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Combined tunneling site investigations with resistivity and refraction seismic in urban underwater environments

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Geophysics can provide important information of underground structures which is beneficial in tunnel construction, but will they work where we need them the most? In the heart of our cities and under water.

Purpose

Due to expanding cities and increasing population infrastructure needs to expand in a safe and sustainable way with little effect on the environment and economy. Years of urbanization doesn't make it easy though, no free spaces are available and culture marked buildings are everywhere. The only alternative left is to construct in layers. Roads and other kinds of infrastructure beneath ground level are therefore attractive and promotes sustainable development. Stockholm is just one of many expanding cities with surroundings of water and there is a high probability that new infrastructure will have to cross straits. With the help of geophysics, underground structures can be mapped, but will they work in these noisy and challenging, urban underwater conditions?

Method

With the use of two different geophysical methods, resistivity (ERT) and refraction seismic, four different underwater areas have been investigated focusing on locating the hard rock surface and weakness zones. The aim of the project was to find differences and similarities between the methods and determine if the they are suitable for urban underwater surveying. The areas of investigation are located both in fresh in Mälaren and saline water in Saltsjön.

The two methods differ from each other by measuring different physical properties of the ground. The resistivity method uses electricity to determine the composition of the ground resistivity while refraction seismics uses mechanical waves to determine the velocity composition.

Result and conclusion

The results from the four investigation lines show both similarities and differences of the methods when comparing potential weakness zones and the hard rock surface. This was expected since resistivity and refraction seismic investigates different properties of the ground and therefore can observe different structures. Both methods show a good estimation of the hard rock surface when compared to probes in the area.

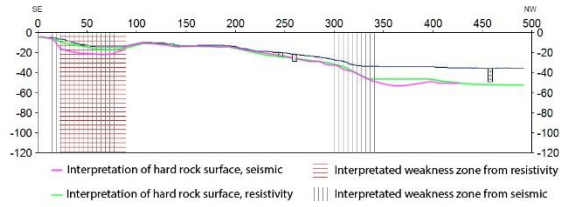

Figure 1 - Hard rock surface and weakness zones interpretations of resistivity, seismic and probes.

The resistivity method generally shows a more elevated hard rock surface level than the seismics due to the different interpretation of geological structures, such as till or weathered hard rock.

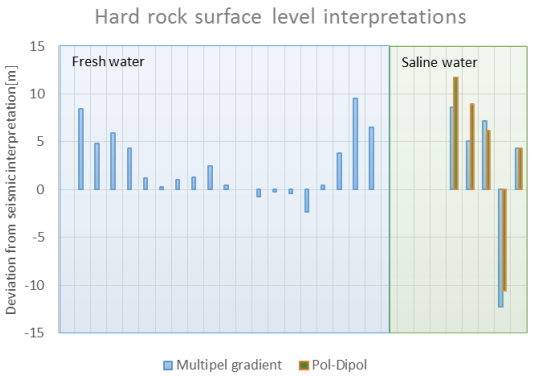

Figure 2 - Deviation between resistivity and seismic interpretations of hard rock surface level. The seismic interpretation is represented by the value of

'0' on the y-axis. A positive bar means a more shallow interpretation of the resistivity.

Noise from the urban area was a problem that easily could be reduced by measuring during nighttime. Movements creating vibrations in the ground effects the seismic data while the subway probably is the No.1 source of noise in the resistivity data, this since it uses a strong direct current to power its motors.

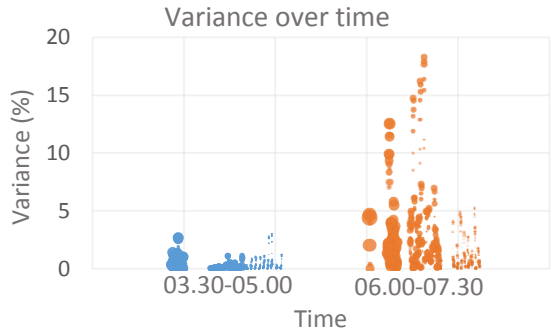

Figure 3 - Comparison of variance caused by noise from the area between two resistivity measurements, one during nighttime and one during the morning rush. The size of the data points represent the distance between the current electrodes. The larger the point, the greater the distance.

Some difficulties were found in surveying resistivity in saline water since it´s high conductivity properties reduced the depth of investigation. Another complication was the presence of gas in the sediments that affected the seismic data by damping the signal and complicating the analysis. Since the two methods are based on different theories and therefore show different strengths and weaknesses the authors recommend using both methods when doing complicated surveys like those done in this thesis, both for verifying and supplementing each other's result.