NMR contribution in sub-horizontal well for porosity-permeability heterogeneity characterization in limestones: implications for 3D reservoir prediction and flow simulation in a world class geothermal aquifer

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Background

The Paris suburban areas concentrate ca fifty, deep seated, geothermal district heating (GDH) systems which contribute to the French energy climate strategy ambitioning a 6,4 TWh_{th} production in year 2023 achieving a four fold increase as compared to the 1,5 TWh_{th} recorded in year 2016. In spite of a highly dependable geothermal resource, the current 70 MWh_{th} yearly development rate will not meet this objective which would require a six to ten fold higher rate instead. Hence, optimizing and mastering the French geothermal energy problematic stand as a major challenge for France at large, and the Ile-de-France region specifically which hosts a population nearing 12 million inhabitants.

Project descriptions

It aims at reconstructing and simulating the heat and mass transfer in the Paris Basin by implementing an innovative methodology addressing (i) reservoir lithological and petrophysical properties as to facies, porosity and permeability trends, and (ii) modelling, simulating and predicting regional hydrothermal flow patterns and reservoir performance at given locations. As a result the study workflow focuses on an area, South of Paris (Cachan and surroundings), concentrating a population of seventeen (nine producers, eight injectors) GDH wells.

At Cachan a subhorizontal GDH doublet, a world premiere in geothermal well architecture, has been drilled in 2018, seeking enhanced well productivities in medium to low permeability reservoir areas which otherwise would have remained unchallenged. Here, Nuclear Magnetic Resonnance (NMR, T2) logs have been recorded on the injector well (GCAH2), providing reliable information on pore size distributions, (connected vs non connected) porosities and permeabilities.

A variety of wireline logging data ranging from Gamma Ray to density, resistivity, sonic, neutron and NMR T2 tools have been compiled on the nineteen wells of the area along 120 thin sections processed for facies description and nomenclature. A total of seven facies, grouped within four facies associations, coded over the whole nineteen wells according to depths and thirteen 3^d order stratigraphic sequences, have been identified. The cell size of the 3D modelling grid was set to 50 m x 50 m in the XY domain, the vertical Z size, which depends on the subzonal thicknesses, averaging 5 m, thus leading to a 3D grid nearing 800 000 cells. Further to upscaling, facies and stratigraphic surfaces set the basis for a reliable modelling exercise applying the « Truncated Gaussian With Trends » algorithm. The petrophysical distribution « Gaussian Random Function Simulation » is used to populate the entire grid with input properties including some 2 000 NMR data and former porosity-permeability data derived from oil well core plug tests.

The most attractive reservoir properties are located within the shoal oolitic grainstone deposits exhibiting porosity and permeability values overaging 12.5% and 100 md respectively. Ultimately, mass and heat transfers were simulated via the Pumaflow software in order to assess the risks induced by interfering doublets and provide guidelines respective to optimum well trajectories securing system hydraulic connectivities and thermal life.

In this respect NMR, especially permeability issued data, provided useful clues addressing the advent of thermal breakthroughs within areas showing a high density of GDH doublets.

Mots-Clés : Flow simulation, Carbonate, Modeling, Paris Basin, NMR

Merci de ne rien inscrire dans cette zone et ne pas modifier les marges des pieds de page et entêtes.