THE ROCKSTAR MAGAZINE
All you need to know about rocks

ENERGY, GEOSERVICES AND WATER

SEISMICS ON ICE

PUSHING THE BOUNDARIES OF GEOPHYSICS

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SEPTEMBER, 2025
– VOLUME 1

INTERNATIONAL

HYDRAULIC UPLIFTING OF LOW-LYING ISLANDS
CLIMATE ADAPTATION

Atoll islands continue to disappear due to sea level rise. Communities in these islands are experiencing coastal erosion, flooding, inundation, and the loss of vital wetlands as aquifer systems are being reduced.

A disappearing island. Tuvalu's Foreign Minister Simon Kofe gives a COP26 statement while standing in the ocean in this handout picture taken in Funafuti, Tuvalu, November 8, 2021. From www.reuters.com.

In 2024 Ruden with the support from the Norwegian Space Center (Norsk Romsenter), assessed the feasibility for site-specific uplift of low-lying areas through injection of pressured seawater into the sub-surface, and for satellite measurements (InSAR) as an effective means of monitoring surface changes.

An essential component of the study is to assess the porosity and permeability of the sedimentary bedrock in coral atolls, which requires knowledge of the subsurface. In this effort we were aided by the findings of the Royal Society Coral Reef Expedition to Funafuti (Tuvalu), which occurred over several visits between 1896 and 1898. The costly expeditions were undertaken to test Darwin's idea that coral atolls in the ocean interiors form above slowly subsiding islands. – *continues*

A remarkable first impression of the Edgeworth cores is the karst/microkarst developments that appears to be widespread over the entire underlying carbonate section penetrated by the core. The carbonates have been subject to rather intense dissolution and karst development by carbonic acid (H2CO3), apparently from rainwater during last glacial maximum (LGM) low stands, -down to -130 m or below.

As part of a collaborative project with Ruden, Claudia Bertoni, a geologist and researcher at the University of Oxford, visited the London Museum to examine drill core samples from the borehole that provided key evidence supporting Darwin's theory of evolution.

The island topography and geometry were different during LGM compared to the miniscule remnants we see of today, and they favoured karst development. Differential dissolution of core samples indicates widespread non-intergranular contact, -which implies karst walls. What was once between these walls is long gone.

Our team carried out simulations of 5 different scenarios in Funafuti, considering variable injection depth, physical properties of rocks, and other injection parameters such as pressure. The outputs predict an uplift varying from 3 to 30 centimetres. The project was also able to highlight best practices for avoiding or minimizing the main risks, which are related to contamination and hydraulic fracture and destabilization of the ground, and for monitoring.
– *continues*

A low-lying island. AI generated in Sora

The use of fluid injection to counter subsidence is not a completely new idea. It also shares many of the same geological, engineering, monitoring, and safety considerations encountered in geothermal power exploitation, and the present-day efforts to sequester carbon dioxide through injection into the subsurface (such as the In Salah project in Algeria).

There are several examples where fluid injection has been undertaken with the primary aim of causing surface uplift, with resulting uplift from a few millimeters to some centimeters. In a few cases tens of centimetres uplift observed. Examples include Long Beach, California, where a large programme of water injection began in the late 1950s to mitigate coastal subsidence caused by oil extraction. There are also several examples relating to mitigation of land subsidence following depletion of freshwater reservoirs, including Tokyo where a subsidence of 4.5 m took place between early 1920s and 1999. Regulations to mitigate subsidence were implemented and fluid injection starting in the early 1970s has resulted in uplift of up to 20 cm.

Finally in Venice, where the world heritage site is threatened by flooding events, a pilot study has been performed to assess potential to uplift a large part of the Venice lagoon by seawater injection, with the resulting uplift was estimated to 25-30 cm over 10 years. The uplift in this case is designed to minimize the use of the mobile barrier that has been built at the entry points to the lagoon, both for economic and environmental reasons.

Written By Claudia Bertoni and Elizabeth Quiroga Jordan

NORDICS

EDITORS' CHOICE

SEISMICS ON ICE

PUSHING THE BOUNDARIES OF GEOPHYSICS

In the heart of winter, a fjord lay locked beneath a thick sheet of ice. While locals drilled small holes for fishing or glided across the surface on skates, Ruden Geo Services arrived with a different purpose. We came to carry out seismic refraction and reflection survey directly on ice, revealing what lies beneath the sea. Our mission was to determine the depth to bedrock beneath the seabed for planning and safety purposes.

Ruden Geo Services team drilling through the ice with an ice auger to create holes for placing hydrophones in the sea.

This challenging project reflects the innovative and client-focused spirit of Ruden Geo Services. Always pushing geophysics into new frontiers.

Conventional marine surveys were impossible with the fjord sealed in ice. Many would have postponed the work until spring, but Ruden Geo Services saw an opportunity. We adapted marine seismic methods to work from the ice itself, transforming the frozen surface into a stable and efficient platform for data acquisition. – *continues*

Thanks to our edge-cutting wireless nodal seismic system, which is designed to operate reliably in extreme temperatures, we were able to carry out the survey without the limitations of traditional cabled setups. This technology allowed us to work efficiently across the ice, placing nodes exactly where needed without worrying about frozen cables or restricted movement. Its resilience in harsh Arctic conditions enabled us to collect consistent, high-quality seismic data even when the temperature plunged well below freezing.

Autonomous wireless hydrophones deployed through the ice in the fjord to acquire high quality seismic data

The fieldwork was demanding due to the extreme conditions, the logistical complexity, and the risk involved. We drilled holes through the ice and lowered hydrophones into the seawater below. To create seismic energy, we used a Buffalo gun, a compact and high-powered source ideal for under-ice operations. It sent strong acoustic pulses through the water column, which were recorded by the hydrophones to produce a high-resolution image of the seabed and the bedrock beneath.

What others might have thought was an unrealistic idea turned out to be a successful and remarkable operation. When others said, "it can't be done," Ruden AS said "*let's find a way*." – *continues*

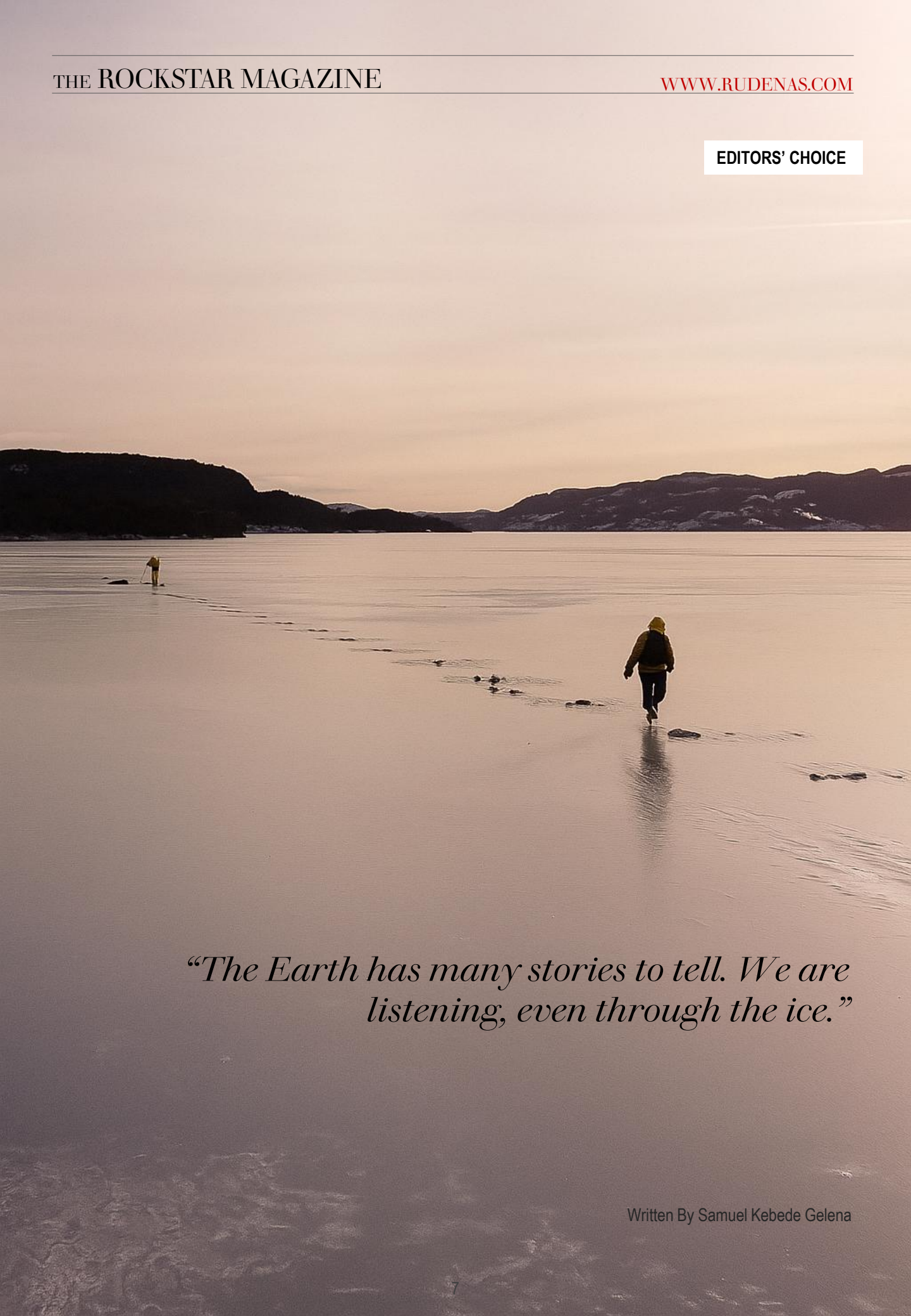
Ruden Geo Services offers a complete geophysical toolkit: Electrical Resistivity Tomography (ERT), Induced Polarization (IP), seismic surveys, and well logging. Yet what truly sets the company apart is its dedication to innovation, precision, and problem-solving. Whether on a frozen fjord or in a remote offshore environment, Ruden's team delivers high-quality subsurface data tailored to each client's goals.

Seismic profiles stretching 500m across the icy fjord.

This project is far more than a single success; it marks the beginning of a new approach to seismic exploration in icy and remote regions. During the winter months, most of the lakes and fjords in polar and subpolar regions become covered with thick ice. While this seasonal freeze can halt conventional marine operations, Ruden Geo Services sees it as an opportunity.

The knowledge and experience gained can now be applied to other polar and subpolar locations where similar geological insights are needed. It opens new possibilities for researchers, infrastructure developers, and environmental planners alike.

EDITORS' CHOICE



"The Earth has many stories to tell. We are listening, even through the ice."

Written By Samuel Kebede Gelena

NORDICS

ELECTRICAL SURVEY ACROSS A POND
REVEALING THE UNSEEN

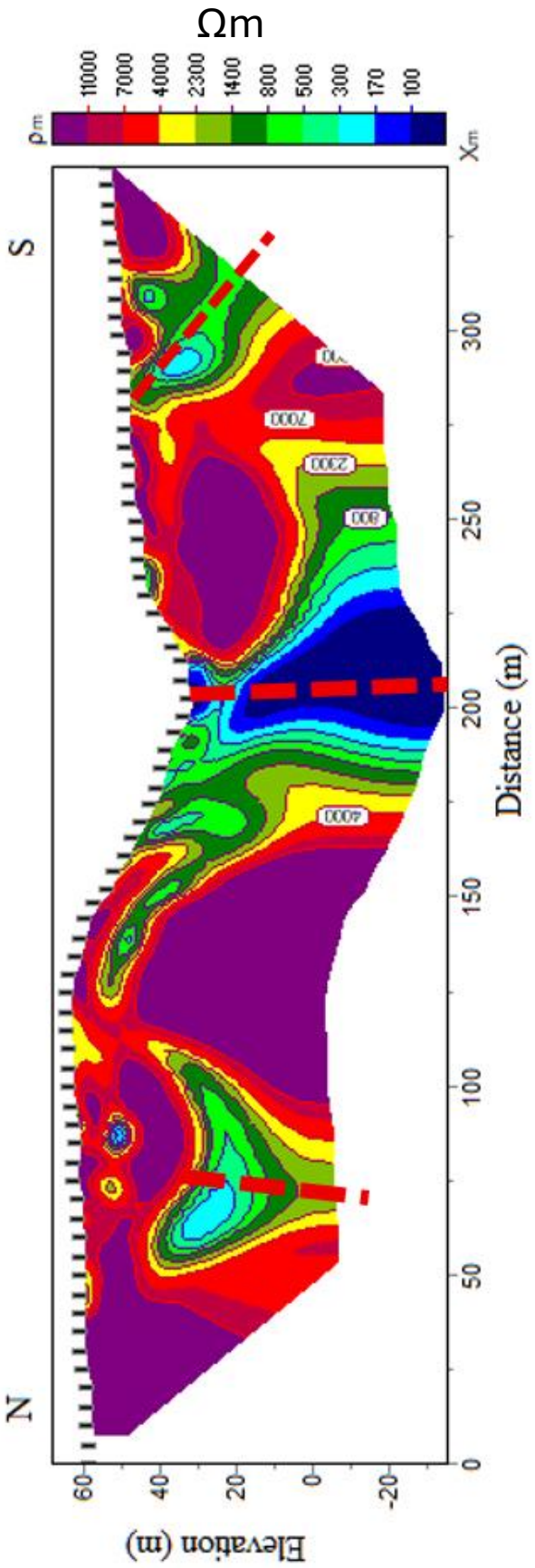
During Statens Vegvesen's construction of a new tunnel beneath a pond in Porsgrunn, electrical resistivity measurements were carried out to identify the location and characteristics of weakness zones in the bedrock.

These geophysical surveys provided valuable input for tunnel planning, delivering physical data without disturbing the pond or its ecosystem.

The ERT equipment had to be modified for measurements in a pond.

By measuring the electrical properties of rocks and soils, engineers gained insights into rock quality, porosity, water content and quality, as well as the distinction between stable and unstable clays—all through a non-invasive method.

Electrodes were deployed in the water using long plastic columns, with cable connectors positioned a few centimeters above the surface. To prevent direct contact between the pond water and the ERT cable connectors, foam insulation was applied. A cable stretched across the pond ensured that the electrode line remained properly aligned along each profile. – *continues*



Resistivity profile: Weakness zones are marked with red, stipulated lines. The dark red colours are associated with unfractured bedrock.

The results revealed lateral discontinuities at 65–80 m, 190–240 m, and 310–325 m along the profile, which are likely associated with weakness zones. In these sections, the apparent resistivity was noticeably lower compared to the surrounding host rock.

The profile presented here formed part of a broader survey conducted in 2023, which included both land and marine seismic investigations in addition to electrical measurements.

While geophysical surveying is not the most commonly used method for ground investigations in the construction industry, it provides a rapid and cost-effective way to obtain qualitative data across large areas.

Importantly, these profiles can be acquired without causing environmental harm and serve as a valuable guide for determining optimal drilling locations for further investigation.

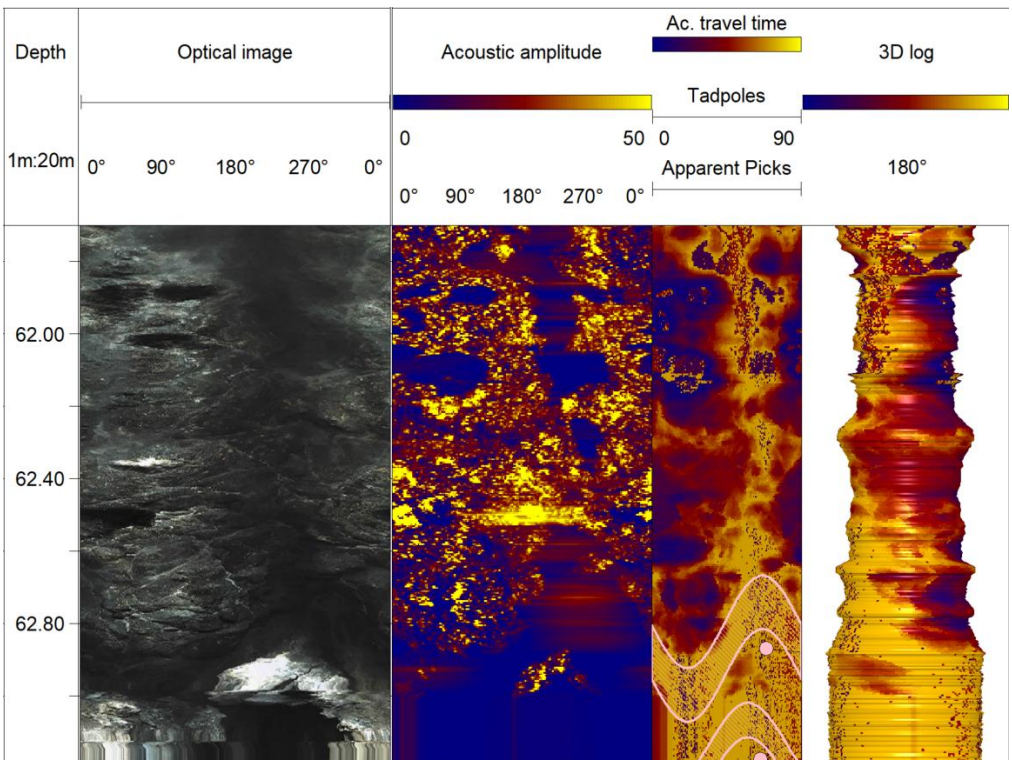
Written By Sunniva Zengaffinen-Morris

NORDICS

GEOENERGY FOR KVALØYSLETTA ELEMENTARY SCHOOL IN TRØMSO

Artesian conditions at Kvaløysletta: Water pouring out of the boreholes, endangering the environment and causing unexpected delays in the construction work

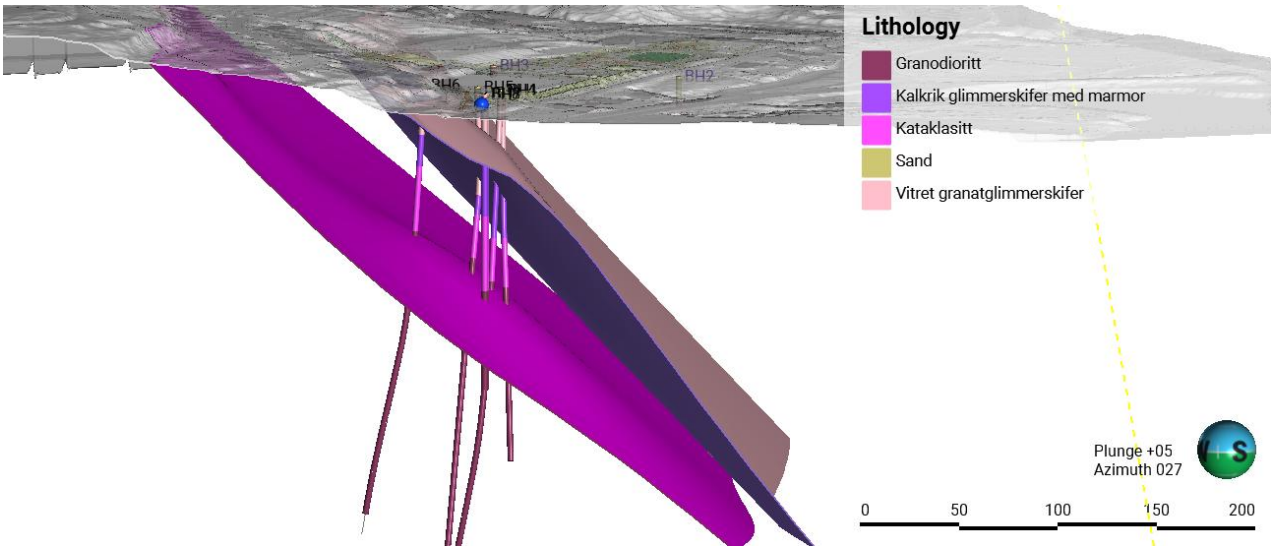
Challenging drilling conditions at Kvaløysletta in Tromsø led Bravida to contacting Ruden for geoenergy advice. Well logging revealed karstified marble combined with intensely faulted granite with artesian groundwater conditions – just how we like it!



Results from borehole logging revealed karstified marble from 58 m depth; The optical and acoustic televiewer reveal the open holes that created problems for the drillers.

After drilling and safely cementing 5 energy wells to between 150 and 270 m depth, the system stood ready to deliver the 160-kW of heat the school needs. *– continues*

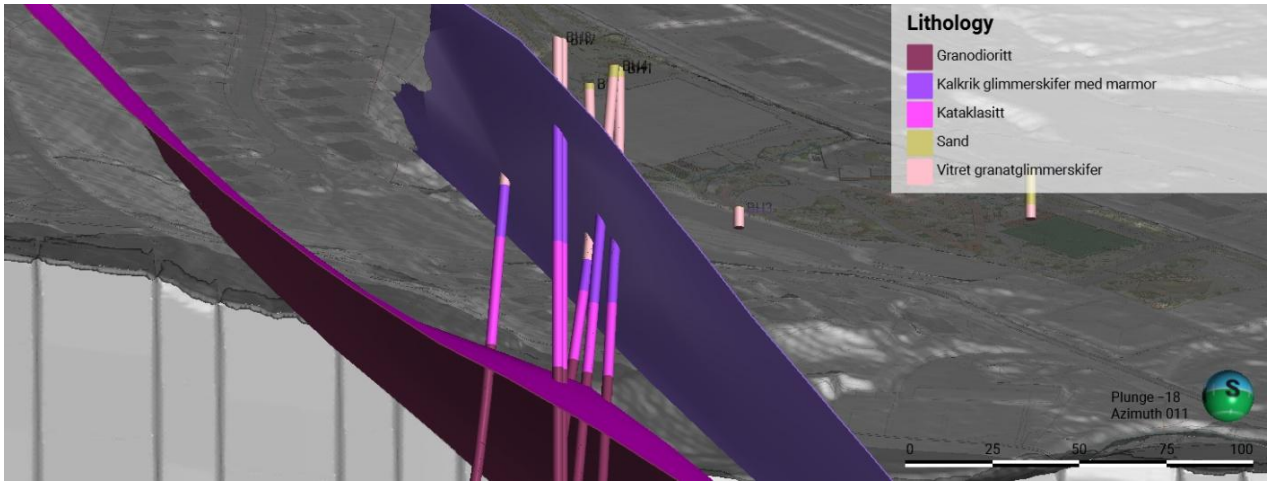
3D geological modelling at Kvaløysletta was essential for achieving a comprehensive understanding of the groundwater system.



Snapshot of the 3D-model of Kvaløysletta Elementary school, created in Leapfrog Works (Software by Seequent Ltd).

By integrating geological, geophysical, and hydrogeological data into a spatial model, we were able to visualize subsurface structures, aquifer geometry, and flow pathways with far greater accuracy than traditional methods alone.

The model supported safe and efficient project planning by minimizing unnecessary disturbance and reducing environmental risks. Ultimately, the 3D model served as a decision-making tool that linked geological interpretation with practical groundwater management and environmental protection.



Written By Sunniva Zengaffinen-Morris

COMMENTS
FROM OUR EXPERTS

"Using geophysical methods, the geoscientists from Ruden can see what lies beneath the surface without leaving a mark on the environment.

It's in challenging areas and conditions that our innovative skills truly shine".
-Sunniva Zengaffinen-Morris

"Seismic surveys on sea ice demanded advanced technology, teamwork, and determination. Our wireless nodal system performed flawlessly in extreme cold, capturing data many thought impossible. Despite harsh weather, slippery and frozen fingers, we delivered the insights our client needed, proving ice is not a barrier but a platform for discovery". -Samuel Gelena

"I never get tired of discovering how oil industry technology can be reused to solve today's challenges.

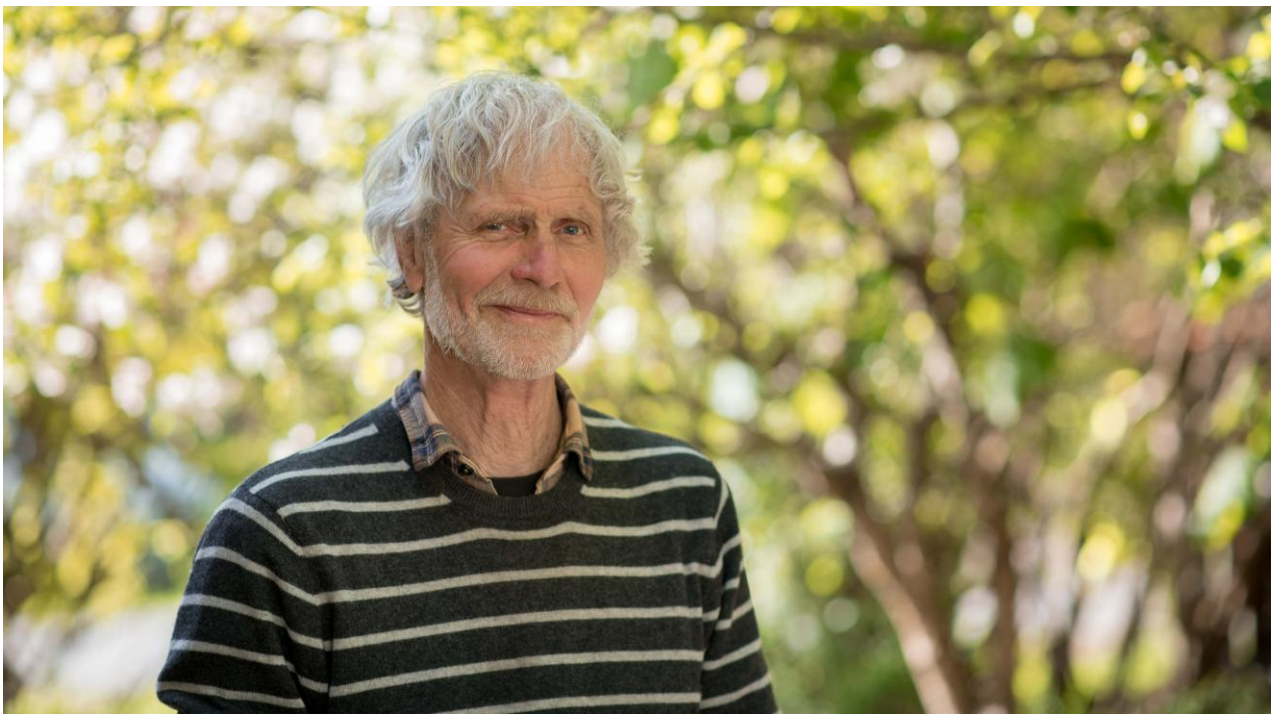
Low-lying islands have done the least harm to our environment, yet they pay the highest price. We hope a pilot test of our research is implemented as it can make a positive difference for them".
– Elizabeth Quiroga Jordan

INTERNATIONAL

APPLIED HYDROGEOLOGY AWARD FOR 2025, GIVEN TO OUR CO-FOUNDER FRIDTJOV RUDEN

"I am delighted to inform you that IAH is giving you the Applied Hydrogeology Award for 2025. IAH's Applied Hydrogeology Award is presented to -a groundwater professional who has made an outstanding contribution to the application of hydrogeology, preferably in developing countries or in support of international development-".

Jane Dottridge - Secretary General IAH



Fridtjov Ruden, co-founder of Ruden AS

Fridtjov Ruden is a pioneering applied hydrogeologist who has made extensive contributions to groundwater exploration, development and education globally.

Fridtjov graduated from the University of Oslo in 1978 as Norway's first university-educated hydrogeologist and has since worked across Africa, Europe, the Middle East, Central America and Southeast Asia. He has often been active in regions dominated by war, drought and famine. Fridtjov has held numerous courses on diesel mechanics, drilling, geophysics and hydrogeology, has worked as a consultant, and researcher (Norwegian Institute for Water Research), at CGS/Pretoria. – *continues*

Fridtjov Ruden at the site of an artesian well he drilled in Ain Musa, Sinai, in 1980

In 1994 Fridtjov initiated water supply development for refugee camps in the wake of the Rwandan genocide. He has also established a Water Drilling Unit for UN peacekeeping in Chad, for well-based water supply. He has also worked on groundwater projects in the West Bank.

Fridtjov has worked across 21 African countries, contributing to geological mapping, groundwater exploration and water supply development. His engagement with governmental bodies led to adaptation of regional and national water strategies, including Somalia and Zanzibar.

In 2007, Fridtjov discovered the 'Kimbiji Aquifer', a deep coastal aquifer system with a proven potential to supply up to 2 million people near Dar Es Salaam in Tanzania.

More recently Fridtjov and his team have promoted use of data from oil well logs, seismics and academic input for deep groundwater exploration in East Africa. His innovative technical solutions extend to seasonal heat storage in fractured crystalline rocks and capturing frost and thermal energy storage in bedrock. Recent innovation include 3D nodal seismic on land.

– continues

A water well drilled in Chad during the 2009–2010 UN Mission in the Central African Republic and Chad. – Fridtjov Ruden

Fridtjov has published several articles, contributed to conferences, including presenting the 2011 Burdon Lecture in for IAH Ireland and the Goldschmidt lecture at Norwegian Geological Survey in 2012. He has received multiple awards for his innovative contributions to energy, groundwater sustainability and submarine groundwater. He emphasizes inclusivity by involving young professionals and academics in projects and has implemented training programmes in several African countries.

Fridtjov Ruden is a very worthy recipient of the IAH Applied Hydrogeology Award, and we celebrate that his work and contributions are being recognized!

WINNER

ONS 2022

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DnB NOR

Innovasjonspris 2008

WATER CHANGEMAKER AWARDS

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FJERNVARMEDAGENE URBAN ENERGI

Innovasjonspris 2022