Assessment of a geothermal project in a petroleum reservoir using Volumetric and Monte Carlo Methods. Study Case

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The petroleum industry's heavy reliance in Ecuador has hindered the development of geothermal resources. Early studies focused on potential geothermal sites that could generate electricity and identified reservoirs with high temperatures. As the majority of petroleum reserves are concentrated in the east basin of Ecuador and contribute significantly to the country's economic income, the potential for geothermal energy projects has never been considered. This research evaluates the possibility of a geothermal energy project in the Sacha field. The key factors for evaluating such a project include reservoir temperature, geothermal gradient, reservoir pressure, and a conceptual reservoir model that explains the heat sources, recharge zones, and reservoir size. To analyze the potential for geothermal energy generation, data from 19 wells around the Sacha field were used to develop a numerical geological model (see Fig. 1). By employing the T-Navigator software, a conceptual 3D model was created to understand the water source and the underground caprock layers of the Sacha field. The Monte Carlo Volumetric methodology was utilized to calculate the volume and energy capacity in the geothermal reservoir (as shown in Equation 1). The Kozeny-Carmen method was applied to estimate the permeability in some wells where data was not available. Additionally, the heat capacity and thermal conductivity were determined using the Hashin-Shtrickman model. The initial analysis indicated a reservoir temperature of 93.63°C at a depth of 3 km, with a moderate geothermal gradient averaging 30.76°C/km. Two shale layers, Napo-Basal and Napo-Superior, could be used as caprock shale. An aquifer located in the central east part of the reservoir provides water for the reservoir. However, preliminary results suggest that the geothermal energy generated would not be sufficient for electricity generation but could be used for other purposes. The potential geothermal energy available in the project is 7.0924e+12 KJ.

$$Q = A\int_{z0}^{z1} C(z)[T(z) - To]\partial Z \qquad (1)$$

A: is the surface area(m^2); Q: is the heat energy(J); Zo and Z1 are the upper and lower depth limits of the reservoir system (m); C(z): is the heat capacity of the reservoir system changing with depth (KJ/Kg°C); To: Is the cut-off temperature for the planned utilization (°C); and T(z): is the temperature changing with the depth.

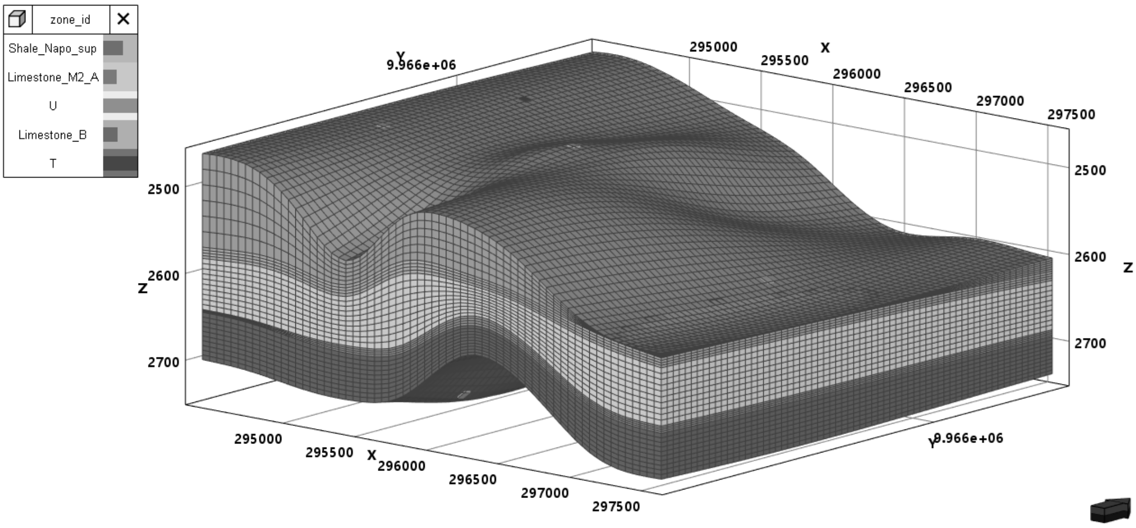

Figure 1. Numerical geological model of the center-east of the Sacha field with the different layers.