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Shallow water radio-magnetotelluric (RMT) measurements in urban environment: A case study from Stockholm city

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The Radio-MagnetoTelluric (RMT) method uses the electromagnetic signal from distant radio transmitters in the frequency range 15 to 250 kHz. RMT applications in near-surface studies have already been well established. Two components of electric field and three components of magnetic field are measured. These measured components are related to each other via transfer functions which contain detailed information about the variation of electrical resistivity of the subsurface.

The present study is carried out in the frame of TRUST (TRansparent Underground STructure) project supported by several research and public organizations as well as industry. The study area is located close to central Stockholm in Sweden where the Swedish traffic authority has planned to construct a 21-km long motorway to bypass the city. In order to reduce the impact on natural and cultural environments, 18 km of the motorway will be located in tunnels. The main objective of this study is thus to identify potential fracture zones and faults as well as the general geological settings. The proposed path of the tunnel partly passes under the Lake Mälaren at a depth of about 60 m. Thus a challenge was posed on the applicability of RMT method in shallow water environments. Successful applications of RMT measurements using the Uppsala University's EnviroMT system on land encouraged us to modify the system to acquire data over lake water especially in urban areas. Pioneered by the Geological Survey of Sweden (SGU), RMT data were collected over the Lake Mälaren in spring 2012. The prototype acquisition system did not only turn out to be appropriate for such a challenging environment, but it was also much more efficient as compared with land surveys. Fifty two lines including 1160 stations with an average spacing of 15 m were covered in three days.

Cultural noise associated with the city-related environment had to be identified and filtered out before inversion could be carried out. Reliable estimates of the impedance tensor were obtained by the parametric representation combined with a Truncated Singular Value Decomposition (TSVD) regularization of Bastani and Pedersen (2001). The processed data were then inverted to obtain 2D resistivity models. The resulting models along 23 lines correlate well and image variation of water depth, thickness of subaqueous sediments as well as the depth to crystalline bedrock. Low resistivity zones observed in the bedrock coincide well with the low velocity zones identified in refraction seismic surveys available along the RMT lines, indicating the presence of possible fracture zones in the bedrock. The experiment illustrates that the RMT methods can be well adapted to this type of environment; it is fast and cost-effective in shallow water especially in urban settings.

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