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Multidisciplinary exploratory study of a geothermal resource in the active volcanic arc of Basse-Terre (Guadeloupe, Lesser Antilles)

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The GEOTREF project (high enthalpy geothermal energy in fractured reservoirs), supported by the French government program, "Investissements d'avenir" develops a sustainable geothermal resource in the Vieux Habitants area, 8-km south of the currently exploited Bouillante geothermal field.

The Basse Terre Island is a recent volcanic arc (< 3 Myr) belonging to the Lesser Antilles subduction zone. It is composed of arc typical calc-alkaline volcanic rocks. Outcrops of the studied area consist either of andesitic lava flows, volcanic sedimentary facies or dikes. Field studies allow to propose a structural framework and highlight three major directions N000°E, N050°E and N090°E, which are consistent with the regional tectonic trends of the arc. Petrographical and petrophysical studies displayed that the major part of outcropping facies in the Vieux-Habitants area are not altered. Andesitic lava flows have poor reservoir properties with porosity and permeability lower than 5 % and $10^{-15}m^2$ respectively. These results are in contrast with measurements performed in volcano-sedimentary rocks, which have heterogeneous petrophysical properties ranging from 15 to 50 % for porosity and from $10^{-15}$to $10^{-9}m^2$ for permeability. Such surface data would probably change and decrease when depth increases.

As there is a lack of underground data under the Vieux-Habitants area (wireline, drill core), exhumated rocks outcropping in the northern part of Basse-Terre Island (Basal Complex) have been studied. Such rocks have been identified in the Basal Complex (2.5 - 3 Myr) located in the northern part of the Basse-Terre Island. Previous works have demonstrated a 1000 m/Myr erosional rate, which corresponds at least to a 2 - 3 km exhumation.

The petrography study of the Basal Complex reveals sub-greenschist type mineralogical transformations (chlorite, white mica, quartz...) changing the andesitic protolith in a meta-andesite. This metamorphism forms cleavage plans thanks to a pressure-solution mechanism. Mineralogical transformations associated with these cleavage planes have an impact on petrophysical properties. The solid phase density and porosity decrease. An anisotropy of permeability develops due to cleavage plans. Thermodynamics modelling based on the rock chemical composition and petrography observations emphasizes a steady-state mineral assemblage between 1.5 - 2 kbar and 280 - 320°C. This is consistent with an in situ measured volcanic arc conductive geothermal gradient of 70 °C/km.