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CSRMT Survey on Frozen Lake - A New Technique with an Example from the Stockholm Bypass Tunnel

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Summary

More than 7% of the Scandinavian landmass is covered with fresh-water bodies in the form of lakes and rivers. This poses a unique challenge to carry out electromagnetic survey on shallow-water bodies for various purposes for example geotechnical investigations. Recently boat-towed RMT (radio-magnetotelluric) technique was introduced and used for measurements over the Lake Mälaren in Stockholm, Sweden. The RMT covers a wide range of frequencies (10-250 kHz) and provides good resolution for shallow subsurface studies although it lacks resolution at greater depths. Using controlled-source frequencies in the range of 1-10 kHz sufficient penetration depths can be achieved for most of the near surface targets. In this study, we present the results from the combined use of controlled-source and RMT (CSRMT) data that were obtained over frozen Lake Mälaren. The objective of this study was to map bedrock surface and fractures in the middle of the profile where using only RMT data these were not adequate. We demonstrate a new technique where CSRMT surveys were carried out over frozen-shallow-water bodies and we expect the idea to be used in the near future for other applications where moderately-resistive water bodies are present.

to bedrock in the middle of the profile is also supported by the initial results from the reflection seismic section available along L4 (Nilsson, 2008).The nearest control source station on profile 4 is located at a distance of 460 m and the farthest is located at 670 m away from the source. Thus a possible near-filed effect (NFE) can be observed at the north-western side of the profile that is closer to the source station, and requiring to be fully investigated in further studies.

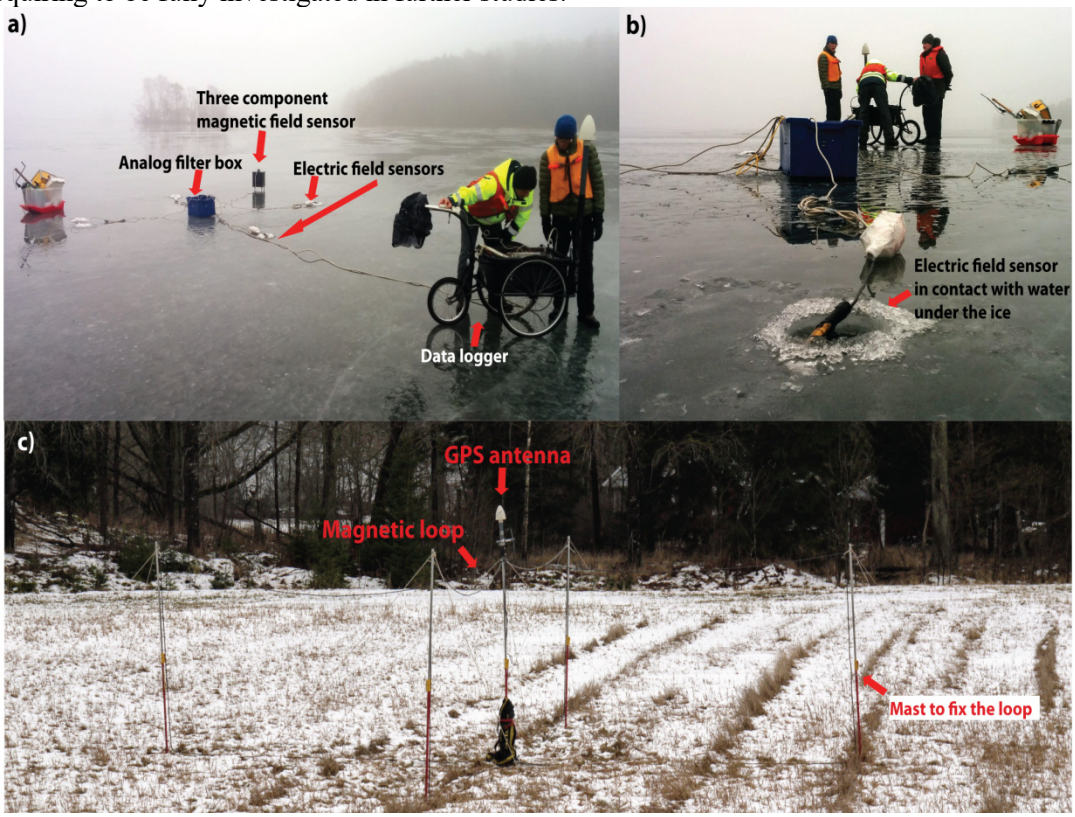

Figure 2 *(a) Photo showing the EnviroMT CSRMT field setup while measuring on the Lake Mälaren near the city of Stockholm, Sweden. Different components of the setup are also shown. (b) A close look at the drill hole made in the ice crust for making the electric electrode contact with water. (c) The setup of the double magnetic dipole transmitter (source).*

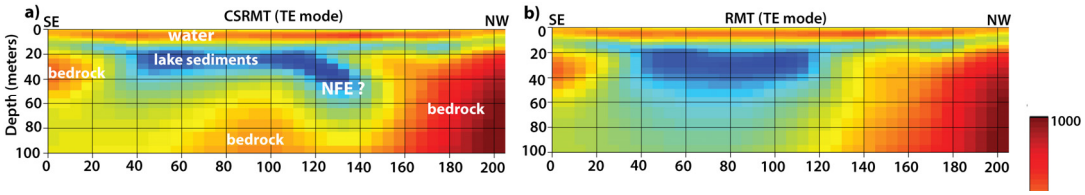

Figure 3 *2D inversion results of CSRMT and RMT dataset. (a), (c) and (e) are CSRMT models corresponding to TE, TM and joint TE+TM modes, respectively. (b), (d) and (f) are RMT models that correspond to TE, TM and joint TE+TM modes, respectively. The location of the controlled-source stations along the profile is marked by '*' in (e).*

Conclusions

For the first time CSRMT data over a frozen-water body was acquired successfully in an area close to Stockholm City. The main objective of this study was to resolve the bedrock surface and possible fracture zones within it where previous RMT data collected at the same area were incapable of resolving such a details. Variation of the modelled resistivity well correlates with the results reported in the previous studies, available boreholes and seismic data. Quality of the CSRMT data collected was in general good although at some stations closer to the transmitter near-field effect could be expected. Future studies will employ all controlled-source stations for modelling along with the other available geophysical data such as reflection seismic, to obtain a wider perspective in understanding geometry of the fractured bedrock at this site where part of the Stockholm bypass tunnel will be constructed.

Acknowledgements

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