Geophysical 3D modeling of kamafugite using audiomagnetotelluric (AMT) data for phosphate prospecting in the Alto Paranaíba Igneous Province (APIP), Central Brazil

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Abstract

The project aims at the structural 3D modeling and delimitation of kamafugitic volcanic rocks in the Alto Paranaíba Igneous Province (APIP), in central Brazil, using audiomagnetoteluric (AMT) data. This method enables the analysis of the electrical conductivity structure beneath the subsurface, which, in theory, would outline geoelectrical contrasts between eocretaceous fluvio-deltaic and aeolian siliciclastic rocks of the Areado Group and volcanic rocks belonging to the Mata da Corda Group, just above the basement i.e., the neoproterozoic Bambuí Supergroup, in the stratigraphical context of the Sãofranciscana basin. Lithological analysis of core and outcrop rock samples were also considered and will be useful in a future correlation of generated geophysical models and log descriptions.

AMT is a passive, non-invasive, frequency dependent method capable of estimating the distribution of electrical resistivity inside the Earth through measurements of the natural temporal variations of electric and magnetic fields, whose signals come mainly from atmospheric activities, such as electrical storms. AMT is commonly applied in shallow subsurface studies and has previously been used to investigate geoelectrical signatures of kimberlitic occurrences in the western Minas Gerais area, besides further mineral exploration studies. Our main objective is to delineate the 3D structure of the kamafugitic rock, by means of analyzing geoelectrical contrasts between the volcanic manifestation, within the study area, and surrounding lithotypes. The methodological proposal presented here would be unprecedented, since, in the literature, there are no works correlating the use of AMT to ultrabasic alkaline rock exploration, such as the kamafugite case.

As for the geological material at matter, which stems for significant phosphate content, kamafugites are a very rare alkaline mafic to ultramafic volcanic group of rocks, with ultrapotassic composition and occurrence restricted to very specific areas worldwide. In Brazil, these rocks can be found in the Alto Paranaíba Igneous Province (APIP) in Minas Gerais state and in the alkaline province of Goiás.

So far, we have obtained ten preliminary 2D geoelectrical sections displaying the conductivity distribution of volcanic and sedimentary rocks in subsurface, up to 600 m in depth, approximately. Data acquisition was taken in 184 AMT stations, which were arranged in ten N-S sections, totaling 26.1 linear km in length. The survey used the ADU-07e (Metronix Geophysics). For data processing and inversion procedures, we have used the procedures described in Egbert (1997). To estimate the transfer functions i.e., impedance tensor and tipper, the robust method of Egbert & Booker (1986) was used. An additional field campaign was held in March 2023, in which several measurements of magnetic susceptibility and electric resistivity were acquired from borehole samples. This dataset will be used to refine and improve the sections previously generated, to better depict the main geological features of the area. Soon, we intend to obtain, by means of 3D modeling, the top and bottom limits (thickness) of the kamafugite body and its surrounding rocks, as well as its lateral discontinuities.

The study is being carried out in partnership with Sirius Pesquisas Minerais Ltda. company, that provided us with a study area, research-wise.