3D imaging of electrical conductivity structures in the Eastern Cheb Basin across the Hartoušov and Bublák mofettes

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SUMMARY

The mofette fields of Bublák and Hartoušov are among the most prominent CO_2 degassing centers in Europe, which are locacted in the Cheb Basin, a shallow Neogene intracontinental basin in the western part of Czech Republic. The massive degassing of CO_2 in the Cheb Basin, especially in the mofette fields, originates from great depths. These mantle/lower-crustal derived fluids might use fault zones for their ascent. In addition, Quaternary volcanoes were discovered in the area; their magmatic ascent paths and the interaction of the other deep magmatic processes as well as the observations at the earth's surface such as mofettes are not yet fully understood. With our research, we would like to contribute to a comprehensive and holistic interpretation of the tectonic regime, and image the ascent paths of fluids. In this context, the magnetotelluric (MT) method was applied which is sensitive to electrically conductive phases such as brines and fluids, partial melts or metallic compounds. We expect that the pathways for fluids from the mantle towards the mofettes have a much higher electrical conductivity than the surrounding crystalline rocks. As part of an ICDP drilling programme, two overlapping experiments along a regional profiles were conducted and one local grid of MT stations were measured in the Cheb basin close to mofette fields. The local dense grid of 97 MT stations, the scope of this work, has an average sites spacing of 500 m. We measured five component broad-band MT data in a frequency range of 0.0001–1000 s with an average recording time of three days. Unfortunately, there are many man-made electromagnetic noise sources such as power plants, DC electrified railways, and the heavily populated study area with its infrastructure. These disturbances had to be removed from the recorded data within the course of data processing prior to any modelling and inversion. It was finally possible to improve the data quality to 1s by advanced processing approaches. The presented high resolution 3D image of the electrical conductivity of the area surrounding the mofettes matches with available drill logs from the Czech Geological Survey and the previous geophysical studies. A shallow high resistivity layer is related to Quaternary deposits NE of the mofette fields. The high conductive layer around and beneath the mofettes might be related to the ascent paths of fluids. A prominent contrast between the sedimentary and the phyllitic-granitic basement can be observed. Large-scale regional models hint at deep reaching pathways fostering the ascend of mantle derived fluids into the regions of mofettes and swarm earthquakes. However, The most prominent large-scale conductivity features of the other two regional models are several channels from the lower crust to the surface, possibly representing pathways for fluids into the earthquake swarm region, mofette fields, and known spas. However, such a conductive channel is absent in our local model beneath the surface expression of the mofettes. To assess whether the experimental layout, the reduced data quality or inversion issues are responsible for the lack of such an ascending pathway, or if fluid migration in this area is rather horizontal than vertical, we applied synthetic inversion test. Results from synthetic modelling studies and available geoscientific constraints hint that such a channel might exist directly beneath the mofette field. Still, it seems to be challenging to resolve due to the given data quality, station distribution, and the subsurface conductivity structure within a conductive sediment basin.

Keywords: Magnetotellurics; West Bohemia; Earthquake swarm; Fluids; 3D inversion