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Geomechanical characterisation of geothermal exploration borehole: implication for the GEo-01 well, in Geneva

To evaluate the geothermal potential of the Geneva Basin (Switzerland), the GEothermie 2020 prospection program started in 2012 and planned four exploration boreholes targeting various configurations of fault system. The geological characteristics of reservoir's rocks have a strong influence on key parameters that control the productivity of wells, such as good permeability, sufficient flow and heat. They also affect the geomechanical properties of rocks that are important to evaluate in order to develop geothermal projects.

This research aims at providing an initial geomechanical characterisation of the Geneva Basin, more specifically of the fractured carbonates reservoir in the Lower Cretaceous units. This is achieved by the analysis of the borehole images and logging data acquired during drilling operations at the first exploration well, GEo-01, drilled in 2018. The study focusses on the assessment of the fracture distribution, the stress field, and the mechanical properties of the fractured limestone surrounding the borehole.

The analysis of the fractures distribution displays a clockwise rotation of the orientation with depth. Steeper dip angles from 460.0 to 480.0 meters deep and highly fractured carbonates highlight interaction of the wellbore with a faulted zone, which induces discontinuities and local stress heterogeneities in the vicinity of the well. The structural settings crossing the basin thus directly stimulate the development of fractured networks that may act as important hydraulic conduits.

From full-waveform sonic module and density logs, elastic moduli are extracted and reveal strong variations of rock elastic properties according to lithology. These stiffness contrasts could affect the in situ stress magnitude and orientation, and in turn influence fracturing intensity and orientation. An estimation of the stress state of the rocks is realised by a local-scaled geomechanical model, which highlights stress accumulations into stiffer layers.

The evaluation of the fracture slip tendency shows that the localisation of critically stressed fractures is correlated with water inflows. A relation between fracture stability and water circulation could thus exist and influence the reservoir permeability. The latter is moreover largely enhanced by the presence of well-developed karstic networks in the Lower Cretaceous carbonates.

Characterised by a high artesian flow rate, the well's productivity seems, as a result, strongly controlled by the fault system crossing the basin, which influences the fracture distribution and the stress state, and by the large potential of karstification of the carbonates composing the reservoir. The geomechanical and hydrogeological characteristics of this productive aquifer provides thus to the Geneva Basin a good potential for geothermal exploitation. Further exploration boreholes will help to study the hydrodynamic behaviour of deepest aquifers and will enhance geological knowledge to improve the success of future geothermal projects.