Hydrogeological functioning of an andesitic island revealed by helicopter-borne electromagnetic survey (Martinique -Caribbean island)

Benoit Vittecoq, Sophie Violette, Pierre-Alexandre Reninger, Guillaume Martelet

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Water resources exploration on volcanic islands is challenging as these territories frequently face high population densities with increasing water demands. Improving the hydrogeological knowledge of these islands is thus a major objective in order to achieve a sustainable management of their water resources.

We take advantage of a SkyTEM helicopter-borne geophysical survey over Martinique Island (Lesser Antilles) which allow, overcoming dense vegetation and steep slope constraints, providing information's on the first 200 m depth. We conducted multidisciplinary studies at different spatial scales on this subduction zone andesitic island. These studies aimed to interpret resistivity data in terms of hydrogeological structures and properties for constraining hydrogeological conceptual models.

We firstly demonstrated, at the aquifer scale, that heterogeneous hydrodynamic properties and channelized flows result from tectonically controlled aquifer compartmentalization along structural directions imaged by resistivity and magnetic maps. Furthermore, we show that the most fractured compartments have lower resistivity and higher transmissivity. Compartmentalization and transmissivity contrasts thus protect the studied coastal aquifer from seawater intrusion.

At the watershed scale, we put in evidence that the main geological structures lead to preferential flow circulations and that hydrogeological and topographical watersheds can differ, influencing river flowrates. Correlation between resistivity, geology and hydraulic conductivity data of four aquifers also reveals that the older the formation, the lower its resistivity and the older the formation, the higher its hydraulic conductivity. Consequently, unlike hot spot basaltic islands, hydraulic conductivity of the studied aquifers, associated to subduction zone andesitic volcanism, show an increase with age. This enhancement of hydraulic conductivity may be the cumulative effect of tectonic fracturing produced by the recurring earthquakes in this subduction zone.

Finally, our approach allows characterizing the properties of aquifer and aquitard units of Martinique, leading to the proposition of hydrogeological conceptual models that suits the complexity of the island at different scale, with heterogeneous geological formations presenting high lateral and vertical variability. Consequently, our result will allow better constraining future exploration drilling campaigns and led to improve management of water resource.

Primary author(s) : Mr VITTECOQ, Benoit (BRGM & ENS-PSL-CNRS)

Co-author(s) : Dr VIOLETTE, Sophie (ENS-PSL-CNRS & Sorbonne Université); Dr RENINGER, Pierre-Alexandre (BRGM); Dr MARTELET, Guillaume (BRGM)

Presenter(s) : Mr VITTECOQ, Benoit (BRGM & ENS-PSL-CNRS)

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