Geophysical Research Abstracts
Vol. 14, EGU2012-5571, 2012
EGU General Assembly 2012

Hydrodynamic properties of the basal aquifer of Santa Cruz Island using seismic refraction, Galapagos - Ecuador

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Santa Cruz Island is the most inhabited of the Galapagos archipelago, Ecuador. It faces important water resource problems which might lead to a major impact on their unique and pristine ecosystem, Endangered World Heritage list (2007). The scarcity of geological and hydrological data combined with the difficulty of access for field measurements lead to a poor understanding of the island hydrogeology. The Island is formed by series of thick fractured basaltic lava flows dissected by faults. The low-lying, extensive "basal" aquifer is the unique groundwater body identified on the island. This basal aquifer is subjected to sea-water intrusion, which has been mapped from electrical resistivity imaging with an airborne electromagnetic SkyTEM survey (D'Ozouville et al. 2008).

In order to better understand the hydrodynamic properties of the basal aquifer, we acquired, in summer 2011, geophysical data based on seismic refraction. The experiment was conducted on three study sites located at different altitudes above the see level (Beagle site altitude +7m , Mirador +20m, and Villacis +393m). The P-wave refraction data were obtained using 24 geophones (1 component) and an acquisition system Daklink III. A hammer was used as an energy source. This source was the most environmentally friendly source that could be obtained and used in the Galapagos Island. Geophone spacing for the spreads was 1.2 or 5 m depending on the site.

From our geophysical data, we could identify the different geological layers that constitute this basal aquifer and to estimate the thickness of these layers. We could as well clearly see the water level in the aquifer. More interesting, we found a P-wave velocity of $\sim$1600 m/s in the dry fractured basalt lava flow, and a P-wave velocity of $\sim$2700 m/s in the water saturated fractured basalt lava flow. The same velocity values were obtained in the different sites. This tends to show that the elastic properties of the aquifer are homogeneous and isotropic (at the scale of the seismic refraction experiment $\sim$100m).

In order to interpret the value of the P-wave velocities, we measured in the laboratory the ultrasonic velocities on non-fractured blocks from the field. By, comparing the ultrasonic and the seismic velocities and using an effective medium model, we can estimate a mean crack density and a mean fracture aspect ratio. Finally this allows to estimate the permeability of this fractured aquifer.