Presentation Title:

Delineating the Geothermal Structure and Flow Properties in a Sub-Horizontal Well with the Use of Wireline and LWD Data in a Multiphysics Approach

Presenter: Erik Wielemaker EWielemaker@slb.com

ABSTRACT

Geothermal projects are rapidly developing in Continental Europe to provide an alternative energy source. These projects typically involve a doublet of a producer and injector well, which are typically vertical wells drilled with minimal measurement technology. We discuss how advanced wireline measurements guided the decision making for completion strategy in a sub-horizontal geothermal well in the suburbs of Paris, France, which at the time was a world premiere in geothermal well design. In addition, we will describe how these measurements aided understanding of the overall structural model. The project provided a 150% increase in geothermal productive/injective capacity vs. previous conventional approaches.

The study was conducted in the Cachan project in the Paris Basin, which was developed to provide a city on the outskirts of Paris with geothermal heat. The project targets thin porous oolitic layers within a dolomite formation as an excellent geothermal target to produce from. The well was geosteered with Logging While Drilling (LWD) density images after which wireline Nuclear Magnetic Resonance (NMR) and dipole sonic measurement tools were operationally efficiently conveyed on tractor throughout the long horizontal drain section.
A multi-physics approach combining the density images, high resolution magnetic resonance poro-permeability data and oriented sonic measurements was applied to study the homogeneity of the layers along the well and determine the flow properties and possible compaction effects.

NMR logs were primarily used to assess the porosity and permeability variations of the oolitic reservoirs with high resolution, highlighting the intervals with the highest fluid movability through the thin layers. NMR measurements were also applied to describe the pore system and assess the fluid movability through the thin layers. NMR carbonate porosity partitioning analysis was used to classify rock type with similar reservoir quality and assist with the definition of rock properties cutoffs for development strategy. In addition to typical applications for rock mechanics and petrophysics, the sonic data in combination with the azimuthal density helped explore any possible effect of the proximity of the adjacent layers within the thin oolitic section (in the order of 1 meter). By combining measurements from different spacings and taking the opportunity to analyze the non-standard individual azimuths from the sonic technology, a more detailed structural model was obtained after integration with the density image. This enabled understanding whether permeability variations are truly related to layer variations or a result of the measurements sensing properties of an adjacent layer and defining the heterogeneity of the oolites.

Moreover, the lateral continuity of the layers and structures were captured by exploring the far field sonic reflectors imaged with a dipole sonic source. Multiple reflectors could be traced over hundreds of meters providing not only a good picture of the overall homogeneity but also how layers extended away from the wellbore. This enabled obtaining a detailed understanding of the structures along the horizontal well. Reflectors could be observed up to 40 m away from the wellbore.

Bio:

Erik Wielemaker is a Principal Acoustic Domain Champion for the Eastern Hemisphere with the Wireline product line of Schlumberger. Based in The Hague. He holds an MSc in Geophysics from the University of Utrecht, The Netherlands. He joined Schlumberger in 1997.

Co-Authos Bio

Chiara Cavalleri is a Principal Petrophysics Domain Champion at the Schlumberger Eastern Hemisphere Domain Center in Bucharest, Romania. She holds a B.S. degree in environmental engineering from the University of Pavia (Italy).

Leon Dahlhaus is a Senior Borehole Geophysicist with Schlumberger since 1997 currently based in Aberdeen, UK. He has an MSc in geophysics from the University of Utrecht and an engineering degree in exploration geophysics from ENSPM.

Alejandra Reynaldos is a Senior Geoscientist working for Schlumberger Software Integrated Solutions in The Hague. She holds a MSc in Geosciences from the University of Utrecht, The Netherlands.

Giovanni Sosio is a technical team leader with Schlumberger Software Integrated Solution in Paris. After earning a master's in environmental engineering and applied geophysics from Polytechnic Institute of Milan, he joined Schlumberger in 2005.

Pierre Ungemach is the Chairman of Geofluid. He has a geophysical engineering degree (IPGP, Strasbourg) and MSc degrees in applied mathematical and physical science. He has 40 years of experience in geophysics, hydrogeology, engineering, reservoir simulation, log analysis, geothermal production and maintenance, thermochemical scaling and corrosion processes, geothermal project feasibility, project management and R&D programs. He has been involved in groundwater, hydrocarbons and geothermal resources. He has served as member of the IGA BoD and vice-president of EGEC and has authored more than 50 scientific and technical Publications.

Miklos Antics, presently Managing Director of GPC IP and GEOFLUID France, is a graduate and post graduate reservoir engineer of the Ploiesti (Romania) School of Petrol. Holds a PhD in well testing, multiphase flow and reservoir simulation. Miklos Antics has gained a wide experience in reservoir engineering, simulation, well testing/logging and drilling/production in teaching, field practice and operation management areas. He is currently President of EGEC (European Geothermal Energy Council). Former member of the IGA BoD and past Chairman of the IGA European Branch. He has authored/co-authored over 50 technical papers and four textbooks.

Melanie Davaux is a geologist with structural analysis background and seismic interpretation work experience. Her task focuses on geological analysis, geothermal reservoir simulation (simultaneous heat, mass and solute transport) and well tests analysis. She is involved in feasibility studies addressing the review of well design and exploration/production permitting documents in the deep sedimentary geothermal aquifers in the Paris Basin. She holds two master's degrees in petroleum geology from IFP School and University Paris VI.