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Structural and thermo-physical characterizations of a potential geothermal system in Basse-Terre Island (Guadeloupe archipelago, Lesser Antilles).

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This study 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 Island) to carry on the development of high-temperature geothermal energy in this active volcanic region.
Although a geothermal plant is currently operating in Basse-Terre since the 80s only few data are available in the study area. Extensive field studies and laboratory analyses were performed to bring out structural, petrological and thermo-physical measurements to develop a conceptual geological model of the geothermal system. Data were acquired on the west coast of Basse-Terre Island and Terre-de-Haut Island where an exhumed geothermal paleo-system was identified in the 80's.
Porosity, permeability, thermal conductivity, specific heat capacity and evolution of paragenesis with advancing hydrothermal alteration were analyzed on more than 100 samples divided in three groups: lava flows and dykes, debris flows and pyroclastics. Fresh samples exhibit two distinct behaviors with: 1) low porosity (4 %), low permeability (0.01 mD) and thermally conductive (1.68 W/m/K) lavas and 2) high porosity (37.5 - 42.3 %), high permeability (56 - 852 mD) and thermally insulative (0.67 - 0.54 W/m/K) debris flow and pyroclastics. On the contrary, advanced hydrothermal alteration tends to decrease significantly thermo-physical properties differences increasing fluid flow properties in lavas and decreasing them in volcano-sedimentary deposits. The progressive transformation of initial minerals with hydrothermal alteration homogenizes the porous network reducing pore throat diameters close to 0.05 μm in every volcanic facies.
Multi-scale structural studies based on aerial photography, high-resolution digital elevation model and outcrop data defined the structural framework of the southern part of Basse-Terre Island and permitted to define precisely the role of fractures and faults on fluid flow for each scale. The N130-150 trending fault family clearly controls the emplacement of recent volcanism. It also controls fluid flows and heat transport associated to N090-110 trending fault family from the active volcano to the island coast where geothermal systems are evidenced by numerous hot springs. Smaller-size fractures mostly caused by cooling of volcanic deposits and faults allow spreading fluid from major structures in volcanic rocks matrix, which are favorable for the major part to fluid storage and flow.
According to our results, Basse-Terre Island presents all the required thermo-physical and structural properties to host several geothermal plays. The volcanic chain acts as a hot water tower spreading fluids in different areas controlled by major faults.