Near-surface Geophysical Investigations

Improving decision making in geotechnics

Near-surface geophysics

Geophysical surveys are valuable for mapping the subsurface in a non-invasive manner. By employing different methods, our expert geophysicists provide valuable insights into sub-surface conditions and structure, helping clients make informed decisions in their projects.

Applications range from geology, infrastructure, mining, and environmental mapping to building and construction projects.

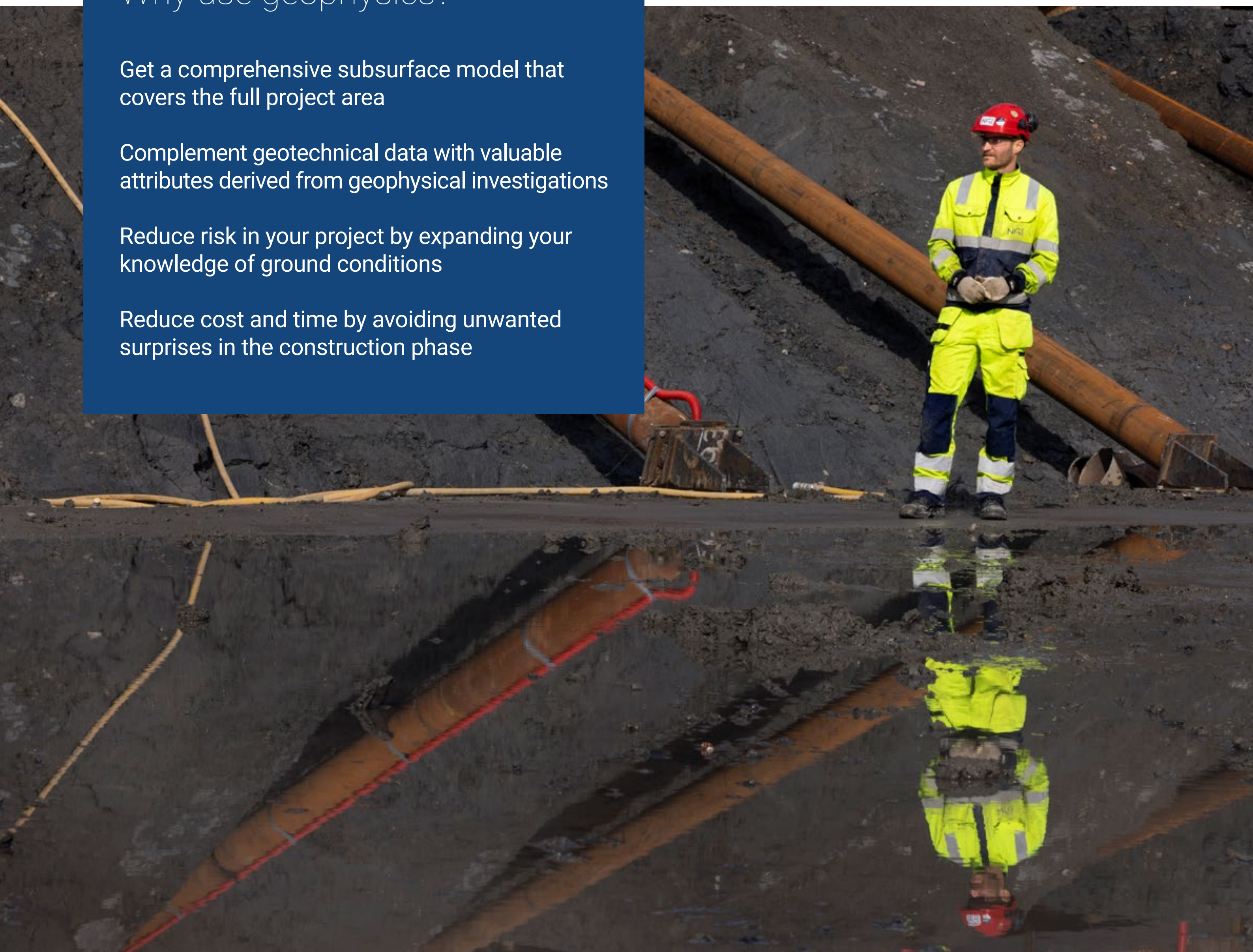
Why use geophysics?

Get a comprehensive subsurface model that covers the full project area

Complement geotechnical data with valuable attributes derived from geophysical investigations

Reduce risk in your project by expanding your knowledge of ground conditions

Reduce cost and time by avoiding unwanted surprises in the construction phase



Benefits of choosing NGI

By choosing NGI, you benefit from a trusted partner that will help you address your geotechnical challenges effectively.

1 Leading Expertise

NGI boasts a long history and a team of highly skilled experts in geophysical and geotechnical engineering, providing in-depth knowledge and experience

2 Customer focus

NGI seeks to find the optimal solution to your challenge by leveraging a wide range of methods within its broad geophysical expertise

3 Comprehensive Services

From site investigations and risk assessments to design and monitoring, NGI offers a wide range of services tailored to meet your specific needs

4 Commitment to Quality

NGI is dedicated to delivering high-quality services and maintaining the highest standards of professionalism

5 Cutting-Edge Research

As a leading research institute, NGI stays at the forefront of geophysical advancements, ensuring innovative solutions

Methods

Near-surface geophysical investigations involve a range of methods, each sensitive to a specific physical property of the subsurface. The optimal method for a given problem is also determined by the required resolution and depth of interest.

The following section introduces the methods most commonly used by NGI, though other techniques can be utilized when necessary. NGI's experts assess each request individually and design a tailored ground investigation to deliver the most valuable results.

Seismic

All seismic methods are based on generating a seismic signal that propagates into the subsurface and is later recorded by receivers (geophones). The signal's properties can then be used to calculate the depth of geological layers and their mechanical properties.

NGI has developed its own seismic source for use in urban environments

NGI performs different types of seismic surveys depending on the site specifications and project requirements.

Mapping bedrock depth is the most common application for **refraction seismic**. An advanced tomographic inversion is applied to travel times picked from seismograms which results in a velocity model along the seismic profile. Zones of lower bedrock velocity may in addition indicate weakness zones and fractures.

Reflection seismic is a valuable tool to image geological structures and does not rely on an increase of seismic velocity with depth (which is a pre-requisite for the best refraction seismic results). Reflection of the seismic signal occurs at interfaces where there is a contrast in the mechanical properties, such as a stratigraphic layer boundary. Reflection seismic is typically better suited for deeper targets.

Multichannel Analysis of Surface Waves (**MASW**) is a method that measures surface waves, particularly their velocity dispersion. Inversion of the dispersion curves yields a vertical shear wave velocity (Vs) profile of the near-surface layers, providing essential information for geotechnical applications. Combined with geotechnical data the results can be used to calculate the elastic parameters of the near surface.

In addition, boreholes can be utilized for a variety of seismic surveys. **Downhole seismic** is an effective tool to obtain in-situ compressional- and shear-wave profiles. **Vertical seismic profiling (VSP)** or **crosshole seismic tomography** complement surface-based methods and enhance the vertical resolution and accuracy of subsurface parameter estimates.

Electrical methods

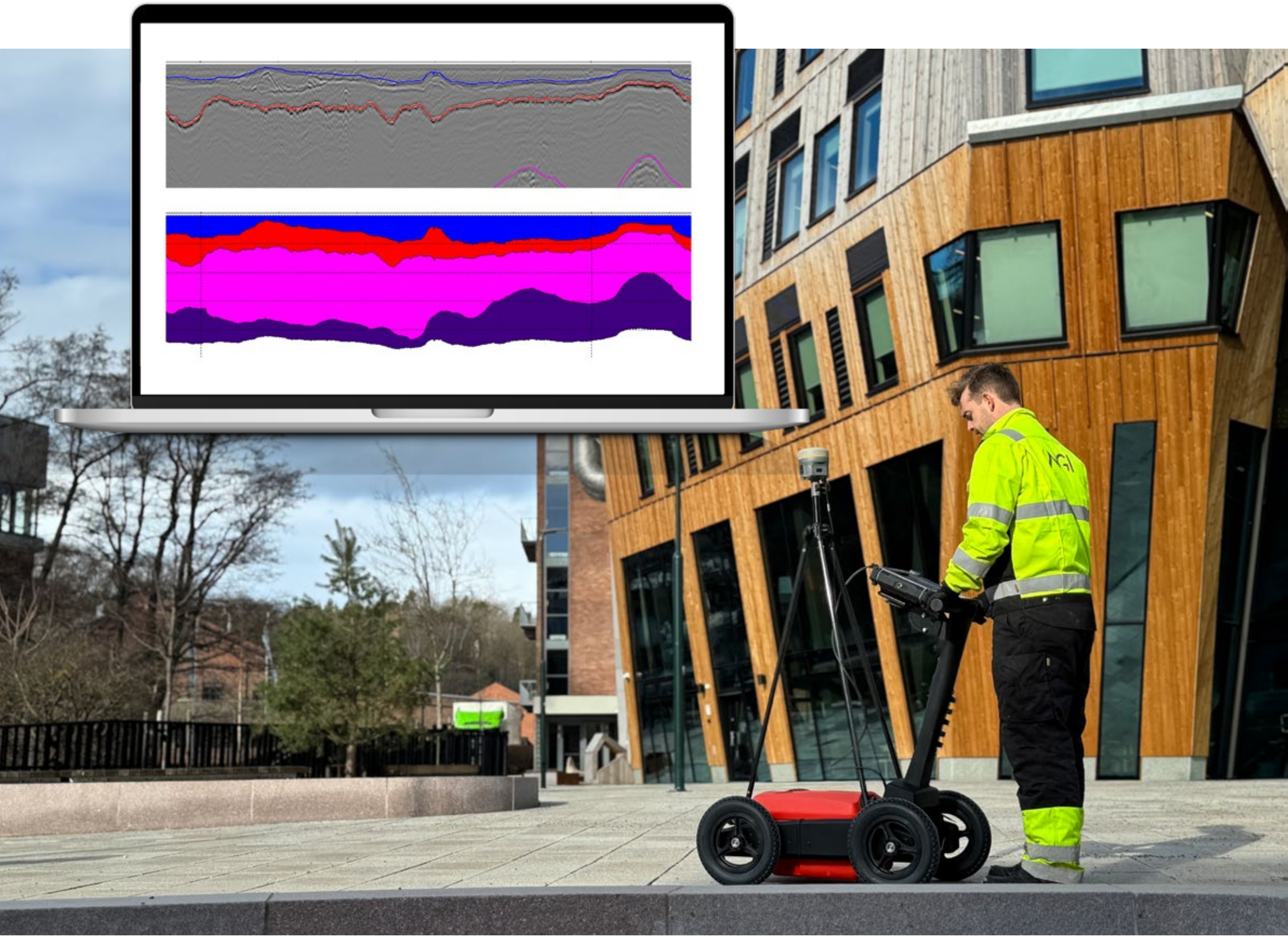
Electric Resistivity Tomography (ERT)

ERT is a valuable tool for mapping bedrock, groundwater and pollution, or for mineral exploration. ERT works by placing electrodes in the ground and injecting an electric current. Measuring the electric potential difference between pairs of electrodes yields apparent resistivity values. These values are then used in an inversion to obtain profiles that show the resistivity distribution in the ground. Differences in lithology or fluid saturation can then be deduced from these tomograms.

The Induced Polarisation (IP)

This method measures the chargeability of the subsurface by measuring the decay of the potential difference. This method can be combined with ERT measurements to provide additional constraints to the interpretation, making it easy to differentiate clay from, for instance, saturated sands.

Ground penetrating radar



Ground Penetrating Radar (GPR)

GPR is an electromagnetic method for mapping underground structures and materials. It has higher resolution than seismic methods, making it particularly relevant for mapping subsurface utilities, but also shallow bedrock and stratigraphy. The penetration depth is however less than with seismic methods and highly dependent on ground conductivity and heterogeneity as well as signal frequency and bandwidth. Under most ground conditions the penetration depth is limited to a few meters, in others it is possible to image to greater depths.

GPR data acquisition is faster than other geophysical methods, and advanced 3D antenna arrays make mapping large areas feasible. A transmitter antenna emits an electromagnetic signal that propagates into the ground and is reflected off objects or interfaces that have a contrast in electrical properties. The reflected energy is then recorded on the receiver antenna, creating an image of the subsurface.

Borehole logging

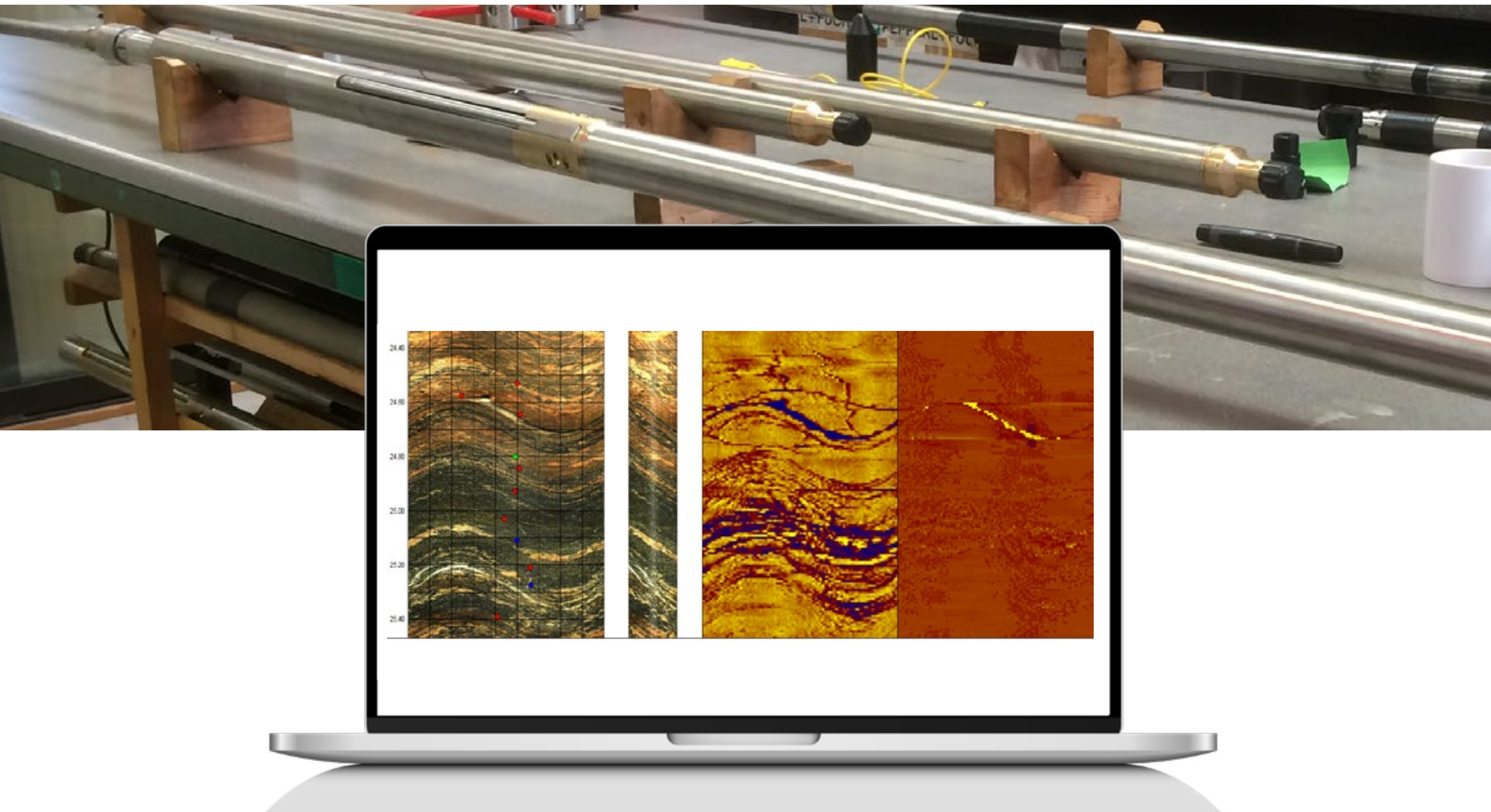
Borehole logging can provide extensive additional insight from boreholes. It is a powerful tool for locating fractures or weakness zones, defining lithology and structural orientations, deriving the chemical profile of the borehole water and obtaining physical parameters of the borehole wall.

Every sonde in the list on the right hand side can provide one or several measurements along the borehole. A sonde or a stack of sondes are connected to a winch and lowered down into the borehole to a maximum depth of 500 meters. The data recorded by the sonde is viewed in real time.

The data is recorded and viewed in real time and later processed and combined into a complete analysis based on all the different sondes. Combining multiple logs yields a more complete picture of the borehole properties.

NGI offers a large variety of borehole measurements using different sondes:

- Inclinometer
- Natural gamma
- Spectral gamma
- Magnetic susceptibility
- Resistivity (DLL3)
- Water chemistry
- Water flow (heat pulse flow meter and impeller)
- Density
- Sonic velocity
- Optical televiewer
- Acoustic televiewer
- Borehole radius (caliper)



Applications

Near-surface geophysical methods provide valuable insights for various sectors:

- **Transportation Infrastructure**
- **Construction**
- **Natural Resources**
- **Environment & Sustainability**

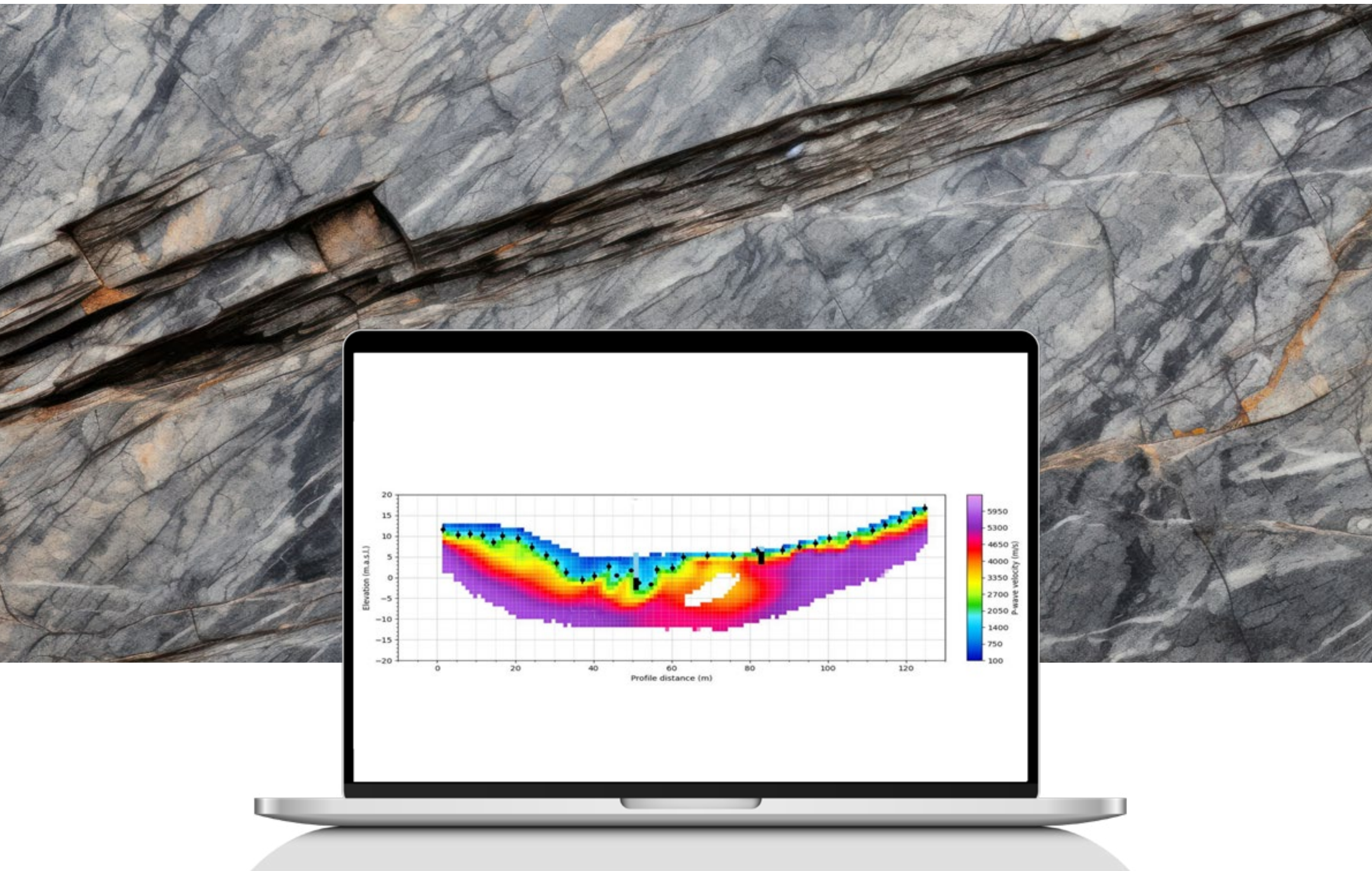
Applications range from assessing the soil stability for infrastructure and construction projects to mapping subsurface utilities or investigating groundwater resources.

Environmental impact assessment is a fundamental challenge in many contexts – be it underground contamination associated to landfills and mines, or natural hazards such as slope stability or quick clay mapping.

Mapping bedrock topography and quality

Knowledge of bedrock topography is essential for many construction and infrastructure projects. Drilling provides the most accurate way to measure bedrock depths but has several limitations. It is expensive, difficult to accomplish in urban as well as remote areas and - most importantly - it only represents the ground conditions at the drill site.

In contrast, geophysical methods such as seismics or ERT allow the bedrock to be mapped across the entire project area. In addition, zones of fractured bedrock and faults can be identified using the same method and data. Using sophisticated seismic survey design and processing algorithms, geotechnical parameters can be estimated, making geophysical surveys even more valuable. Validating geophysical results with less drillings then provides a comprehensive and reliable result, reducing the risk and cost for your project.



Soil investigations – Mapping quick clay

Accurate soil layer discrimination is essential for safe and efficient construction projects. Understanding the subsurface conditions helps engineers design appropriate foundations, prevent settlement, and mitigate potential risks.

As an example, quick clay can pose a serious risk to construction and infrastructure projects.

Knowledge of the amount and extent of quick clay in your project area is crucial to planning and implementing countermeasures such as soil stabilization.

Geophysical methods can provide additional data that can help with interpretation of quick clay zones. Rapid and cost-effective techniques such as electrical resistivity tomography (ERT) combined with induced polarization (IP) can help identify areas with quick clay – in a non-invasive manner.

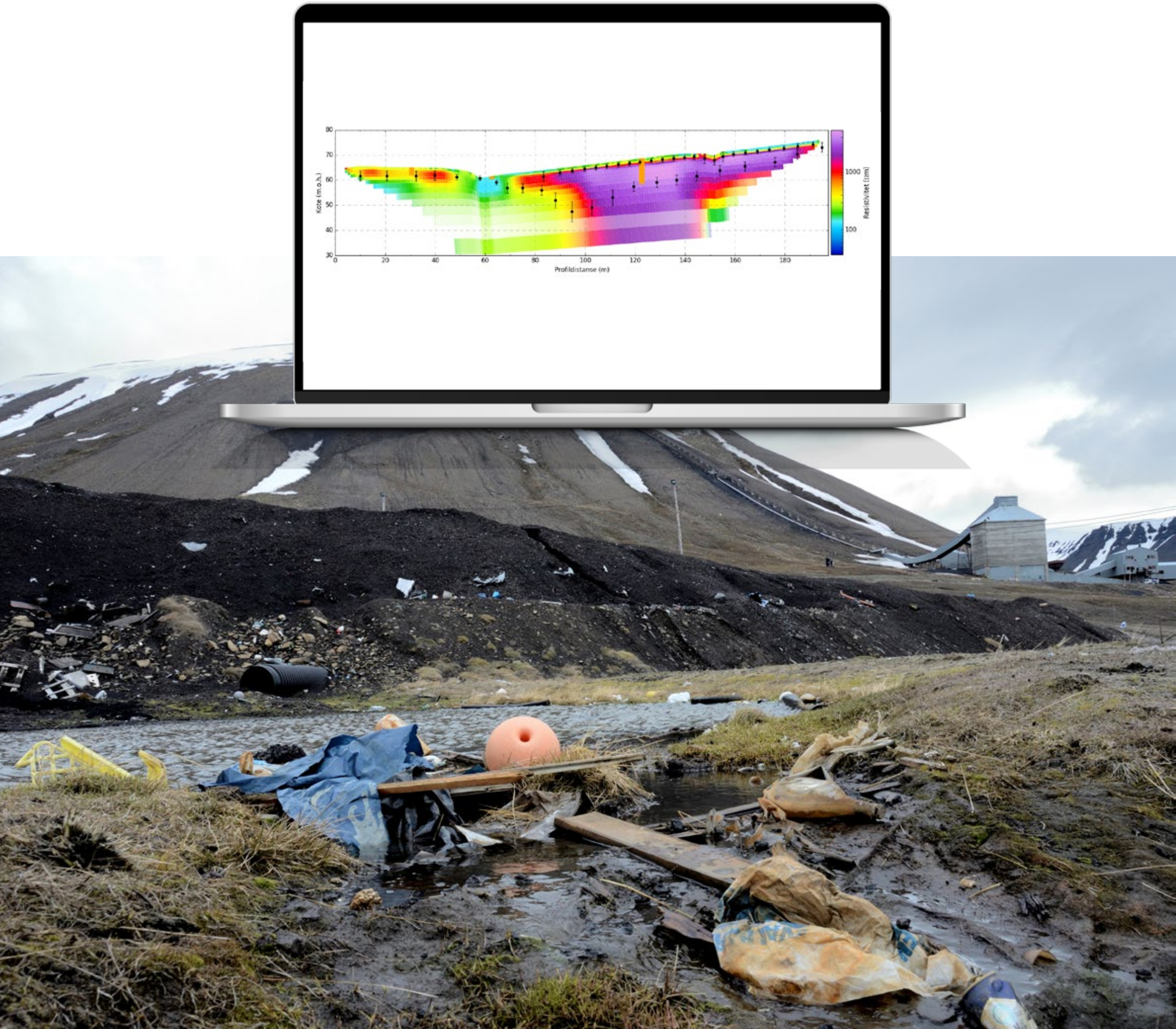
By combining these geophysical methods with other data, such as borehole information and historical records, NGI can create detailed maps of quick clay distribution to help assess landslide potential and implement risk mitigation measures.

Environmental geophysics

Contaminated soils can cause a risk to health and environment. Containment and remediation will rely on detailed mapping to avoid expensive delays.

Using non-invasive geophysical techniques, NGI can gather detailed information about the geology of the subsurface, including water content and the presence of contaminants. Mapping contaminant extent reduces uncertainty and provides data to facilitate remediation actions.

NGI offers a full range of environmental geotechnical and geological investigations that complement results of geophysical surveys. The benefit of this interdisciplinary work is a comprehensive assessment for your project.



Mapping subsurface infrastructure

Damage to subsurface infrastructure caused by construction and excavation can lead to significant cost to developers and society every year.

Accurate mapping of subsurface infrastructure and other buried objects is crucial for all construction projects. Mapping enables efficient project planning by providing accurate information about the location and depth of utilities.

NGI uses Ground Penetrating Radar (GPR) as a versatile geophysical technique for locating buried objects. Detailed images of the subsurface are then interpreted by our experts and the result is delivered to the client in a digital format ready to use in their planning tools.

Mineral exploration

Geophysical methods are essential for mineral exploration. By detecting anomalies in the Earth's magnetic field, gravity, or electrical conductivity, NGI can identify potential mineral deposits, guiding exploration efforts and reducing exploration costs.

NGI uses magnetic surveys to detect variations in the Earth's magnetic field caused by magnetic minerals like iron and nickel. These anomalies can indicate the presence of mineral deposits.

Gravity measurements are used in mineral exploration to detect variations in Earth's gravitational field caused by differences in subsurface densities. Dense ore bodies, particularly sulfide deposits, which often contain heavy minerals, exert a stronger gravitational pull than surrounding less dense rock. By precisely measuring these subtle variations, NGI can identify areas with potentially high concentrations of valuable minerals.

Certain minerals have distinct electrical properties that can be detected by measuring electrical conductivity of the subsurface.

By combining geophysical data with other relevant information (e.g., geologic maps and cross-sections, drill core data, remote sensing data, and geochemical data), NGI can identify potential mineral deposits and guide exploration efforts, reducing exploration costs and increasing the chances of discovering valuable mineral resources.

Related services

The value and accuracy of geophysical investigations can be significantly increased through combination with other sources of information. Here NGI has the advantage of possessing a wide range of expertise and equipment to carry out many different geotechnical and geoscientific investigations.

Geotechnical drillings, for example, provide accurate information on bedrock depth which can be used to verify results from geophysical bedrock mapping or to constrain tomographic inversion of seismic or electrical data.

Core samples taken from investigation sites can be analyzed in our world-renowned laboratory. Laboratory measurements of density and shear-wave velocity allow us to more accurately compute geotechnical parameters from the velocity models we derive from seismic measurements.

Our experts in areas such as dams, environment and contamination or natural hazards and climate, can combine geophysical results with other investigation methods to produce a comprehensive description of ground conditions, potential hazards and mitigation measures.

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