Facies, porosity and permeability prediction and 3-D geological static model in the Middle Jurassic geothermal reservoir of the Paris Basin by integration of well logs and geostatistical modeling

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In France, heating networks are largely dependent on fossil fuels (42%), and deep geothermal energy represents less than 5% of the energy mix of heating networks. Deployment of geothermal energy in large cities is limited by a geological risk, difficult to predict. This risk constitutes an obstacle to the future development of geothermal energy in the Ile-de-France region. The aim of this work is to develop a predictive 3D reservoir model in terms of stratigraphic geometries, facies, porosity, permeability and temperature at a given location in Ile-de-France. We focus on the main geothermal reservoirs in the area: the Middle Jurassic limestones. In order to create this 3D model, 80 wells (630 logs), drilled over the last 60 years, were studied over an area of 800 km². The first phase of this study consisted in digitizing the old well data, particularly log data on 80 wells (GR, Sonic, resistivity) and adding all recent wells (with neutron porosity and NMR logs). We also compiled from the drilling reports 694 porosity (phi) – permeability (k) values previously measured on cores from plugs, and we imported them into the geomodeller Petrel®. Two reference wells with cores of the reservoir were studied in detail from a sedimentological and stratigraphic point of view in order to link sedimentary facies, logs and phi-k in a well-defined sedimentological framework. We also digitized temperature in 40 wells. The sequence stratigraphy framework allows to define 11 3rd order stratigraphic sequences from the Bajocian (jason Zone) to the Middle Callovian (zigzag Zone). Twelve surfaces from Bj5 to Ca3 corresponding to 3rd order Maximum Regressive Surfaces (MRS) allow to correlate all wells and to define stratigraphic geometries. A total of 10 facies are grouped into 4 facies associations (1) marls of lower offshore (facies association FA1), (2) marl-limestone alternations of upper offshore (FA2), (3) oolitic grainstones of the shoreface (FA3) and (4) lagoon micritic limestones (FA4). These facies associations were coded in all wells according to the log depths. The best reservoir is mainly located in the oolitic and bioclastic grainstones (FA3) with average porosity of 12% and permeability of 130 mD. The lagoon micritic facies also presents interesting properties with average porosity of 8.2% and permeability of 46 mD. The model has been meshed into 6.5 million of cells split on 64 vertical cell layers of 150 m x 150 m x about 5 m (length x width x height) each bearing specific property information (facies, porosity, permeability). The final model shows a high variability of the facies distribution over the
11 depositional sequences. The maximum thickness of the oolitic reservoir is about 50 m in the western part of the study area between surface Bt2 and Bt4. By combining the isopach map of oolitic facies between surface Bt2 and Bt4 with porosity above 10%, permeability of more than 100 mD and temperature larger than 60°C, we locate areas of interest for geothermal development in the Paris Basin.