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Characterization of geothermal paleosystem in the Lesser Antilles volcanic arc: structural, petrographic, thermodynamic and petrophysics analysis of Terre-de-Haut (Les Saintes archipelago, Lesser Antilles)

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This survey takes part in the GEOTREF project (high enthalpy geothermal energy in fractured reservoirs), supported by the French government program "Investments for the future". The program focuses on the exploration of geothermal resource in the Lesser Antilles volcanic arc. An exclusive license has been issued in the Vieux-Habitants area (Basse-Terre, Guadeloupe) to carry on the development of high-temperature geothermal energy in this active volcanic region.

The deep geothermal reservoir on the Basse-Terre island could be characterized in exhumed paleosystems. The reference paleosystem in the Guadeloupe archipelago is located in Terre-de-Haut.

Four major fault directions have been highlighted N000-N020, N050-N070, N090-N110 and N130-N140. Field observations emphasize three major cleavage directions overlaying the fault systems: N035-N060, N080-N110, N145-N165. Volcanic rocks affected by cleavage display several metamorphic transformation grades. The more transformed calc-alkaline rocks are located at the intersection of several cleavage directions. Mineralogical transformations due to metamorphism and surimposed fractures are also responsible for strong changes of petrophysical properties. In comparison with the reference protolith of andesitic lava flows outcropping in Vieux-Habitants, which have porosity and permeability lower than 5 % and 10^{-15} m2, andesites of Terre-de-Haut have better reservoir properties with connected porosity and permeability higher than 15 % and 10^{-14}-10^{-15} m^2 respectively.

Thermodynamic modelling based on petrography and chemical composition of the most transformed rocks highlights a steady state mineral assemblage between 0.25 – 1.5 kbar and 350 – 450 ˚C. It corresponds to a geothermal gradient higher than 120 to 150˚C/km. This is consistent with temperatures measured in Bouillante wells. However, this geothermal gradient is notably higher to a usual volcanic arc conductive gradient estimated to 70-100˚C/km. It can be explained by the addition of a convective processes caused by hydrothermal fluid flows.