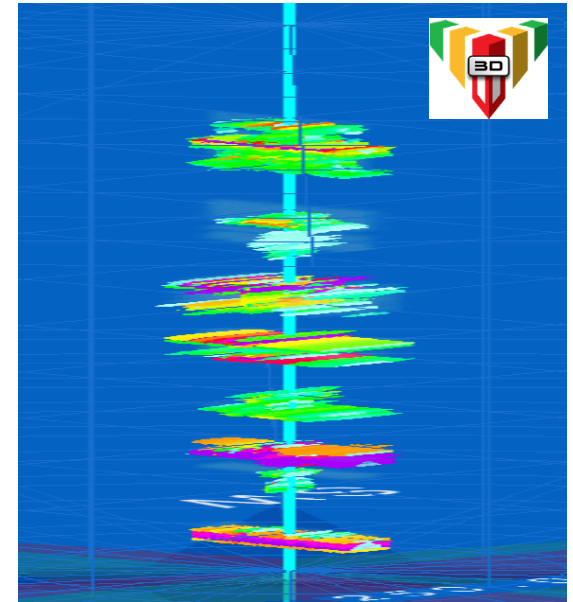
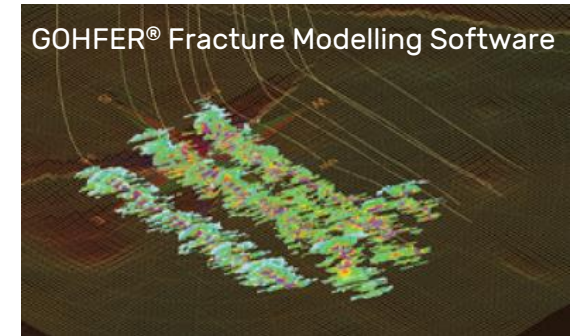
- Pinpoint stimulation to penetrate and open natural fractures
- Dynamic diversion with Bernoulli Principle in cased hole or horizontal open hole completions



SurgiFrac
Pin-Point Stimulation

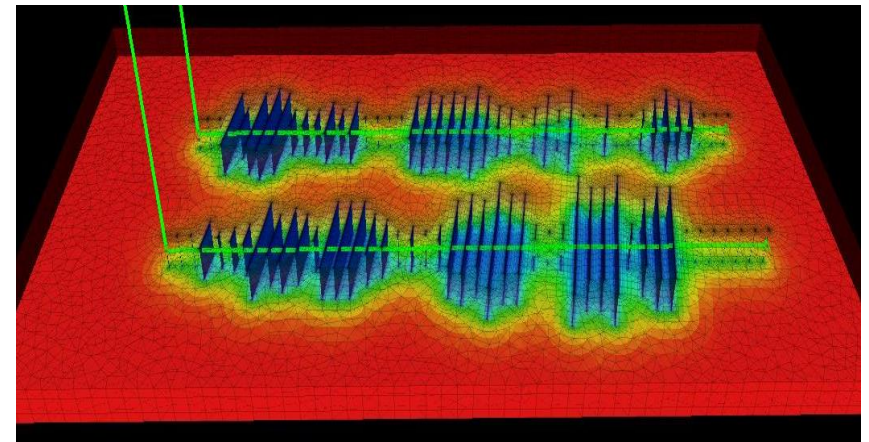
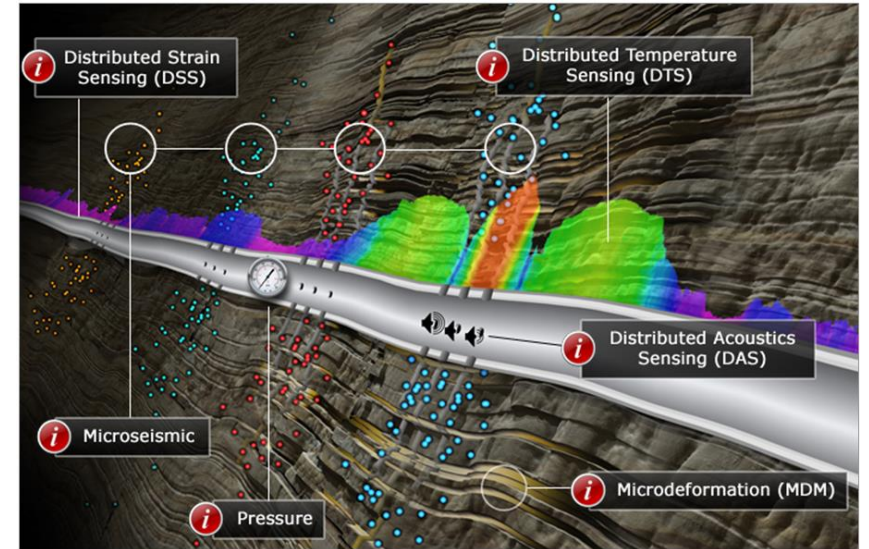


SurgiFrac Multiple Stages



Pinnacle Microseismic Fracture Mapping / DTS Monitoring

- Microseismic monitoring provides key information on reservoir structure and permeability
- Pinnacle services allow the tracking of real-time microseismicity, fracture geometry and injection profiling
- DTS Fibre allows permanent/semi-permanent reservoir monitoring **Rated to 300°C**
- Allows fluid flow paths and reservoir structure to be better understood
- Tilt-mapping applications for subsidence monitoring
- Halliburton pumping capabilities allow flow rates to be sustained to enhance thermal stimulation
- **The results influence future drilling and reservoir management decisions**



Europe Project Experience

- Environmental permitting
- Project Management
- Optimizing Stimulation and Completion Design
- Integrated Service Lines
- Personnel Logistics
- Traffic Management plan
- Micro-seismic Monitoring
- Subsurface Insight with Fiber Optic Technology



Custom Chemistry to address Geothermal Challenges



- Scale Treatment Services

- HalKleen® Scale Removal
 - Suite of fast acting scale dissolvers
 - Single stage fluid systems
 - Non-corrosive and non-damaging for elastomers
 - Surfactants for faster dissolution

- Stimulation Services

- Silica Scale™ Acid
 - System to remove silica scale from geothermal wells
- Volcanic Acid™ I and II
 - Organic acid system compatible with HCl-sensitive minerals and can be used in higher-temperature applications
- SandStim® Plus
 - Chelant-based acid system for formations with uncertain mineralogy and high carbonate content

Fluid System	Calcium carbonate	Iron Carbonate	Calcium sulfate	Barium sulfate	Strontium Sulfate	Iron Sulfide
HalKleen™ C	●	●				
HalKleen™ G			●			
HalKleen™ B	●	○	○	●	●	○
HalKleen™ S					●	
HalKleen™ F						●

● Best Option

○ Recommended under certain conditions



Downhole Tools for Geothermal Wells

- Pulsonix® TFA Near Wellbore Fluids Placement Tool

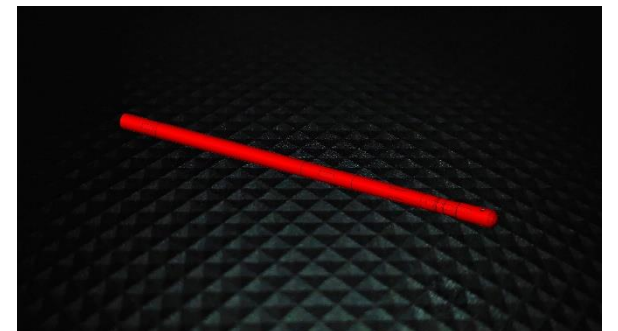
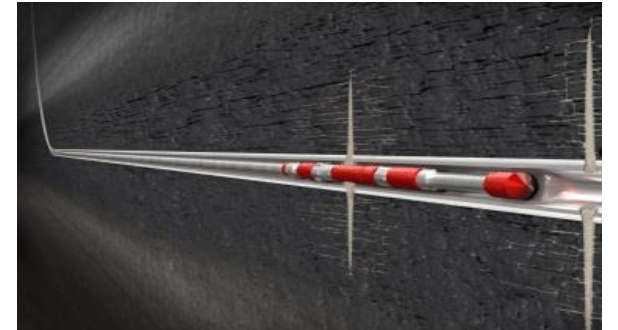
- Superior near wellbore treatments efficiency with greater fluid delivery
- Cyclic loading to break up many types of near-wellbore damage
- Reliable and simple (no moving parts), with unlimited configurations

- SurgiSqueeze Pinpoint Acid Stimulation

- Thru tubing perforation (multiple cut in a single run) to open new intervals
- Pinpoint stimulation treatment to place high intensity of small treatments placed surgically along the entire interval

- Hydra-Blast® Pro High Pressure jetting technology

- Removal of heavy build-up
- Controlled RPMs for best impingement
- Can clean large diameter casings, completion components and ID changes



Diagnostic Solutions

- SPECTRUM® Real-Time Electric and Fiber Optic Coiled Tubing
 - Integrated Logging Capability (Wireline and Fiber Optic DTS/DAS)
 - Open Architecture Platform
 - No Power Limitation
 - Enhanced Single Trip Capabilities
 - Transparent to Operations
- SPECTRUM® 360 Real-Time Camera Services
 - Augmented Diagnostic and Interventions
 - Real-Time high resolution color video
 - 360 Degree Lens Coverage
 - Integrated LED Lighting
 - Chemical services, Flow Thru and Wire Thru Technology
- SPECTRUM® IRIS Real-Time Down View Camera
 - Add on to 360 for better understanding of downhole conditions

