



GEOPHYSICAL INVESTIGATIONS

Ramboll applies geophysical methods in a wide range of projects within nature and environment, infrastructure, marine works and energy

Ramboll's geophysical team supports investigations of underground and submarine structures. These investigations are for example used in:

- Marine and land based construction works
- Investigation of geothermal resources
- Mapping of groundwater resources
- Mapping of mineral resources
- Localisation of buried objects
- Pavement analysis

Ramboll applies state-of-the-art acquisition equipment and performs advanced data analyses and processing to meet the highest standards.

The studies are customized for the client's needs and are supported by our in-house team of geologists, hydrogeologists, geophysicists and engineers.

The methods described on the next page can be applied individually or in various combinations depending on the specific aims.

Land-based surveys

Ramboll has developed a technique for seismic data acquisition, called Pulled Array Seismic (PAS), using a towed land streamer instead of traditional cables and geophones planted in the ground.

The data quality of the PAS method is fully comparable to traditional reflection seismics, but PAS is faster and more cost effective. PAS brings fast progress, low expenses and detailed information from 20 m to more than 500 m below ground level.

Refraction seismic surveys are applied by Ramboll in order to map shallow layering, for example the depth to bedrock, and also weak zones in bedrock.

The thickness and elastic properties of shallow layers are mapped using multi-channel analysis of surface waves (MASW).

Marine site investigations

In marine site investigations the water depths, seabed texture and sub seabed structures are mapped.

Ramboll maps geological structures from just below the seabed to a few kilometres depth using refraction and reflection seismic surveys. We are specialists in marine refraction surveys, where the thickness of the soft sediments above the rock is mapped.

CONTACT
 Uffe Torben Nielsen
 Project Director
 +45 5161 6782
 utn@ramboll.dk

Kristoffer Vrang
 Head of Department
 +45 5161 6767
 kv@ramboll.dk

Rambøll Denmark
 Hannemanns Allé 53
 DK-2300 Copenhagen S

Our primary fields of expertise are:

- **Seismic profiling including reflection and refraction and surface wave seismic surveys**
- **Marine site investigations: Mapping of water depth, seabed texture and sub seabed structures**
- **Geophysical borehole logging and Vertical Seismic Profiling (VSP)**
- **CVES and PACES: Electrical method used for detailed mapping along profiles to 120 m depth**
- **SkyTEM and TEM: Airborne and land based electromagnetic methods that can map geological structures down to a depth of 300 m (150 m for TEM)**
- **Georadar: Electromagnetic method used to map geological structures or buried items in the subsurface**
- **EM31/EM61: Electromagnetic method used as a fast screening of the upper 3 m and 6 m depth/to detect metal in the subsurface**
- **MRS: Magnetic resonance method used to estimate water content and permeability as function of depth down to 120 m depth at point locations from surface measurements**

Geophysical borehole logging

Ramboll conducts geophysical borehole logging in connection with mapping of fresh water resources and for construction purposes. Our logging programme includes temperature, flow, resistivity, natural gamma, EM-induction, deviation, caliper, acoustical- and optical viewers, magnetic susceptibility, density, porosity and full-wave-form sonic logs.

In addition to this we use Vertical Seismic Profiling (VSP) for measuring the P- and S-wave velocity for calculating the dynamic parameters of the soil.

Electrical and electromagnetic methods

Ramboll uses a variety of methods to map groundwater reservoirs and their vulnerability to pollution from saltwater, industry or agriculture. We hold a broad spectre of electrical and electromagnetic (EM) equipment, the choice of equipment being based on the type of survey.

Shallow structures are mapped both with electric and electromagnetic methods. Continuous Vertical Electrical

Sounding, CVES MEP) is commonly used to map the electrical resistivity of the upper 30 - 60 m. The transient electromagnetic method (TEM) is used to map the depth to deep-lying layers with high conductivity (typically clay layers or saltwater boundaries). The maximum depth range of TEM is approx. 150 m depending on soil type and set-up. Helicopter electromagnetic methods (SKYTEM, HEM) are used for mapping of electrical conductivity over large areas.

These methods are all low priced and have traditionally been used by the Danish counties to recover and protect the Danish drinking water.

Ground Penetrating Radar (GPR) is used for mapping geological structures, pavement analysis, location of underground storage tanks, cavities, archaeological objects etc.

EM-61 works by electromagnetic induction and is designed for locating near-surface buried metal objects. It is therefore suitable for locating archaeological objects, underground storage tanks etc. PACES (Pulled array continuous electrical soundings) is an electrical method used for

various purposes within environmental and geotechnical investigations. PACES is relevant in all cases where information on the lithology of the subsurface is useful. Ramboll uses PACES when mapping the upper soil-layers e.g. mapping of the natural vulnerability of underlying ground water reservoirs. PACES are also used in connection with geotechnical mapping prior to setting of a drilling program or prior to geotechnical surveys for establishment e.g. larger construction projects and road constructions.

MRS (Magnetic Resonance Sounding)

The MRS method is the only non-invasive geophysical method that directly estimates water content and permeability without drilling.

Ramboll uses the MRS method to map hydrogeological conditions in groundwater, to correlate resistivity to hydrogeological conditions. The MRS method is also used to optimize borehole locations among several possible, to improved coverage of hydraulic parameters and is useful to determine water content when designing dewatering or groundwater table lowering in construction projects.