A floating transient electromagnetic system to acquire dense data on volcanic lakes
- Investigation of the Furnas hydrothermal system (São Miguel Island, Azores)

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Often geophysical surveys leave out water covered areas due to inaccessibility, leading to a lack of resolution in derived subsurface images and consequently leading to interpretation uncertainty. For measurements on volcanic lakes we used a floating transient electromagnetic system (FloatTEM) composing an in-loop TEM configuration. The current FloatTEM system allows for earth exploration down to approximately 200 m depth but can be modified to a semi-FloatTEM system for deep exploration down to 500 m depth using large sources and mobile receivers. The existing FloatTEM system was successfully applied to image sedimentary deposits of a volcanic maar lake in the Eifel/Germany. Recently, the FloatTEM system was successfully used to image the hydrothermal system and CO₂ outgassing areas of the Furnas intracaldera volcanic lake. The Furnas Volcano is located in the eastern part of São Miguel Island. Volcanic activity is mostly prominent in the northern part of the caldera, where fumarolic fields, thermal springs and intense CO₂ outgassing are the main hydrothermal manifestations. The Furnas lake is roundly shaped and has a diameter of around 1.5 - 2 km. As there were no previous geophysical measurements conducted on the lake, the structures below the lake as well as the extent of the hydrothermal system were unknown.

The floating 18 m x 18 m square measurement system is built of a frame of conventional plastic drain pipes. While on water, the TEM construction is pulled by a boat also containing the measurement equipment. The pipes are tight together using several tow ropes with adjustable tension belts to ensure stability on water. Additional fenders and floats are used to ensure sufficient buoyancy. To allow for enhanced survey speed and dense data acquisition the FloatTEM system was continuously pulled with a maximum speed of 0.2 m/s. During the field survey 52 stations were measured while the boat and the pipe construction were anchored on the lake. In order to provide a dense data coverage in the northern lake area where intense CO₂ outgassing was detected, measurements were conducted continuously while the boat was slowly pulling the FloatTEM system. The continuous driven measurements resulted in around 500 soundings near the fumarolic fields. The exploration depth of the continuous measurements is around 80 m, whereas the anchored soundings provide depth information down to approximately 180 m. We achieved to collect a large and very dense data set, consisting of more than 650 TEM soundings in total on the lake and six land-based reference stations. The data is inverted using conventional 1D inversion schemes. In addition, a 2D modeling study is performed to analyze 2D effects in the TEM data and rule out misinterpretations. The results show a well conducting anomaly in approximately 50 m depth below the water level in the northern part of the lake, that correlates well to the already known CO₂ outgassing anomalies and the hydrothermal system. Towards the main lake in the southern part, the good conductor dips downwards to approximately 120 m depth. This well conducting structure is currently interpreted as the shallow aquifer that feeds the surface hydrothermal manifestations, although other interpretations cannot be excluded. This mobile measurements are a rather new approach for TEM surveys on volcanic lakes, that proved to be a success with respect to survey speed and data coverage.

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