Study of Integrated Geophysical and Geological Research Methods on Mapping Weakness Structures in Bedrock at Urban Areas

Introduction

In year 2013 was started a short project where the idea was to test different ground geophysical methods for mapping weakness structures in bedrock at Helsinki Capital region. The main idea of the project was to develop integrated geophysical and geological research methods for the urban studies to detect fracturing and orientations of it if possible in the bedrock. One site where the methods were tested is briefly presented here. The site is called Hannusjärvi and it is located in the route of second phase of West Metro line in the City of Espoo in Finland (Figure 1).

The geological interpretation in this project is mostly based on the existing data and interpretations. The West Metro Project in Espoo distributed to this project bedrock drilling data from the Hannusjärvi area.

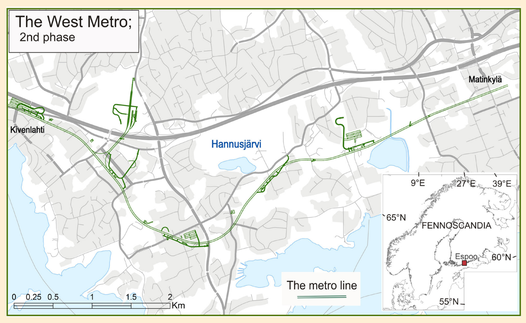

Figure 1 The second construction phase of the West Metro from Matinkylä to Kivenlahti in Espoo, southern Finland. In the middle of the figure the Hannusjärvi area. Topographic data © NLS and HALTIK.

Methods

The Figure 2a presents the interpretations of weakness zones produced in two old projects. The prevalent fracture directions in bedrock were detected using trend analysis of aeromagnetic high-resolution data (Figure 2b). An association between the orientation magnetic trend lines and the orientation of joint sets has been detected. The susceptibility change in the data has been connected to weathering processes.

The ground geophysical methods utilized and tested together with geological mapping at the test area can be seen in the Figure 3. Figure 4 shows example of the measurements at the example profile L1 visualized more details.

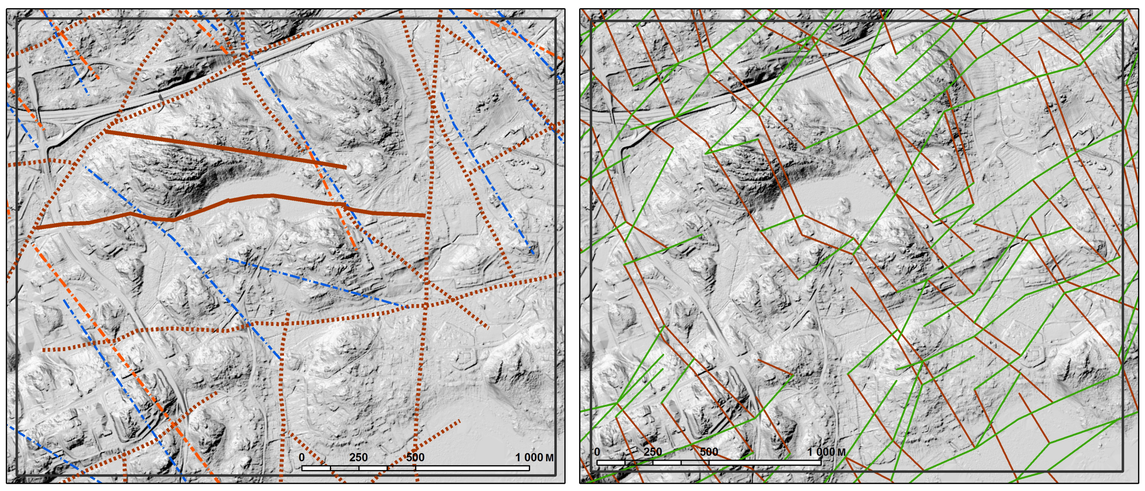

Figure 2 a) Solid brown lines express zones observed at the field and dotted brown lines show zones interpreted using aerogeophysical data and topographic models combined with structural geological analysis. Orange (interpreted from magnetic data) and blue (interpreted from different DEM data) dotted lines show NW-trending brittle normal faults which have been observed to be connected with NW-trending vertical to gently sloping fractures. Laser scanning data © National Land Survey of Finland 2015.

b). Local trend analysis of magnetic data for the Hannusjärvi area (in the middle) shows systematic orientation in northwest (NW) and northeast (NE) trends. LIDAR data © National Land Survey of Finland, 2015.

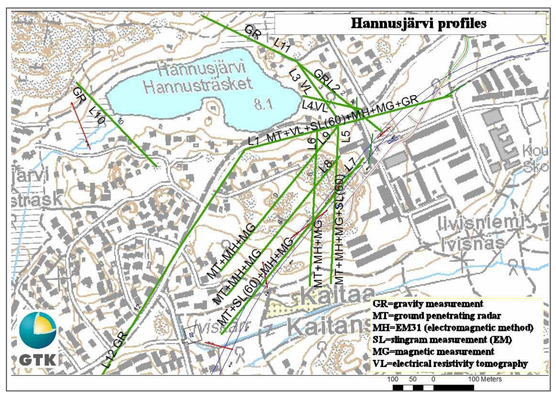

Figure 3 Planned profiles at Hannusjärvi area. Basemap © National Land Survey of Finland and HALTIK 2016. Red marks are drillings.

Figure 4 GPR measurements on Hannusjärvi profile L1. Photo by Marit Wennerström, GTK, 2013

Conclusions

The combined geological and geophysical interpretation illustrated in the Figure 5 gave promising results and new information about the possible fractures and weakness zones in the vicinity of the new metro line.

ERT method worked best for detecting fractures in bedrock in the places with thin soil cover. It also gave a hint of the dip of the bigger fracture boundaries. GPR data gave detailed information about the fractures in the bedrock and it helped in the estimation of the continuation of the fractures visible at outcrops. The ongoing excavation of the metro tunnel gives data to verify the geophysical and structural geological interpretation made in this project.

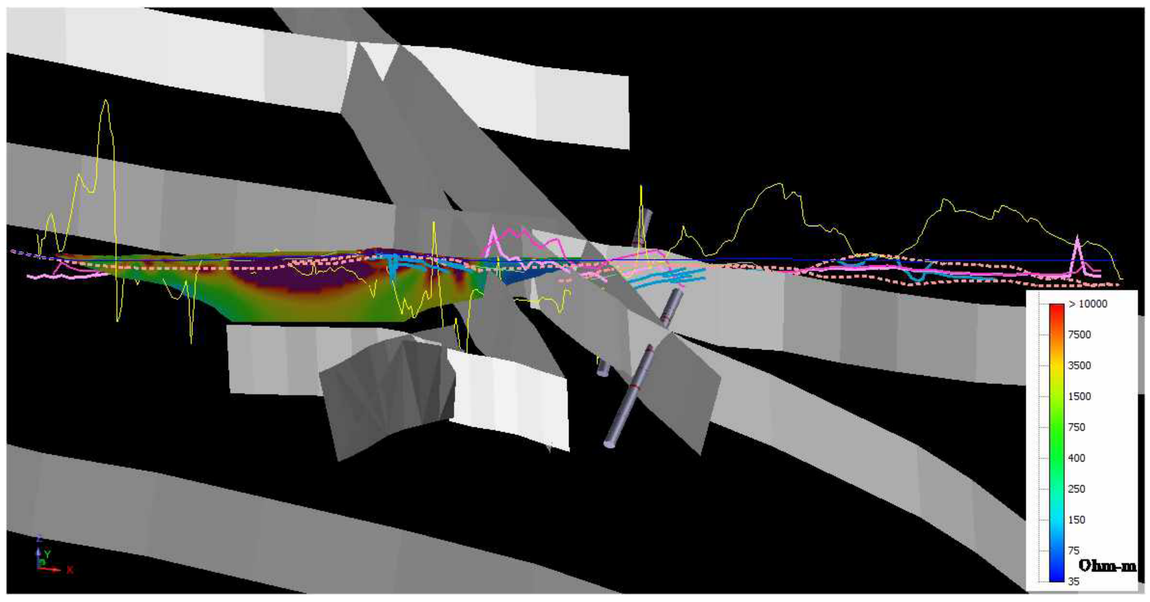

Figure 5 Combined data and interpretations on Profile 1 (Figure 3). The ERT interpretation on profile one has been presented in colours. Yellow colour is magnetic anomaly (min 50941.5 nT, max 52649.7 nT), blue lines are interpreted fractures in the bedrock measured by GPR (100 and 200 MHz). Light orange colour is bedrock topography interpretations from gravity and GPR measurements. Purple colour is EM-31condV and pink is condH. Light grey planes are observed and interpreted weakness zones (Figure 2a) and drill holes with red fracture zones are illustrated with darker light colour.

Acknowledgements

We thank the City of Espoo for organizing us an opportunity to use the site for testing and letting us use the data collected during the planning project. We would also like to thank all people who participated to the project in the field and in the office.

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