INNOVATIONS IN DRILLING
DAP 2015

MAARTEN MIDDELBURG (HWT & WEP)
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DELFT

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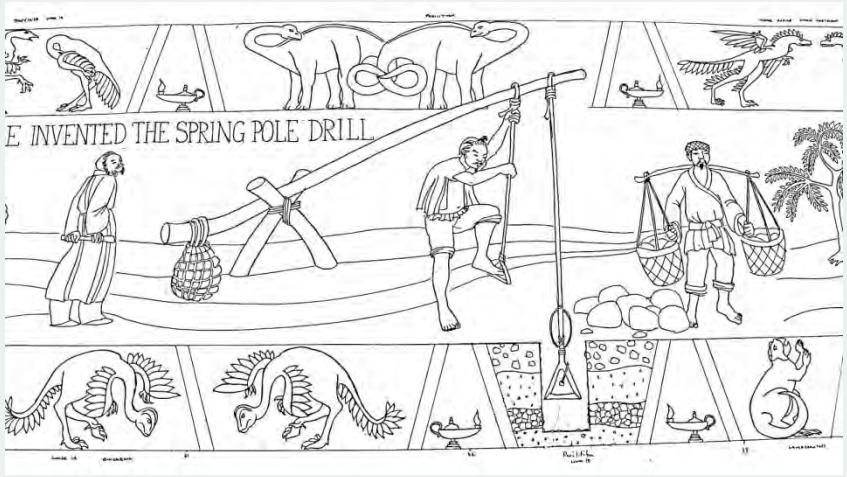
HISTORY OF DRILLING



Spring Pole drilling, 1000 B.C.

Ruffner Brothers 1806-1808

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HISTORY OF DRILLING

China, Sichuan Province, 200BC

Colonel Drake, Titusville PA,1859

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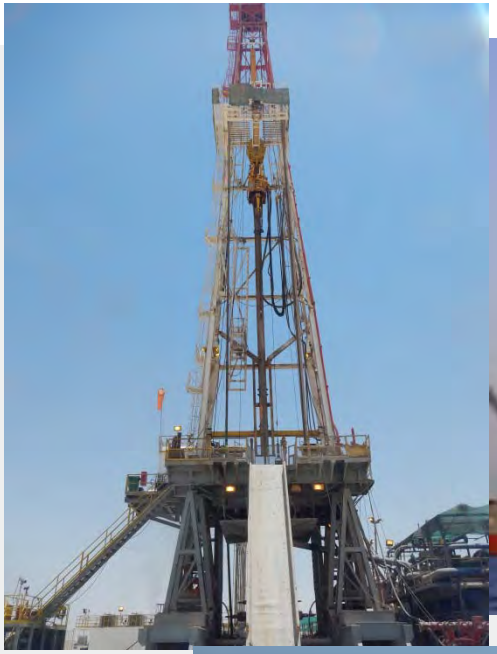
EVOLUTION



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BETTER CONTROL OF PROCESS NEEDED REDUCE RISK

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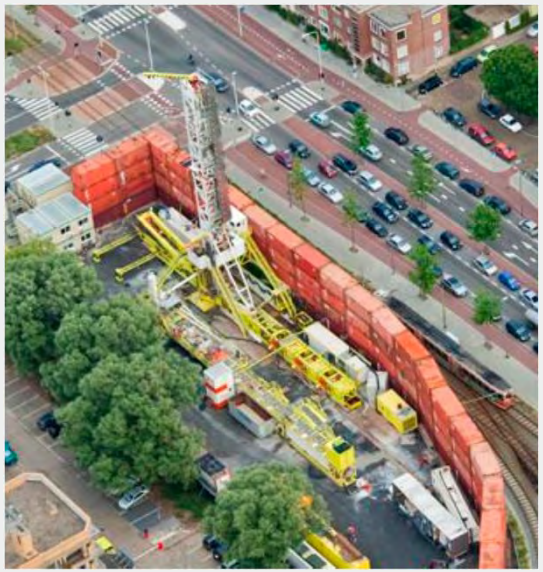
SIMPLER OPERATIONS



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AUTOMATION

1950’s ?

today

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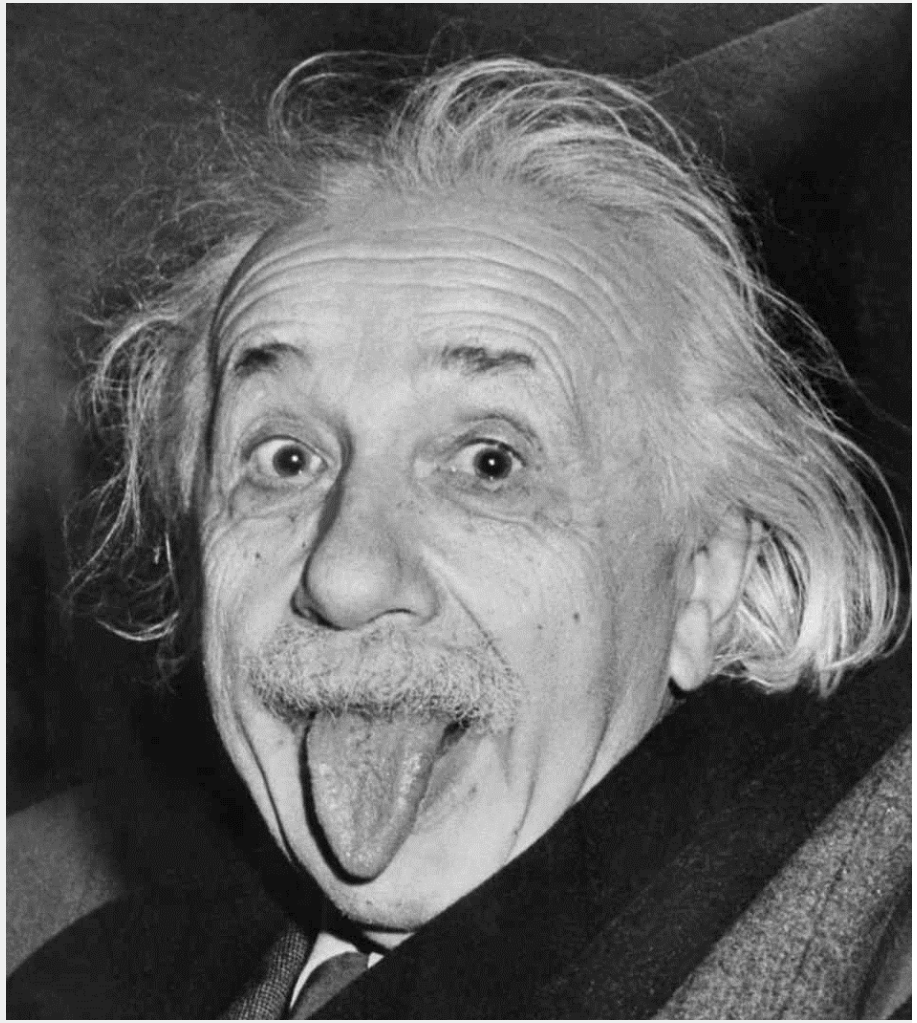
INNOVATION

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius -- and a lot of courage -- to move in the opposite direction.“

EINSTEIN



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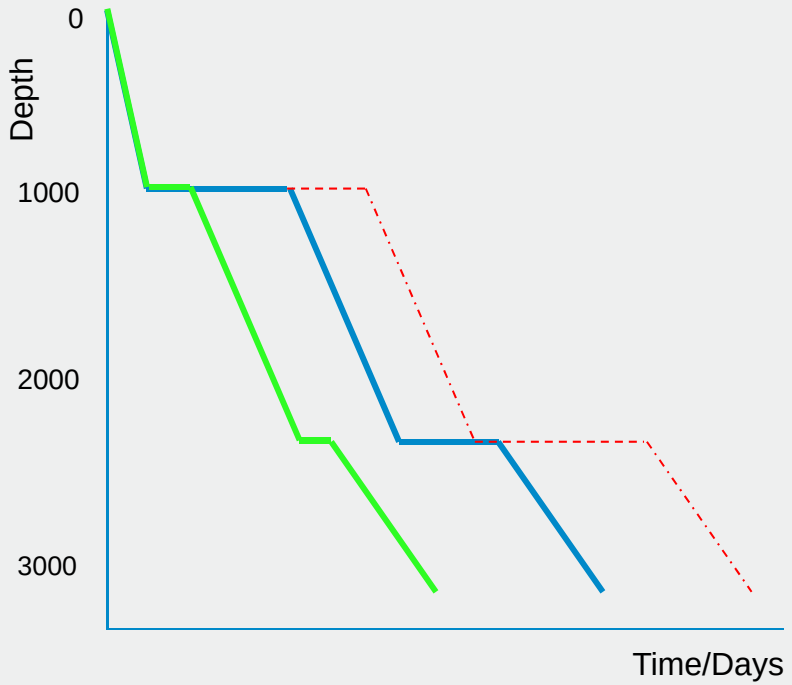
EFFICIENCY UP, COST DOWN

- Well Construction Cost plus Cost of Risk show stopper for many Geothermal projects

- Need for:
  - Higher operating efficiency
  - Reduce risk
  - Smaller and cheaper rigs
  - Safer and less human interaction
  - Wells with a longer life and less maintenance



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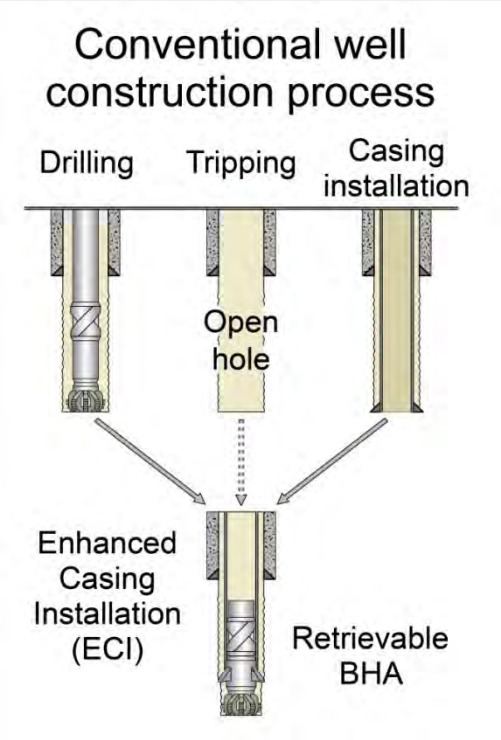
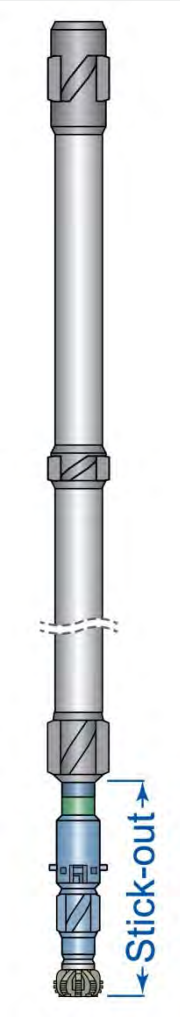
ECI - ENHANCED CASING INSTALLATION



- Retrievable & Directional casing drill system
- Well stabilized
- Minimal stick-out (<1m) even with M/LWD in BHA
- Cable, drill pipe, pressure retrievable
- Equipment inside casing i.e. low lost-in-hole risk & minimum wear; composite casing shoetrack allows logging through casing.
- Operated by rig crew (no external DD service)



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ECI ADVANTAGES

- Fast tripping for BHA changes (cable or pressure assisted):
  Less handling increases personnel safety, saves time, reduces energy consumption and reduces rig footprints.

- Drill pipe vs ECI drilling: smaller and near flush annulus:
  Increased drilling efficiency: better hole cleaning, simpler mud system, lower mud weight, less losses, less reservoir damage, better cement jobs, dynamic kill method in case of influx.
  Less drill string failures and inspections needed

- Casing sits directly in place after drilling:
  Less open hole time, less hole quality problems, smaller hole being drilled, lean casing profile, immediate contingency sidetracking.

ECI/RSS - ROTARY STEERABLE SYSTEM

- Development of a cost efficient RSS
- Drill vertical to horizontal section with the same casing size
- Point the bit technology -> precise steering, also in soft soils
- Continous controlled from surface without down linking
- Controls integrated in rig so operated by rig, crew or remote:
  - **no need for 3rd party directional drillers or steering tools required**
- Only standard MWD electronics are used downhole
- DLS capability upto 5 degree/30m
- Equipment sits inside casing so small stick-out (<1m) and well protected

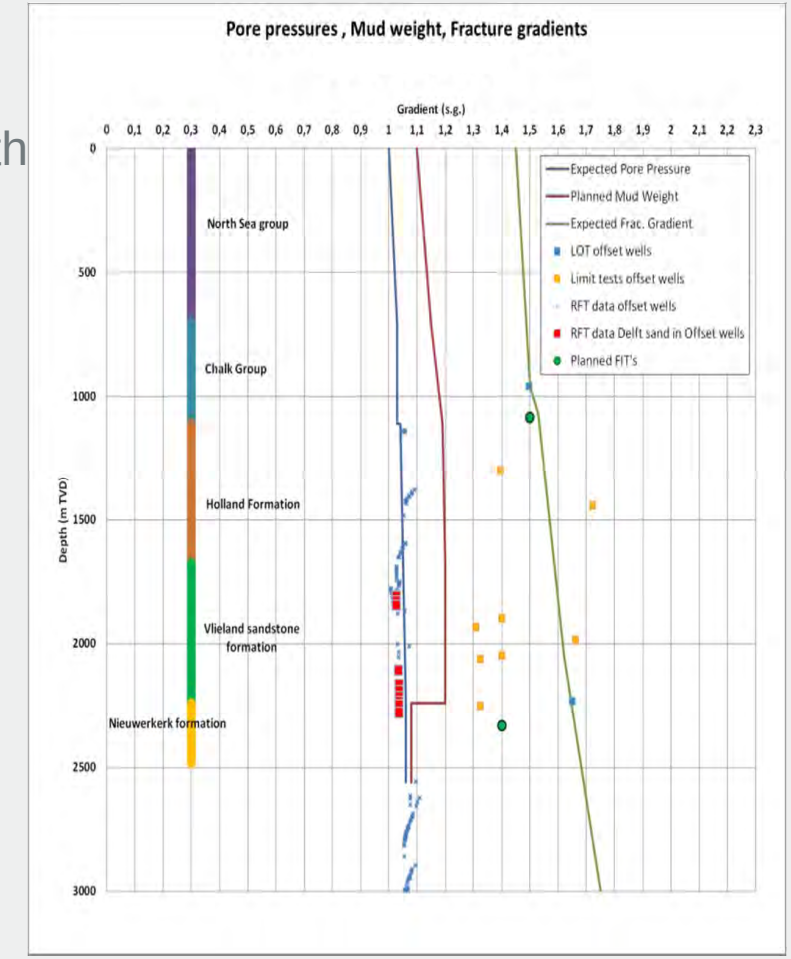
MPD - MANAGED PRESSURE DRILLING

- MPD - Managed pressure drilling system

  - Control annular pressure close to balance with formation pressure
  - Maintain pressure control at all times (also in narrow pressure window)
  - Control ECD effect

- MPD Advantages

  - Faster penetration rates
  - Improved wellbore integrity
  - Reduced fluid loss and reservoir influx
  - Avoid reservoir damage



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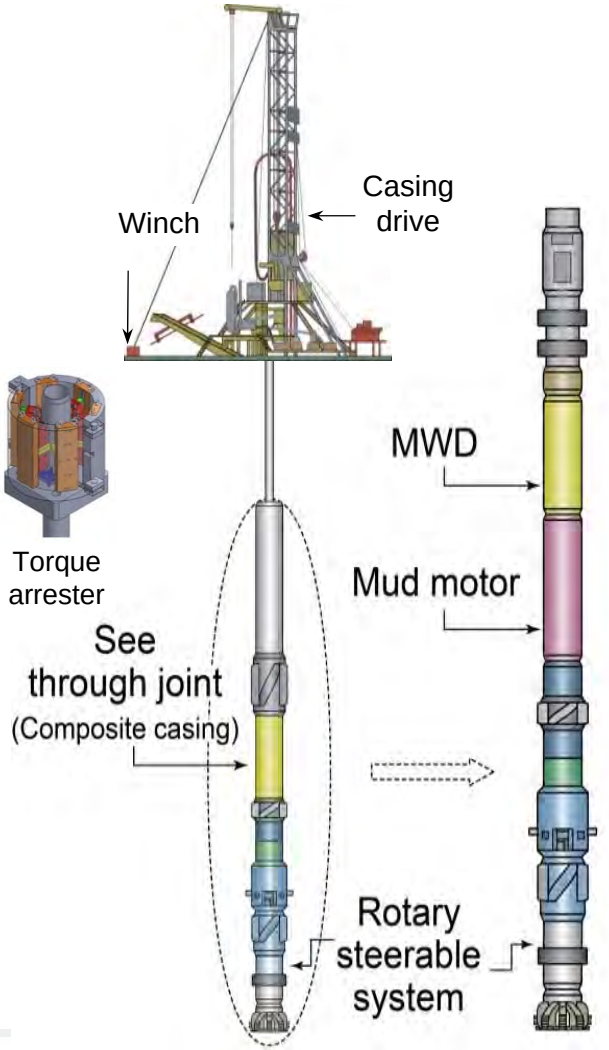
SIMPLIFY DRILLING PROCESS

- Increase Process Efficiency:
  - ECI
  - Automated Rotary Steerable
  - Integrated Continuous MPD

- Reduce rig (size) requirements (reduce dayrate)
  - Reduce hookload >> composite casing
  - Reduce footprint
  - Reduce pump capacity (ECI)
  - Reduce Energy requirements
  - Reduce specialist services (and personnel)
    - directional drilling (rig crew operates ECI)
    - TRS (rig equiped with casing drive, power slips, torque m/u software)
  - Eliminate topdrive



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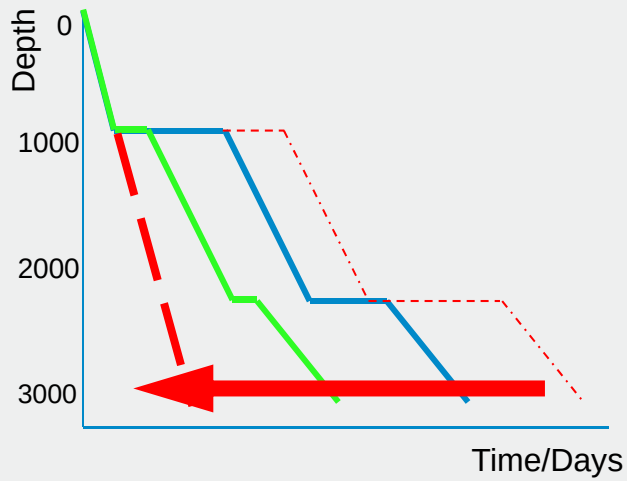
ROADMAP FOR GEOTHERMAL

- Everyone wants innovations but nobody wants to be the first (serial no.1 syndrome) >> Will DAP be first?
- HWT developments will lead to cost efficient drilling, but this will not happen overnight and we welcome operators to explore the possibilities with us.
- Implement new technology and start realise savings.



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