Der Geothermie Kongress 2018

Haus der Technik Essen, 27.-29. November

GEOTHERMIE KONGRESS 2018
GEOSTEERING IN GEOTHERMAL WELLS

Paul Bitmead
Field Operations Manager

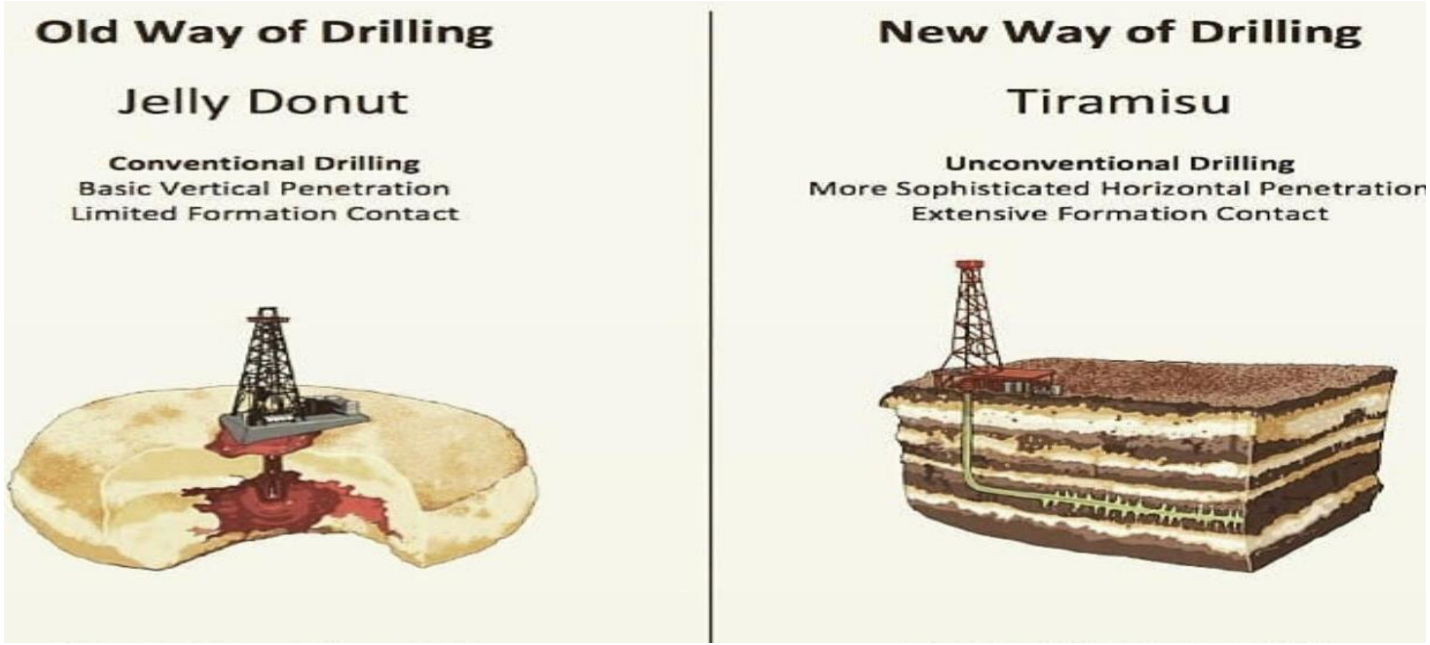
October 30, 2018

Weatherford®

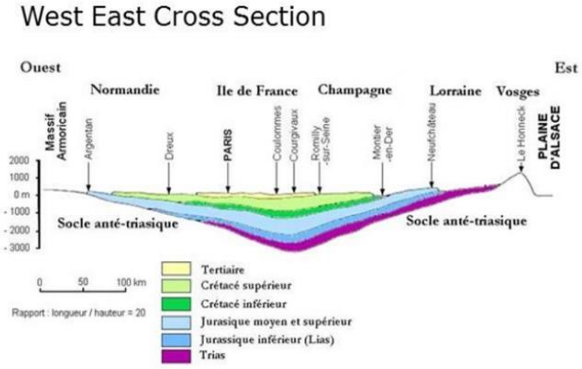
GEOSTEERING IN A GEOTHERMAL WELL

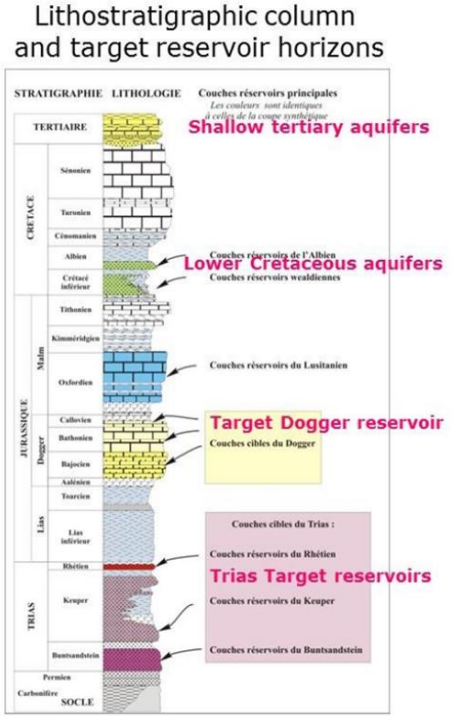
- Real time Geosteering with integrated services. A key issue in maximizing geothermal exposure and minimizing drilling/completion risk. A Paris basin case study.

DIRECTIONAL DRILLING



GEOLOGICAL BACKGROUND – PARIS BASIN

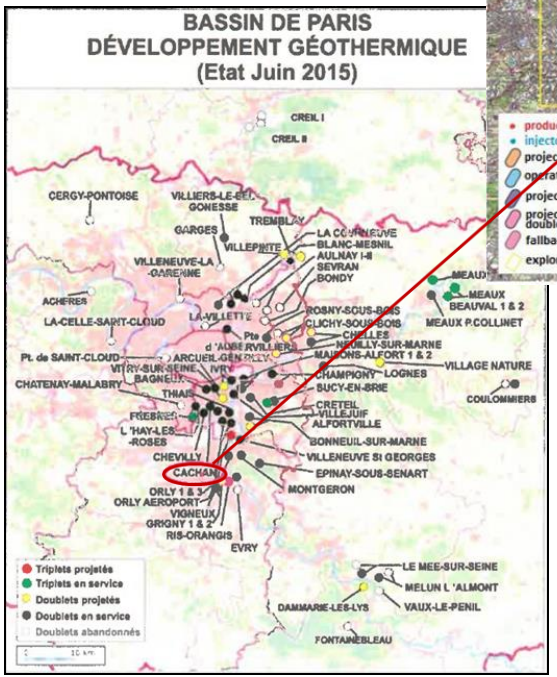




- Dogger (mid-Jurassic) Bathonian member occupies the upper part of the carbonate platform complex.
- Oolitic limestones showing highly connected porosity and subsequent permeability.

FIELD BACKGROUND

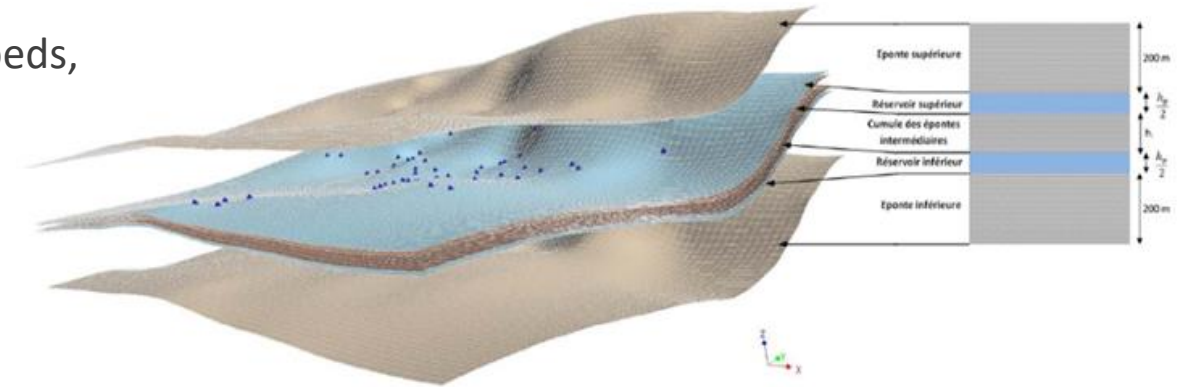
- 76 Geothermal District Heating (GDH) doublets drilled of which 46 (including 6 triplet recompleted doublets) remain online (June 2018 status).
- Only 27 GDH plants show brine temperature higher than 65°C
- Since 1985 30 doublets were abandoned mainly for technical (corrosion or scaling damage) or economic reasons
- Located in sensitive, densely populated, urban environments.



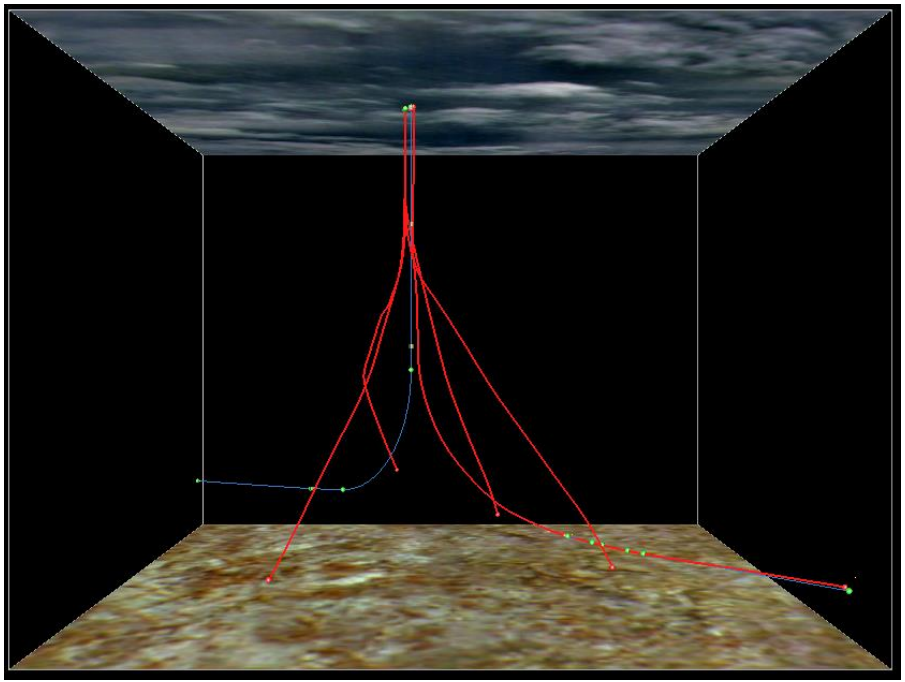
CHALLENGES

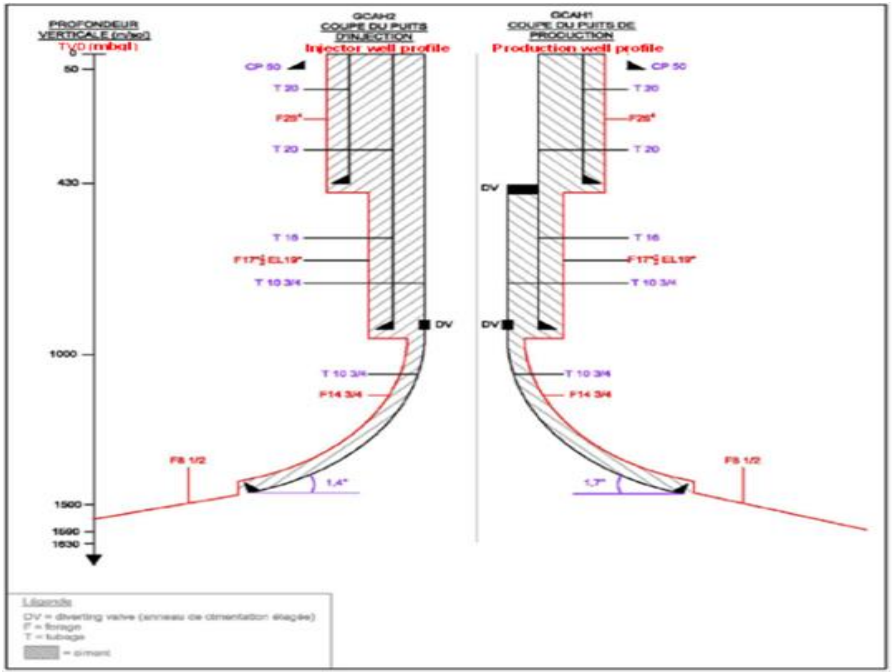
- GDH doublet densities, approaching in some areas overpopulation, which limit well replacement opportunities and cloud new development issues bearing in mind space limitations in urban areas.

- Multilayer equivalent Sandwich reservoir structure, stacking productive and non productive beds, for modelling heat and mass transfers.



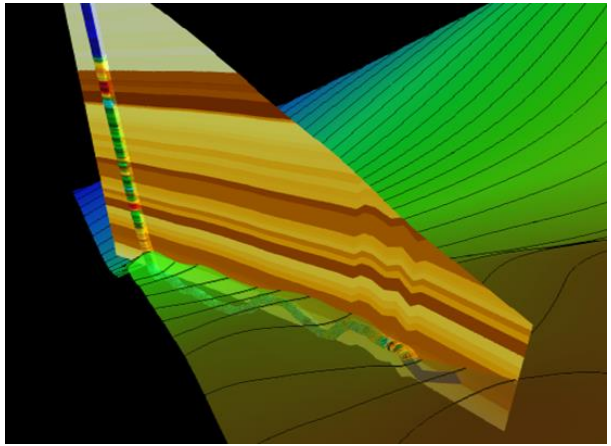
CACHAN PROJECT





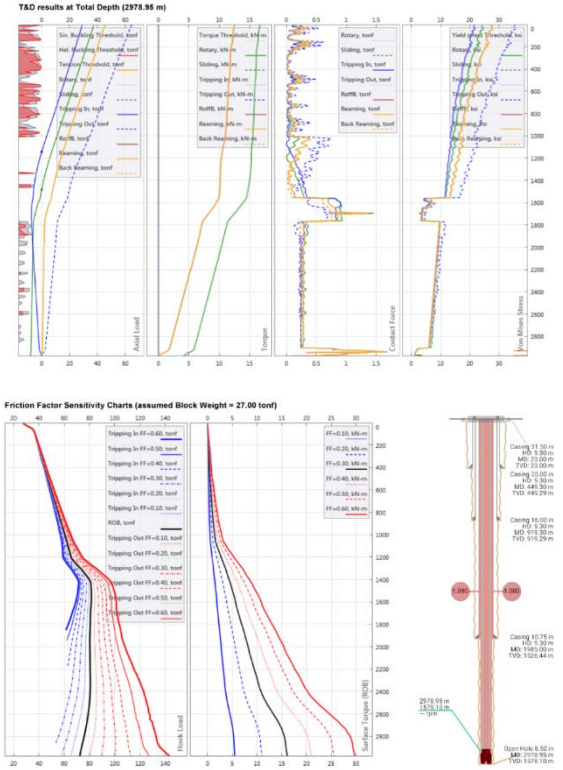
WHAT IS GEOSTEERING ALL ABOUT

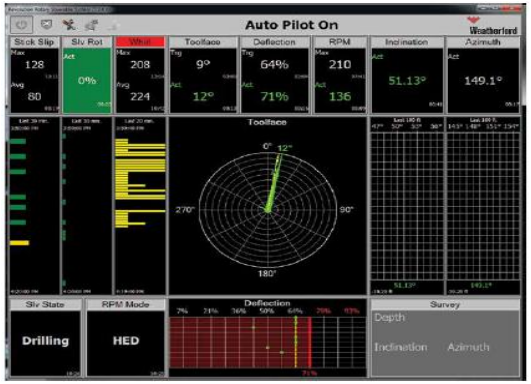
- Geosteering aims at optimal well placement, in real-time, of high angle / horizontal wells targeted at the optimum reservoir location based on the results of downhole LWD, real time information and a multi-disciplinary team approach.
- Well Placement components:
  - ✓ Downhole Tools
  - ✓ Advanced Software
  - ✓ People and process
  - ✓ 24/7 on the spot and remote coverage and communication
- The purpose of geosteering is to:
  - ✓ Maximize production
  - ✓ Reduce drilling time and cost
  - ✓ Avoid drilling ‘unwanted zones’ to drill at faster ROPs
  - ✓ Avoid sidetracks



DIRECTIONAL DRILLING AND RSS

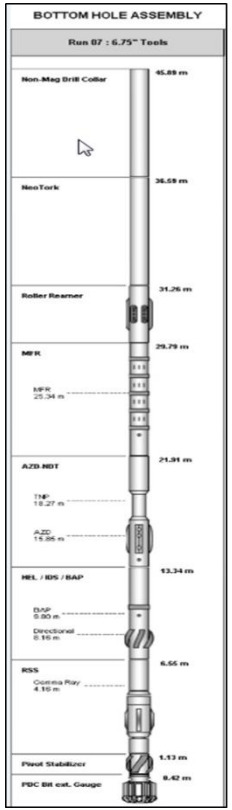
Drillstring Analysis - Design Report





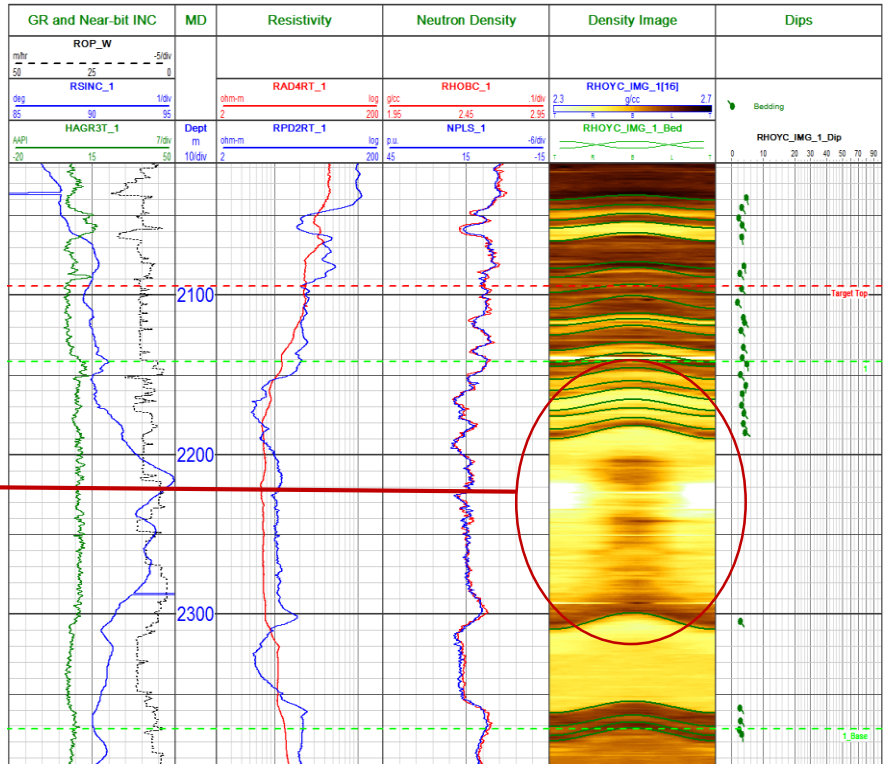
Rotary Steerable Systems (RSS) and Real Time Parameter Screen

LOGGING WHILE DRILLING (LWD)



DESCRIPTION OF COMPONENTS
RSS: Point-the-bit Rotary Steerable System (with Near Bit Inclination)
IDS: Azimuth and Inclination Survey
BAP: Bore and Annular Pressure sensor
AZD: Azimuthal Density tool
TNP: Thermal Neutron Porosity tool
HAGR: Near Bit Gamma Ray
MFR: Multi-Frequency Resistivity tool

Approaching low porosity layer from the bottom. Built angle to remain in the target.

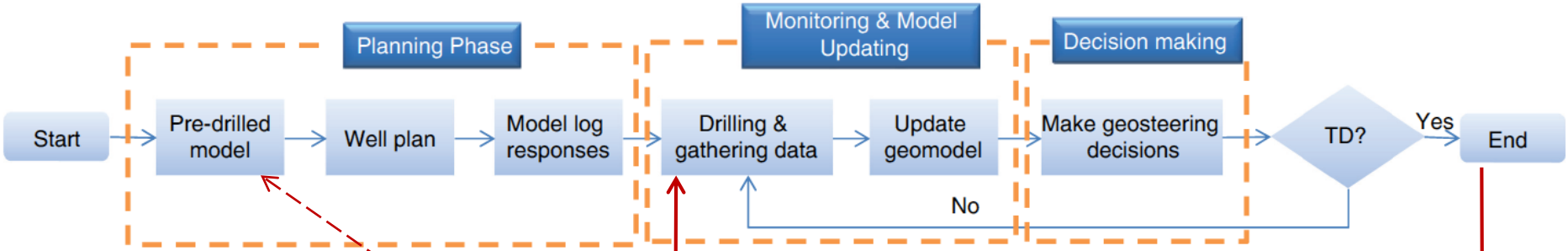


XRF-XRD AND MUD LOGGING

- The integration of X-Ray Fluorescence (XRF), Diffractometry (XRD) with mud logging data, provides detailed chemostratigraphy on drilling cuttings, close to real time;

- In order to support the MWD/deviation activites, to optimize the drilling and to lay down the foundations for the Paris Basin geothermal target refining;

GEOSTEERING WORKFLOW IN CACHAN



INTEGRATED REAL-TIME INFORMATION FOR GEOSTEERING:

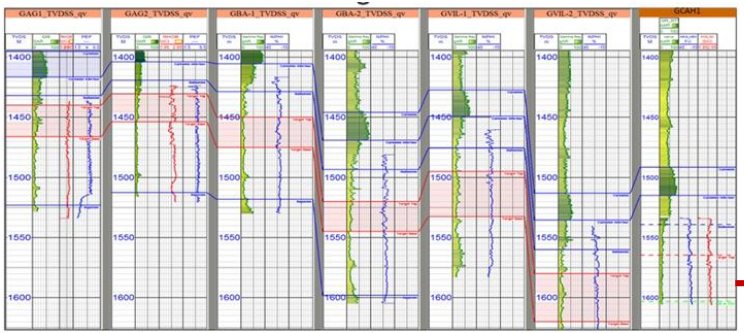
- **Directional Drilling:** monitor and control Rotary Steerable downhole tool performance.
- **Logging While Drilling:** gamma ray, resistivity, porosity, azimuthal density with images.
- **XRD and XRF:** geochemical and mineralogical analysis.
- **Mud Logging:** cutting petrography.

POST DRILLING ANALYSIS:

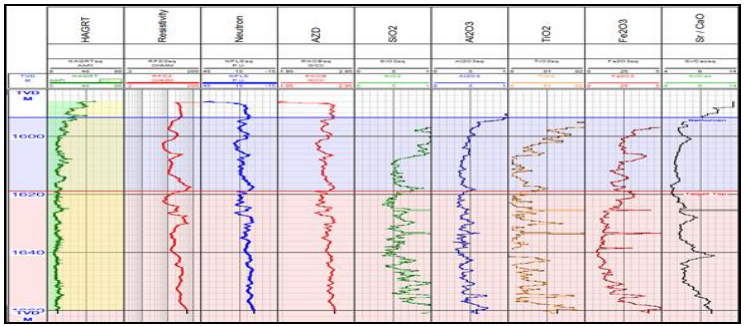
- Integration of real time data with Wireline nuclear magnetic resonance and dipole sonic to identify drain productive segments.
- Production logging tool spinner flow-metering provided flow and dynamic temperature profiles along the entire drain path.
- XRD/XRF advanced analysis from first production well was used as an input to improve the geosteering process in the following injection well.

GEOSTEERING

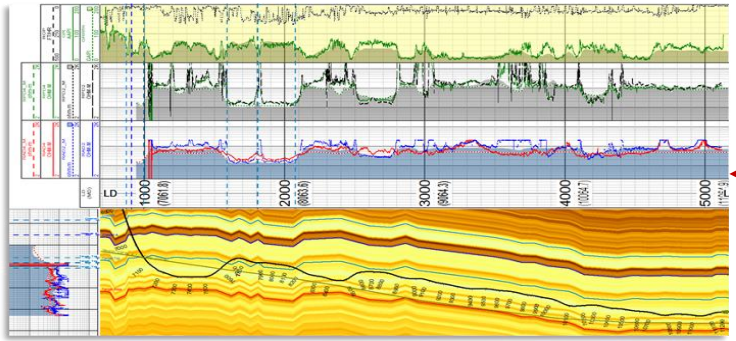
Collect and correlate data from offset wells



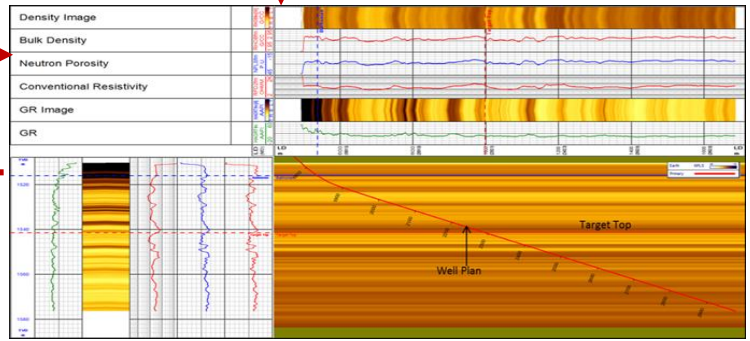
XRF data from GCAH1 for input



Structural Earth Model Modification to correlate offset/model with RT data



Pre well model



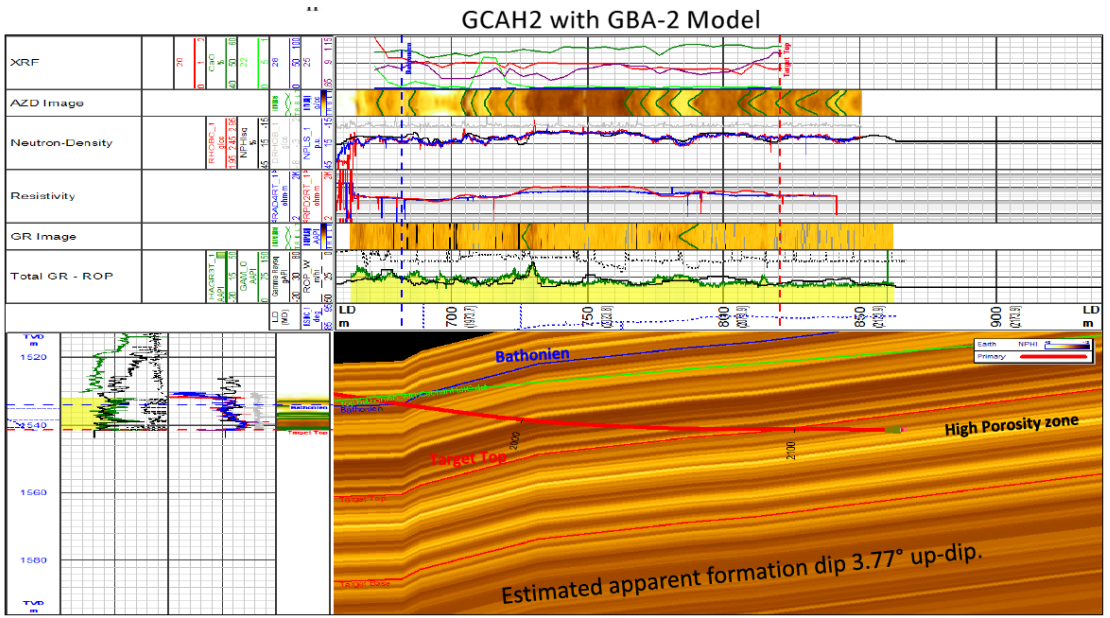
EXAMPLE OF RT OPERATION

Current depth: 2139m MD

As agreed, drop Inclination to 88° at a 1°/10m DLS and hold 88° Inclination over the next 20m MD.

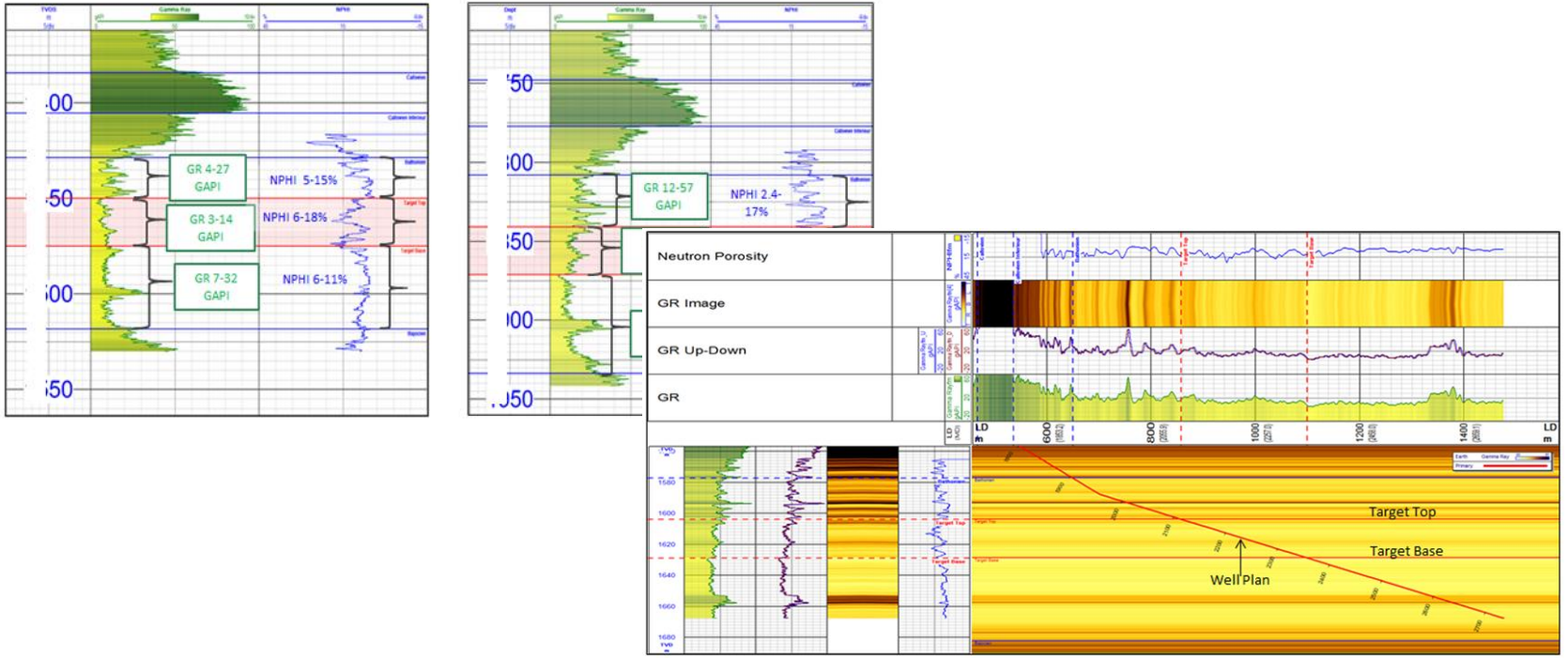
While penetrating into the high porosity layer, start chasing its trajectory.

Formation apparent dip stands at 3.77°(up-dip).

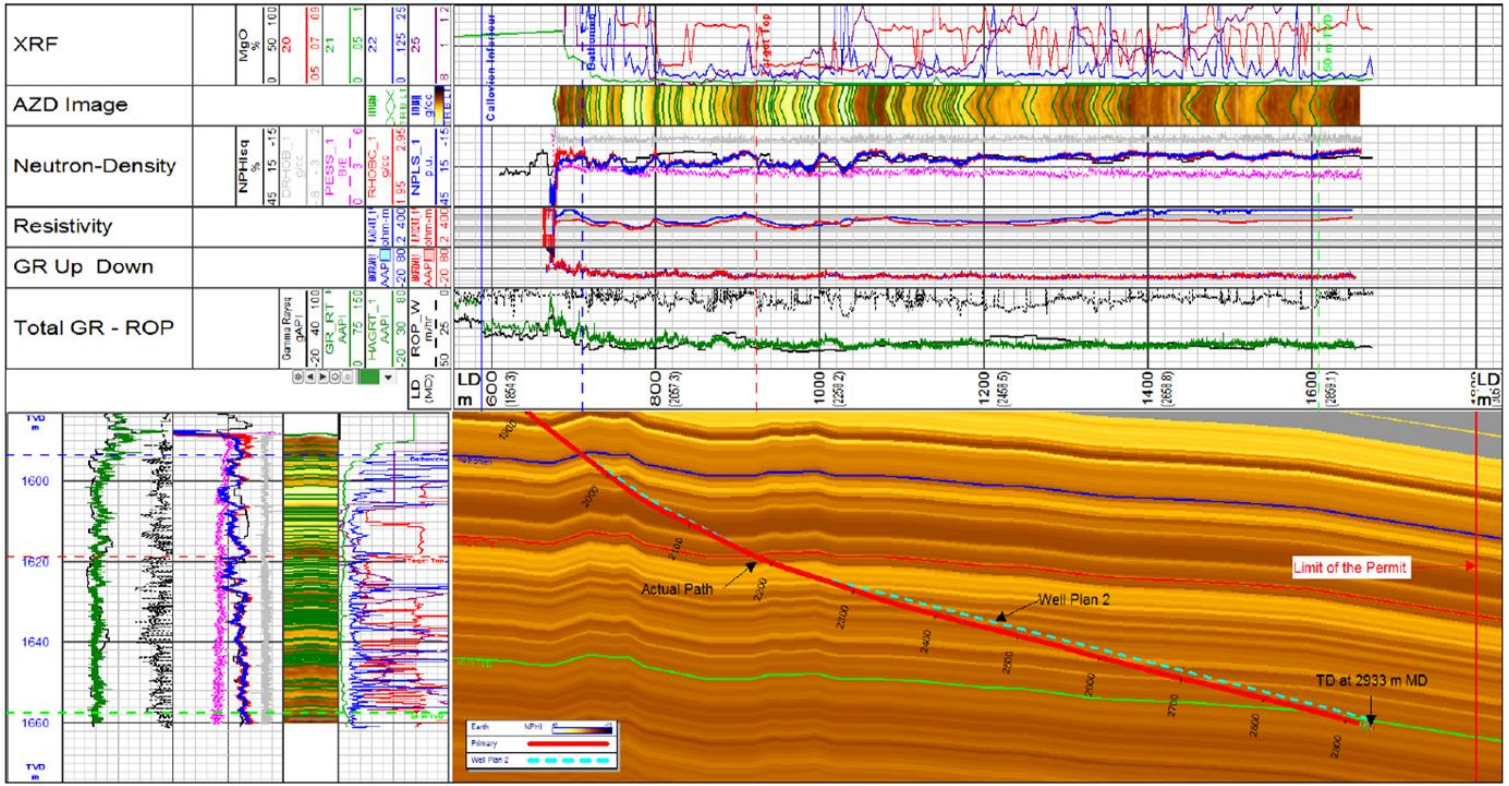


GEOSTEERING PREWELL MODEL GCAH1

GBA-1 & GBA-2 Offset Wells - Petrophysical Properties

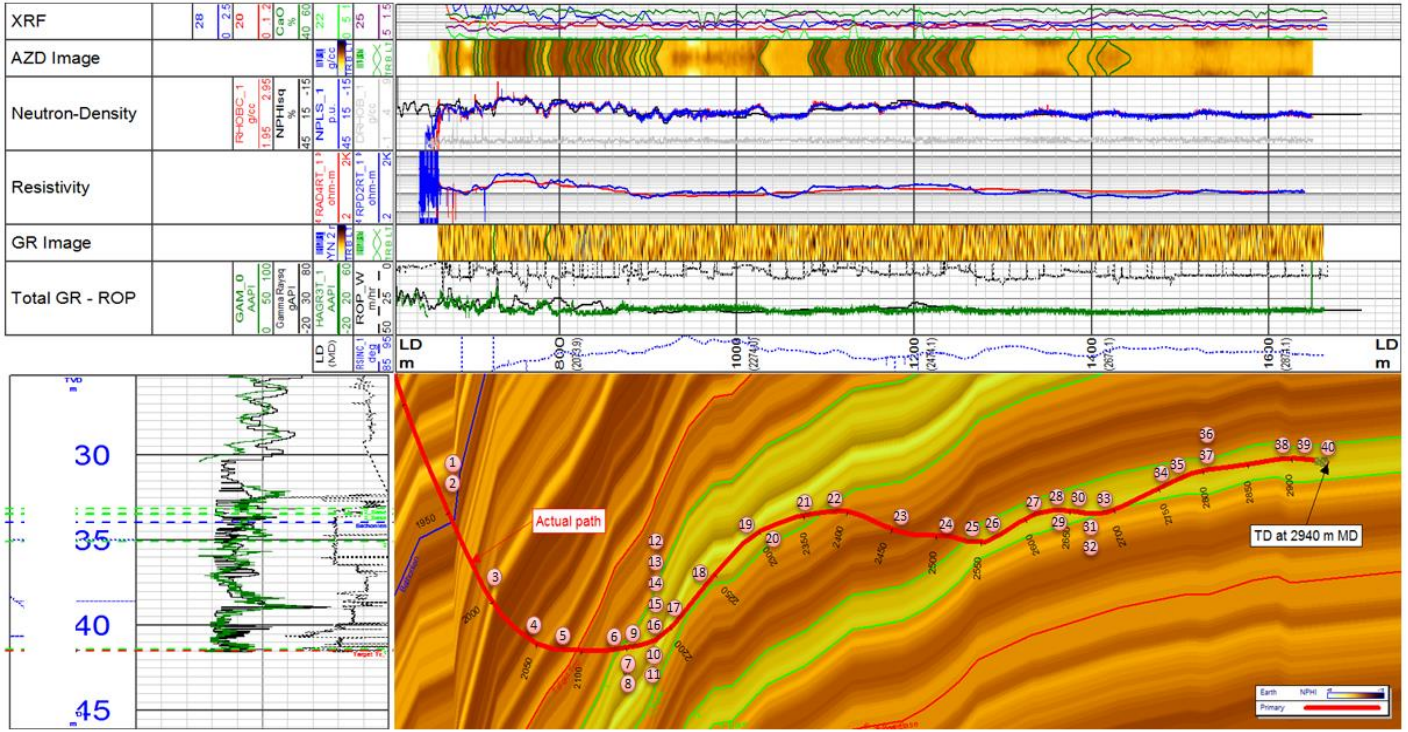


GCAH1 - END OF WELL TRAJECTORY



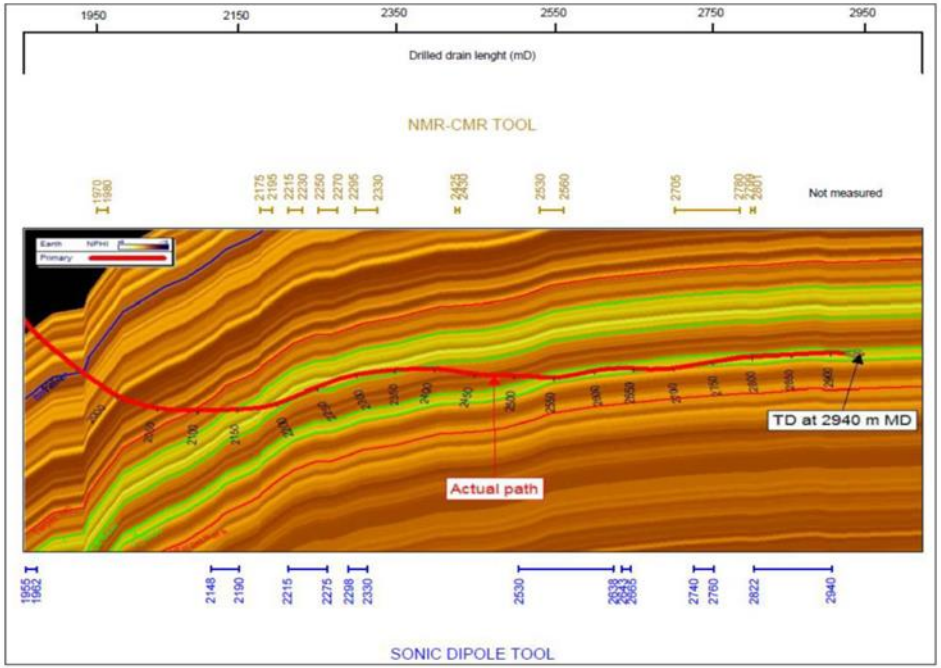
GCAH2 - END OF WELL TRAJECTORY

Each numbers represent a main event/decision during drilling execution

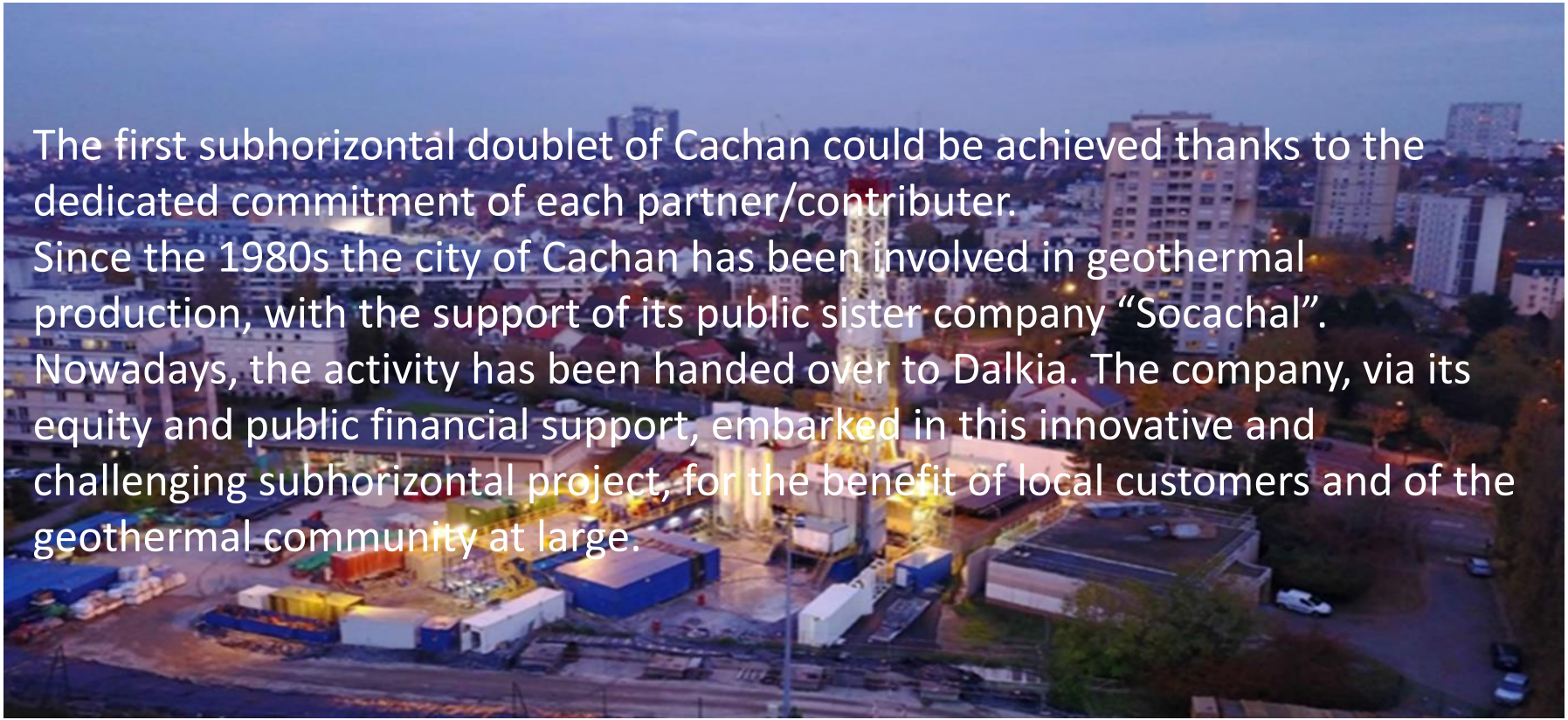


CONCLUSIONS

- Successful integration of the chemostratigraphic, mud logging, Wireline, Logging While Drilling and production/injection tests optimizing well placement and reservoir characterization.
- Transfering modern petroleum technology and know-how to geothermal objectives.
- Targeted at 450 (nominal) and 500 m3/h (maximum) productive and injective capacities, the new doublet will replace two existing doublets, ageing (33 years) and rated 180 and 170 m3/h (total 350 m3/h) respectively.



ACKNOWLEDGMENT



The first subhorizontal doublet of Cachan could be achieved thanks to the dedicated commitment of each partner/contributer.
Since the 1980s the city of Cachan has been involved in geothermal production, with the support of its public sister company “Socachal”.
Nowadays, the activity has been handed over to Dalkia. The company, via its equity and public financial support, embarked in this innovative and challenging subhorizontal project, for the benefit of local customers and of the geothermal community at large.