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Electrical geophysical exploration of Lac Abhé's geothermal system, Djibouti

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With the development of geothermal energy in response to the 21st century environmental challenges, it appears that developing geothermal energy in off-grid regions can be a durable investment, providing electricity production and various direct thermal use, and bypassing the usual development of fossil energy in remote areas. In this context, the European Union funded project "Geothermal Village", within the Horizon 2020 LEAP-RE program, aims to set up the geothermal exploration process for isolated areas in the East African Rift Valley. A field mission at Lake Abhé (Djibouti) was set up in late 2021, with geophysical, geochemical and geological researchers, in order to investigate the hydrothermal features of the area and to assess the feasibility of setting up a small-scale geothermal plant for local communities.

The area analysed with electrical resistivity tomographies (ERT) on the lake's eastern shore is characterized by the presence of linear chains of active travertine chimneys built up on top of fluvio-lacustrine deposits. Chimney alignment orientations match those of the major structural lineaments observed through the basaltic units surrounding the lake. The ERT survey was set up with the aim of describing the main accessible fault structures, getting the resistivity information of the local lithologies to calibrate the magneto-tellurics (MT) survey, and getting the chargeability information to describe alteration processes over the geothermally active zones. Profiles of spontaneous polarization have also been done over the majority of ERT profiles.

The method used was technically challenging, because of field conditions (especially because of the very low resistivity top layers) and incompatibilities between the data logger and the cable set. To process the data, pre-processing has been implemented with Python scripts, which allows poor quality data to improve, essentially thanks to geometrical reallocation of electrodes. The injection protocol is a randomized Wenner, in order to minimize noise due to near-electrode polarisation with steel electrodes.

The main results show fault structures, and allow to determine fault offsets for some basalt blocs. It also provides resistivity values for the sedimentary top layer, allowing with the basalt resistivity for a low depth calibration of the MT survey, and a preliminary assessment of the distribution of pore water salinity across the area. The chargeability values are less accurate, showing in the best cases good signatures of the chimney's structure, and demonstrating in the

worst cases the artefact effects of the very conductive values of this salty area.

In conclusion, this survey has faced a lot of technical issues, but the results are defining more precisely the previous surveys done on this area. The results can be used for geothermal modelling (describing the fluid path within the reservoir and along the chimney's structures), water exploration (with the salinity assessment), and geotechnical safety (depth of hardened rock for drilling).