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Hydrogeological framework of San Cristóbal Island (Galápagos, Ecuador) inferred from airborne TEM and field investigations

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Galápagos Islands owe their existence in the middle of the Pacific Ocean to the joint activity of a volcanic hot spot and the Galapagos Spreading center. They are world famous for their endemic and relatively pristine ecosystems. Yet, the hydrogeology of these islands remains to a large extent unknown. While the vast majority of the archipelago is totally devoid of surface water and faces an acute lack of freshwater, a single island defies the rule: San Cristóbal. Located at the easternmost limit of the Archipelago, it is the unique island with a permanent stream network.

In the frame of the Galápagos Islands Integrated Water Studies project (GIIWS), we conducted a large airborne transient electromagnetic SkyTEM survey over the windward side of San Cristóbal Island. Soundings have been inversed with the Spatially Constrained Inversion procedure (SCI), and post-processed with a newly available code to construct a regional 3D grid of resistivity. In addition to the geophysical investigations, the mapping of streams and fractures has been completed from SRTM DEM and SPOT satellite imagery. Furthermore, a field survey has been conducted to characterize major streams and springs. These datasets have been geo-referenced to be jointly visualized in 2D and 3D GIS softwares.

In the coastal area, we clearly observe a very low resistivity fringe below sea level, gently dipping toward the inland. This is interpreted as the occurrence of a basal aquifer buoying over intruding sea water. Higher inland, most of the springs identified at the surface are related to upslope buried low resistivity bodies, which were subsequently interpreted as perched aquifers. Similarly, we observed a good accordance between the location of the permanent streams and low resistivity gullies in the geophysical data.
In the highlands, a major east-west trending corridor of low resistivity is revealed. It is highlighted by the extraction of volumes based on resistivity threshold on the 3D grid of resistivity. With resistivities ranging from 50 to 120 Ohm.m, this buried corridor presents characteristics close to formerly identified aquifer formations or highly weathered layer. Along the limits of the corridor, volcanic cones identified at the surface imply the existence of dikes, which can behave as barriers to groundwater flow and explain the observed sharp contrasts in resistivity.

Gathering this information, we propose the first hydrogeological conceptual model for San Cristóbal Island based on this integrated study. It is characterized by a basal aquifer subjected to sea water intrusion, and high-level perched aquifers discharging to springs and feeding the perennial streams. Additionally, a potential water-saturated corridor at low depth may be found in the center of the island. Though it requires further validation, this exploratory work shows that starting in a totally unknown environment, we can get valuable insights on the regional hydrogeology through the combination of a large geophysical survey with remote sensing and field data.