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Magnetic mapping for structural geology and geothermal exploration in Guadeloupe, Lesser Antilles

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This work is implemented through the GEOTREF program which benefits from the support of both the ADEME and the French public funds “Investments for the future”. The program focuses on the exploration for geothermal resources in Guadeloupe, Lesser Antilles, where a geothermal power plant is in production since 1986 (Bouillante, Basse Terre).
In Les Saintes archipelago, in the south of Guadeloupe, the outcrop analysis of Terre-de-Haut Island allows to point out an exhumed geothermal paleo-system that is thought to be an analogue of the Bouillante active geothermal system.
We show that a detailed marine magnetic survey with a quantitative interpretation can bring information about the offshore structures around Les Saintes archipelago in order to extend the geological limits and structural elements. A similar survey and workflow is also conducted offshore Basse-Terre where more geophysical data is already available.
In order to correctly link the offshore and onshore structures, the magnetic survey must be close enough to the shoreline and sufficiently detailed to correctly outline the tectonic structures.
An appropriate solution for such a survey is to use a three component magnetometer aboard a speedboat. Such a boat allows more navigation flexibility than a classic oceanic vessel towing a magnetometer; it can sail at higher speed on calm seas and closer to the shoreline. This kind of magnetic acquisition is only viable because the magnetic effect of the ship can be compensated using the same algorithms than those used for airborne magnetometry.
The use of potential field transforms allows a large variety of structures to be highlighted, providing insights to build a general understanding of the nature and distribution of the magnetic sources.
In particular, we use the tilt angle operator to better identify the magnetic lineaments offshore in order to compare them to the faults identified onshore during the outcrop analysis.
All the major faults and fractures directions observed onshore are well represented through the magnetic lineaments except the main N90-110 system which is almost inexistent.
We also invert the magnetic data to obtain a magnetization intensity map. This inversion assumes a constant depth magnetized layer and a constant magnetization’s direction. The calculated variations on the map are consistent with on-field measurements showing that hydrothermalized rocks have a lower magnetic susceptibility (2 orders of magnitude) than fresh ones.
Our interpretation and the onshore structural and petrographic analysis allow us to recognize the offshore extension of the hydrothermalized area, as well as different structural orientations.