ANNUAL REPORT 2019

The dream

GEOLOGICAL SURVEY OF NORWAY

- NGU -

IT IS THAT DREAM

It is the dream we carry
that something wonderful will happen,
that it must happen –
that time will open,
that our hearts may open,
that doors shall open,
and the mountain shall open
that springs will gush forth –
that our dream will open,
and that one morning we'll glide into
a cove we didn't know.

Olav H. Hauge,
in "Luminous Spaces - Selected Poems & Journals"
Translated by Olav Grinde (2016) from "Det er den draumen" (1966)

Nine young scientists look ahead

NGU's Annual Report for 2019 is about young scientists and the future. We will look ahead, and not dwell on the past, or what has already been done. We want to link our stories to one of the most well-known poems written in Norway, "It is that dream", by Olav H. Hauge.

We challenged nine of our young scientists, one from each of our geoscientific teams, by asking them to write a personal essay about their choice of profession, their career, and about the role geology can be expected to have in society in the years leading up to 2050.

In this annual report, you will find the opinions and a portrait of each of our young scientists. They represent many of the talented scientists in Norway who have a long career ahead of them. They combine use of traditional tools and instruments such as hammers and shovels, maps and compasses, with state-of the-art equipment transported by helicopters, planes, ships and drones.

They map the surface of the Earth upon which we live, study slow geological processes, investigate how landforms develop, examine mineral grains to understand how the mountains in Norway were formed, sample sediments on the seabed and model past changes in the climate, all of these strategies in order to understand the future. Our scientists also search for mineral resources and contribute to methods for reducing the risk of catastrophic landslides.

They carry proud historical traditions, from 1858 into the future. They manage knowledge which helps us to understand how Norway was formed. They cooperate in making Norway an even better place in which to live.

The dreams they carry lie here.

May Britt Myhr

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“Alpine skiers are crazy about mountains! And mountains = rock = geology

Ida Hilde Gunleiksrud

Age: *27*
Leisure activities: *Skiing*
Education: MSc (geology), NTNU
NGU: *Bedrock Geology Team*

Born to ski in the mountains

"Ida, what the heck are you staring at?" My ski mates tease me. They don't understand why I am staring at the rock face which extends up towards "Bec des Etagnes", located in Verbier in the Swiss Alps. We are surrounded by majestic mountains as far as the eye can see. You have perhaps heard of the Matterhorn or the Mont Blanc massif?

The view cannot bear any complaints! Nevertheless, there I stand with my nose nearly touching the rock face. I discover some beautiful crenulation cleavages adorning the cliff of mica schist hanging over us. If you have never heard of crenulation cleavages before, that is in order, neither have my skiing companions. Still on the slopes, I attempt a tiny lesson in geology, but just as I started on the topic of metamorphic grades, Mont Blanc won everyone's attention. I was a consolation that I lost to a world-class competitor!

My geology lessons are often received with curiosity and inquisitiveness. After all, alpine skiers are crazy about mountains! and mountains = rock = geology. But this explanation is too frequently met with a flat 'ha', 'hm' or 'cool', often poorly timed, which means that it is time to wrap up and continue up the slope. After all, that's what we're here to do! Without the mountains, the life of an avid skier would be quite boring, but without mountains, skiing would be less exciting. If mountains are integral to skiing, so is geology, right? Well, at least I think it is so.

I am a structural geologist employed at the Geological Survey of Norway, in the team for bedrock geology. How did I end up here? My fascination with mountains was probably an important influence in my choice. So, where did this fascination with mountains come from? I believe that skiing played an important part. I have toured, raced, and played on skis for long as I can remember. I have always loved it. However, I don't remember spending much time thinking about mountains in my childhood. They were just there. Going up was exhausting, but wow, they were so fun to go down! Eventually, maybe in my teens, I gradually began to appreciate the mountains in their own right. I realized how wonderful they were and what wonderful opportunities they offered. An entire playground full of skiing opportunities and adventures!

Only when I started studying geology at NTNU did I really start to reflect on the enormous forces that underlie the formation of mountains. About 500 million years ago, the ancient continents of Laurentia and Baltics 'collided' (i.e. North America and Scandinavia) to form the Caledonian mountain range with peaks higher than those we find today in the Himalayas. Norway's geology is characterized by Caledonian mountain range - the highest peaks have worn down, a bit.

Now, let's go back to crenulation cleavages in Verbier. You might be thinking, "She was just talking about continents that moved thousands of miles, collided into each other, and formed mountains up to 10,000 meters high! What do these crenulations have to do with that?"

The answer? We need to understand the small details before we can see of the big picture. Think CSI workflow: hair strands, DNA, face recognition, registration numbers, the chaos of sirens, and the BAM! Hands in the air!

In one of the projects, we map the bedrock in Telemark. In projects like this, the first step is to get the best possible overview of the information that is already available. After this, is fieldwork: this might be the favourite activity for most geologists. We map rock types, take measurements and collect samples. Data, measurements, and samples are then processed and analysed before being compiled and interpreted to produce a final bedrock map. Through this process we form an understanding of how the bedrock was created - in the context of the rest of the country.

During my first half year at NGU, I have already had the pleasure of being involved in many aspects of our Teams workflow - an incredibly educational and exciting experience. I look forward to continuing my work at NGU and skiing in the mountains!

“Now, as a marine geologist, I have sailed in the same waters where my great-grandfather once fished cod.

On an ocean wave

Frank Werner Jakobsen

Age: *28*
Leisure activities: *Climbing, skiing, cycling, music, outdoor activities in general*
Education: *MSc (Geology), University of Tromsø Arctic University*
NGU: *Marine Geology Team*

As I was growing up, I wanted to be a fisherman like other family members before me.

I always felt close to nature, which for me represents something unadulterated, untainted, but is yet so familiar. I was probably a ‘natural romantic’, and maybe still am to some extent, after all, that’s where we came from.

Although the classroom was not my favourite place, it turned out to be here that I ended up working overtime. We heard about volcanoes and earthquakes during geography class, learning about the enormous forces that play out on the earth’s surface, even though they originate from well below our feet. I was quite impressed.

I started studying geology in Autumn 2011. In the beginning, minerals and sedimentary deposits interested me the most. It is amazing how much you learn from the flashing colour spectra through a microscope. For me, studying geology was akin to learning a whole new language. Examining and interpreting sedimentary layers was like reading the Earth’s autobiography, filled with stories about ancient glacial times, sea level change, shifting of river courses - and much, much more - all written in rocks and sand. In a way, a geologist is pumped-up historian.

I also travelled to the volcanic archipelago of Hawaii, in the middle of the Pacific Ocean. Obviously, I needed to study natural phenomena like volcanoes and earthquakes, right up close.

But I had to explore further, closer to my roots, before I found peace. Now, as a marine geologist, I have sailed in the same waters where my great-grandfather once fished cod. We sail to map both geology and biology, the interaction of which makes this marine environment so rich and productive. How can we keep it that way?

At times, it almost seems that the mapping we do in maritime Norway could be pioneering. Afterall, there are few people who can say that they have been to an unexplored part of the earth, but we can. It is a privilege to be involved.

In recent years, a greater focus has been placed on the oceans. The work we do today will benefit society, and it is work we can build on in the future. My role in the future is not easy to predict.

Maybe I will one day stand at the front of a classroom and teach students to read through the pages of the Earth’s history? I think it that would be nice.

In the forefront of my thoughts is Antarctica’s huge ice sheets that add to the uncertainty of our future. I am probably drawn to extremes, and the Ice Age is as extreme as volcanoes, and maybe even more so, when we consider how it can affect the formation of the landscape. Did you know that we find some of the largest landforms created during the Ice Age on the seafloor in offshore Norway? Without the Ice Age, the continental shelf would have looked very different, and accompanied by conditions that might have made it impossible for cod to travel south each year.

It is no surprise that we are concerned about climate. Today, it is not the Ice Age threatening Norway’s cod, it is the disconcertingly warm seawater creeping northwards. We don’t know what the future will look like or how we manage all the challenges; however, mapping is a good place to start.

Marine geologists will continue serve society in 30 years-time, because much remains to be mapped. The sea level rises at pace with the ice melting, and besides the fish, perhaps only we marine geologists can.

“It’s not easy to find all these unstable slopes areas hidden along the Norwegian mountainsides.

Detecting ground motion

Marie Bredal

Age: *30*
Leisure activities: *Skiing and mountaineering*
Education: *MSc (Geology), Arctic University of Norway - University of Tromsø*
NGU: *Geohazards and Earth Observation Team*

Calculating resistance and the necessary propulsion of boats in waves was not what I was meant to do.

I was by no means the type to skip lectures, but as I gradually prioritized mountains over the lecture hall, I realized that something had to change. After a summer of jamming anchors into Lofoten granite, and a winter of skiing in Canada and West Finnmark, it was clear to me what I wanted to pursue. Geology.

That way, if I couldn’t be in the mountains all the time, I could at least study them.

Today, I work with landslide mapping and radar measurements from satellites, InSAR data, which I use to map landscape deformation, such as urban subsidence and movements in unstable mountain slopes.

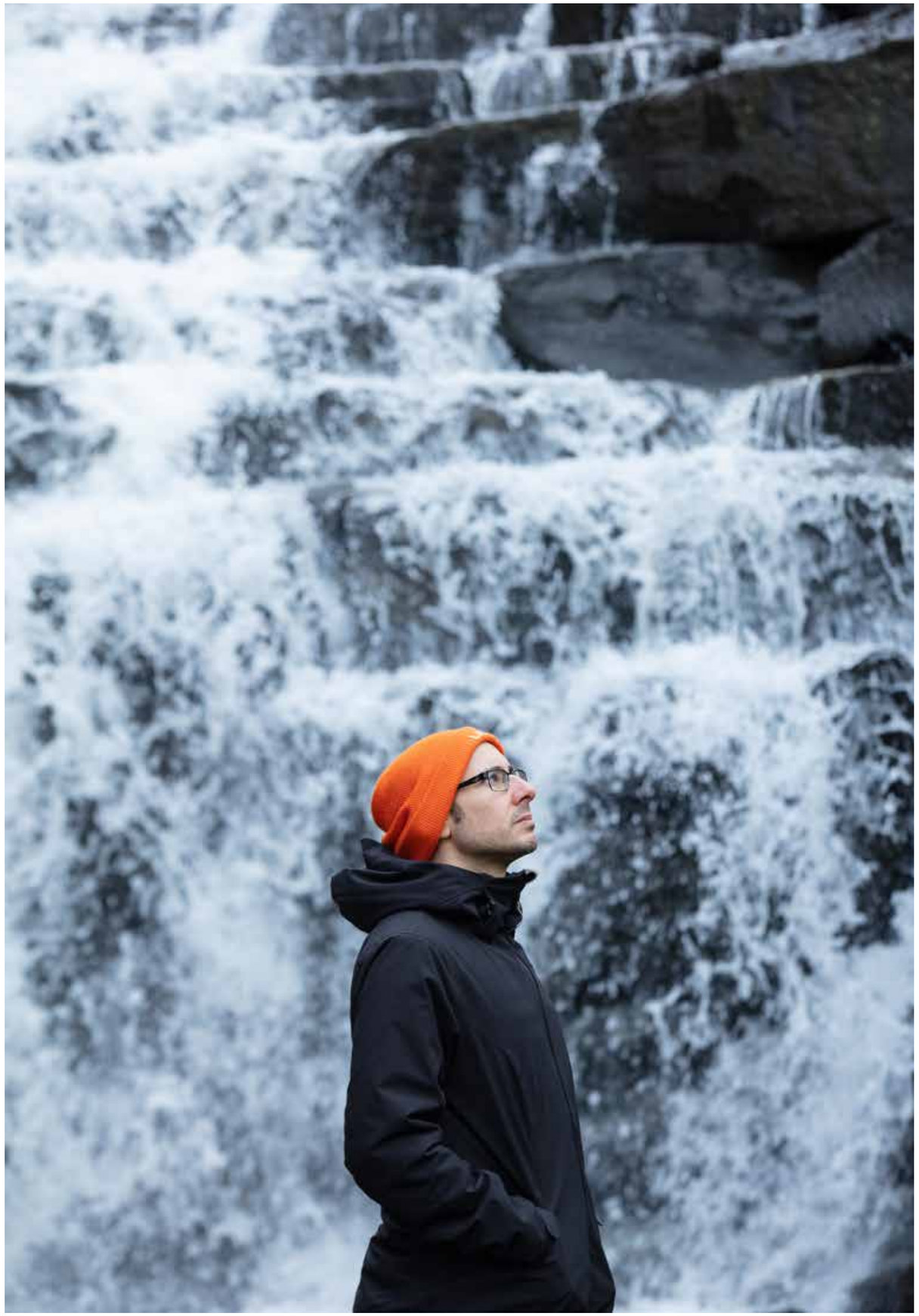
The 1934 Tafjord disaster, when 40 people lost their lives as a result of a landslide and tsunami, is a good example of an event we hope not to see repeated. But it is not easy to find all these unstable slopes hidden between the hills and mountains in Norway. This is where the satellite-based ground motion measurements help, because if bedrock is moving, this will probably show in InSAR data. How quickly a slope moves helps us understand the danger it represents for the cities and towns that would be affected by an event.

Although InSAR is a useful tool for detecting and monitoring landslides, not everything can be done from space. We also need to understand the geological conditions that cause some slopes to move.

And I, who would rather spend my time in the mountains, appreciate that this is best done by mapping in the field.

In cities, there are a few other problems. There, with InSAR data, we can keep track of settling of buildings and along important roadways. We can investigate how construction projects can influence ground settlement patterns, and in this way implement early mitigation measures.

The InSAR Norway map service is open and accessible to everyone. InSAR data itself is nothing new, but open access to it is. Because InSAR data is not quite straightforward for everyone to use, part of my job is to disseminate information about this data and how it can be used in the best possible way. We also want to hear about everyone’s experience with using the mapping service, so that InSAR Norway can be more widely accessible.



“Whether you are looking for mineral deposits, mapping bedrock or the marine environment, the biggest challenge lies how to approach research more holistically.

The long journey

My name is Pedro Acosta-Gongora. I was born and raised in Costa Rica, but during the past ten years I have been fortified by the cold weather of Canada.

Unknowingly, my love affair with geology started quite early, as a child. Due to the country’s geological ‘architecture’, you will always be affected by two natural phenomena if you live in Costa Rica: Earthquakes and volcanoes. What a combination!

Towards the end of high school, my interest in earth sciences grew to such an extent that I finally decided to enrol myself in the Geology programme at the University of Costa Rica. As an undergraduate, I flirted with various geoscientific topics, like volcanology, seismology and sedimentology. What I found the most seducing, the one topic that gave me both professional and personal meaning, was the study of mineral deposits.

A decision to pursue this field could be quite controversial in a country where mineral and oil exploration and extraction are illegal. So, I ended up doing my graduate studies and post-doctoral research in the USA and Canada, which allowed me to work in very remote places within South and North America. Most importantly, this work helped me understand first-hand the impact of geology in our daily life.

Essentially, I am a geochemist that, up to now, has spent most of his time investigating the mobility of metals from the mantle to the upper crust, and exploring “data mining” techniques on geochemical databases for mineral exploration.

Pedro Acosta-Gongora

Age: *35*
Leisure activities: *Swimming, running, cycling, reading*
Education: *PhD from the University of Alberta, Canada*
NGU: *Geochemistry and Hydrogeology Team*

Two natural phenomena will always impact your life if living in Costa Rica; earthquakes and volcanoes

Interestingly enough, the “data mining” aspect of my research is one of the main things that brought me to NGU. Now, however, my current research has a radically different perspective. I am currently applying the same techniques used in mineral exploration for developing the geoscientific basis to develop ecological maps.

Although this may seem like a contradiction, and to a certain point ironic, it is a good representation of how I see the evolution of geology advancing over the next 10 to 25 years. We live in an era where decades of geoscientific data can be accessed remotely from a computer. At the same time, new data is generated every year as geoscientific models improve, and advances in technology take place. Whether you are looking for mineral deposits, mapping bedrock or the marine environment, the biggest challenge lies in how to approach research more holistically.

To me, this means we need to develop methodologies to efficiently integrate geoscientific databases to produce more accurate maps and 3D models useful to government agencies and industry. In a globalized world, geoscientific-driven policy will have direct consequences on the quality-of life of millions of people living today and affect generations to come.

Therefore, I feel very privileged to be part of NGU, which gives young geoscientists like myself an incredible opportunity to make a real difference and provides us with an environment in which we can carry out innovative research.

Back to Nature

“We humans are affecting the planet more than ever. Our use of nature has given us a high standard of living. We should be grateful for this, but something has been lost along the way.

Marianne Christoffersen

Age: *26 years*
Leisure activities: *Walking, paddling kayak, knitting*
Education: *MSc (Geology), University of Tromsø Arctic University*
NGU: *Team for Quaternary Geology*

I love working with science. Nature and outdoor recreation have been a big part of my upbringing. I have grown up with a scientist in the family who always had answers to questions, both big and small, about the world around us. As a result, I have maintained my curiosity about interactions in the natural world and how it is built up, which has inspired me to work with field-based geology.

In 2019, my first year at NGU, I worked on quaternary geological mapping which was to be included in NGU's National Surficial Deposits Database. The mapping activity I have been a part of, and which I will continue for a few years to come, is in the Bodø area. It is important to map where marine deposits are likely because this information can be used for landslide risk assessments.

My work in 2019 has also consisted of mapping geology to be used as a knowledge base for nature management. There are many of us at NGU who work with various forms of geology in natural resources management. As part of the abiotic system, geology can often determine an ecosystem's species diversity and dynamics. This includes, for example, the composition of the bedrock, the chemistry of surficial deposits and the topography of landscapes and landforms.

My work consists of mapping landforms. I map red-listed landforms for the Norwegian Environmental Agency and glacial landforms for the Norwegian Biodiversity Information Centre. Both are new types of projects at NGU and in Norway. Glacial landforms are associated with glaciers, those currently existing and especially those ice sheets from the last glaciation period.

The latter project involves mapping in various areas in Norway that will form the guidelines for further mapping of the entire country. We will initially deal with glacial landforms, but in the long term we will also develop mapping guidelines for other types of landforms. Landform mapping will become part of NGU's National Surficial Deposits Database, and will also be included in Nature in Norway (the NiN system). These will be used as a knowledge base for many activities, such as nature resource management

Humans have today a greater impact on the earth than ever before. Our use of nature has provided us with a high standard of living. We should be grateful for this, but something has been lost along the way. Ravines are an example of an endangered habitat type unknown to many people and constitute a red-listed landform. Found mainly in Trøndelag and eastern Norway, these landforms serve as good agricultural land, which means that today many ravines facilitate active farming. Pristine ravines are often moist, lush valleys that serve as ecosystems for select plants, insects, birds and mammals. Once a ravine is levelled, it is lost forever.

It is therefore important to map ravines and assess current state, so that this information can be used as a knowledge base for future natural resource management.

Human activity has led to a great loss of natural diversity in recent decades. In Norway, we are certainly better at preserving nature than in many other places in the world, but we must not take this for granted. I hope and believe that in the future we also see the importance of preserving nature, where geology is an important part. Therefore, the inclusion of geology in the NiN system and in natural resource management is important.

I am proud to participate in this work, now and in the years to come.

Focus on locally-sourced stone

“My goal was to be involved in projects with outcomes that would steadily drive the sector towards a more sustainable, economical and quality-driven mineral industry.

Thomas Hibelot

Age: *31*
Leisure activities: *Climbing, training, skiing*
Education: *MSc (Geology), Arctic University of Norway - University of Tromsø*
NGU: *Team for Construction Raw Materials*

I was walking by the ruins of this 2,000 year-old Roman theatre in Autun, my childhood town. The stone staircases were worn out, and yet still, every summer, hundreds of people sat there at a time to enjoy the theatre productions. I was impressed. After more than two millennia, this theatre was still in use. In fact, the whole town was peppered with ancient, but still “breathing”, Roman structures and cobbled roads. I just couldn’t imagine modern construction lasting so long. I suppose that those old stone buildings left a mark on me. I must have been around 9 years old when I started collecting rocks.

Some years later, I remember telling my classmate, “geology is essential for everyone; geology courses are the best; I have cool rocks at home.” I recall them leaving the room, visibly bored. True, I was not a popular kid. But geology wasn’t doing great either, competing with mathematics and philosophy for the title of “most hated topic in secondary school.”

“Why do you like geology so much?” I was asked. “Rocks are cool,” I would answer. Clearly, I fell a bit short of selling the discipline.

It got me thinking, though. As I began to understand more about the importance of geosciences and how our society depends on it, I wondered why the discipline remained unpopular and why, in France, it was only taught in the shadow of the so-called “real sciences”.

“You know, university is not the best career move for you. You are a good student, you should enter one of those elitist and expensive preparatory schools,” my teacher said, when I applied for a geology program at the university. “Well, there is no real geology program in those preparatory schools; only state universities offer proper geology studies,” I answered. My teacher could not talk me out of it, but I was left with a feeling that geological sciences where undervalued.

A decade later, from the windows of my lab in southern Norway, I could watch processing at a quarry. The crusher and sieving machines were turning the massive, dark grey bedrock into aggregate of different sizes. The “Wilson Saga” cargo boat, down by the docks, was being loaded with crushed gabbro-norite before leaving for Denmark, where the material would be unloaded and used for road construction. Business was good, but that can’t be taken for granted. Everyone wants good roads, buildings, smartphones, and green technologies, but there is a strong popular opinion against quarrying and mining. Businesses were under constant pressure, and the smallest mistake led quickly to bankruptcy. This was not a sustainable situation.

I started at NGU in 2018, still promoting construction raw materials. I felt that we, as geologists, were the first link in the chain towards successful quarrying ventures. My goal at the time was to be involved in projects whose outcomes would steadily drive the sector to be more sustainable, economical and quality-driven. Resource management was one of our biggest challenges and quality data was essential to solving it. By improving sourcing, with more local material, the sector could become more sustainable and the final product would increase in quality. By studying the life cycle of quarrying material, one could prevent ecological disaster, health hazards, or economical loss resulting from the use of the wrong rock or inadequate material handling.

The date is March 15th, 2050. My new holographic smartphone’s calendar projects my daily schedule in front of me. It seems that this will be a busy day. “All days are busy, you know that,” my colleague tells me. “Yeah, you’re right,” I reply, as I reflect on my last 30 years working at NGU.

Since courses in “Geological Resources Management” were introduced into the school programs in 2025, people became increasingly aware of the need for a strong and efficient mineral industry. Thanks to improved knowledge and new technologies, sustainable quarrying flourished and led Norway to develop many local quarries supplying the country and parts of Europe with high quality rock material, while drastically reducing transport distance. The construction industry normalized recycling and is now able to reuse most geological materials. And because of the availability of better material, roads and buildings last longer.

As I scroll through the news feed, I read that Tromsø is now buying aggregates from a newly established quarry in Kvaløya. “One more step closer to locally-sourced stone,” I mumble.

“Do you remember when Tromsø was importing most of its construction material from Rogaland? How inefficient was that?” I ask my colleague. The man in his “40s” pivots on his squeaky chair, looks at me and says with a mocking smile, “Not really, no... I was a teenager back then, I had other priorities.”

At NGU, the geophysicists gather their own data. High-resolution magnetic, electromagnetic and radiometric data are efficiently collected over large areas by mounting NGU's instruments on a helicopter.

Full speed into the future

“Geoscience measures the present in order to investigate the past and model the future behaviour of our planet, Earth.

Name: Ying Wang

Age: 34

Leisure activities: *Training and traveling*

Education: *PhD in Mathematics from the University of Science and Technology of China; City University of Hong Kong*

NGU: *Geophysics Team*

“Your life is complete, now!” Pilot Gunnar laughed while nodding towards a moose not far off to one side of the helicopter. There it was, in the middle of a valley, magnificent and calm, seemingly unbothered by our helicopter that dangled a probe, sweeping it 80 m above the ground. Minutes later, we reached a snow-capped mountain that looked down at a fjord, less than a kilometre away, glittering shades of blue under the summer sun. Right then, I couldn’t help thinking that I was living the dream.

It was mid-July 2019, a few months after I joined NGU and became part of the Geophysics Team. Before that, I had been working under the title of "geophysicist" for a couple of years, although I was really a mathematician analysing data and dealing with equations. “Physics” yes, but without so many associations to “geo.”

At NGU however, geophysicists acquire their own data. This change took me out of my office and into the mountainous Hinnøya of Northern Norway, where airborne geophysical mapping was carried out. High-resolution magnetic, electromagnetic, and radiometric data over large regions were collected efficiently with NGU’s survey system mounted on a helicopter. The pilot followed the contours of the rugged terrain, so we occasionally found ourselves deep at the bottom of a valley, then suddenly elevating to the level of a mountain peak. The view and my emotions were indescribable. At one moment, we’d see a flock of sheep scattering along a gentle slope; in the next, a couple of jellyfish floating in the shallow coastal waters, enjoying the warm sunlight. Once, we even saw a herd of reindeer cooling off in a patch of snow in the shadow of a cliff.

I couldn’t contain my excitement, as I had said to Gunnar that my life would be complete if I could see the legendary moose. Check that one off the list!

Born and raised in a typical Asian society, it was expected that I should be good at mathematics or to become a doctor. Voila! A Ph. D. in mathematics was my solution to such an overabundance of choices. Jokes aside, I was very fortunate to be able to choose a career in which my qualifications align with my passions. I grew up with a strong curiosity to see more, and experience more. I was obsessed with the travel channels on TV, and at a young age fascinated by Jules Verne’s “Extraordinary Adventures”

Years later, I find myself flying between the mountain peaks over a beautiful Norwegian island in summer, racing against the rising sea mist. The word “dream” best summarizes it all.

Due to my mathematical background, my research mostly comprises data processing, modelling, and ultimately multi-geophysical data integration. Inspired by the actual data acquisition experience, shortly after the field season I worked out an algorithm for draping height correction to apply to aeromagnetic data collected in mountainous terrains. I have also been working on incorporating machine learning into joint interpretation of airborne geophysical maps.

Geoscience measures the present in order to investigate the past and model the future behaviour of our planet Earth. Important observations have been made to serve this purpose. Modern technologies such as digitalization, big data analytics, and machine learning are evidently growing in appeal in this old branch of natural science. In the years to come, extracting information from the increasing amount of complex data collected in geosciences, and gaining new insights via predictive simulations will become much more efficient as these new technologies rapidly evolve.

Living in an era in which technology is booming at an unprecedented rate, I enjoy the convenience and possibilities it brings to my everyday life and work. At the same time, the spectacular nature of Norway reminds me that being a new generation geoscientist is not only about using trendy technology to exploit resources more efficiently, but also about exploring how to ‘live in peace’ on this ball of rock that we call home.

More metals and minerals

Hanne-Kristin Paulsen

Age: *38*
Leisure activities: Skiing, climbing and training
Education: *PhD in Geology from Arctic University of Norway - University of Tromsø*
NGU: *Mineral Resources Team*

It's a bit of a coincidence that I ended up as a researcher in ore geology, but my interest in the outdoors clearly influenced my choice.

My detective work as a researcher most often begins in the field. I can hardly imagine a better job than spending a sunny day in a mountainside studying mineralisation right in nature's laboratory. But often I am left with more questions than answers, and I return with samples to be taken back to laboratory. In the lab, I use many different methods and techniques in an attempt to answer the big question: How are these ore deposits formed?

So why is it so important to know which geological processes form an ore deposit? On a personal level, my curiosity drives research. But from a societal perspective, one of the main goals is to provide basic information about where we can find new economically viable deposits: If we know what we are looking for, it is easier to find more.

Metals and minerals have been an essential part of the development has had and has. The demand for various minerals and metals has changed, and will continue to change over time. Today, the transformation of the energy and transport sectors includes reduction in fossil-fuel dependency which leads to increased demand, in particular for metallic raw materials.

Although some metals can be recycled, much is "locked" in current infrastructure. It is therefor necessary to find new economically viable deposits. In addition, there is a need to develop the technology so that extraction of metals can be made energy efficient and environmentally friendly. This is precisely why I am convinced that we should have mineral extraction in Norway. In Norway, strict mining regulation in addition to with many advanced technological solutions. This provides a basis for further technological development and potential for significantly reducing mining's environmental footprint.

I believe and hope that there will, in the future, be a greater awareness of where raw materials, including metals, come from. We, as consumers, will hopefully have a greater opportunity to influence the mineral- and metal-mining industry. Each of us will perhaps be able to make informed choices when purchasing products containing materials from mines, when they are labelled as "ecological" and/or "fair trade."

At the same time, as a researcher, I see the challenges of finding these deposits as we move towards 2050. Many deposits that have already been found, are located on the surface of the Earth's crust, where they are visible to the naked eye. In the future, my task will be to find more hidden deposits. Such deposits might be hundreds of feet under moraines, deep in the crust, or perhaps even on the ocean floor. Reaching such sites requires costly specialized, equipment and will be inaccessible to most of us. To be successful we need to apply technology that can "see through" the earth's crust and ocean floor, to a much greater extent than we are able to today. You will still, in the foreseeable future, regardless of the kind of exciting, new technologies that emerge, still find me with a hammer in my hand as I search for evidence for new deposits.

However, my compass has been replaced with an iPhone. Unfortunately I don't know where the exact sources for the metals in this gadget are. It would be exciting to see if I, by 2050, have this knowledge.

> *"Today, the transformation of the energy and transport sector to reduce fossil- fuel dependency results in increased demand for metallic raw materials in particular.*

Small things with big meanings

Graham Hagen-Peter

Age: *32*
Leisure activity: *Skiing, hiking, running, cooking*
Education: *PhD in geology from University of California, Santa Barbara*
NGU: *NGU Lab Team*

As Norway moves away from reliance on petroleum (...) we should see this not as a problem but as an opportunity.

The time- and spatial-scales that we deal with as geologists can be difficult to comprehend. For many, this invokes the reaction that what geologists operate with is incredibly large-scale and complex. Why do we care about events that occurred millions or billions of years ago? Why is it important to study the micro-scale composition of minerals, or, at the other end of the spatial scale, the processes that shape vast areas of the Earth's surface?

Whether out of passion or pragmatism, it is stereotypical for a young person to dream of becoming a doctor, an astronaut, or perhaps an engineer, but a geologist? How does this happen? I cannot say, in general, what inspires people to pursue a career in geology, but I can share my own experience.

Before I began studying geology, my exposure to "the world" was rather limited, both geographically and culturally. My only travels abroad were to neighbouring Quebec (I grew up in northern Vermont, not far from the border). I enjoyed outdoor activities such as hiking and camping, but I never imagined that this could be a significant component of my career.

In my first year at university, I was tremendously fortunate to have taken (in an almost random decision) an introductory geology class with a very inspiring teacher. I was immediately fascinated by the subject, both in the classroom and on local field trips, and my teacher encouraged me to pursue geology as a course of study for my bachelor's degree. I do not regret taking her advice.

Since then, I have had the good fortune to travel around the world for my work: Mongolia, Italy, the western U.S., Antarctica, New Zealand, Taiwan, South Africa, and now Norway. I have seen seeing fascinating places and have met fantastic people. I would never have had these opportunities if it was not part of my work as a geologist.

Fast forward, about 13 years from my first geology class, and I am now very happy to be living in Norway and working for NGU. I work primarily in a laboratory for measuring the composition of minerals (and other materials) on microscopic scales using a laser and mass spectrometers. Perhaps a job in the laboratory seems contradictory to the passion for travel and working outdoors which originally inspired me to pursue a career in geology, but I still have opportunities to do fieldwork in Norway and am involved in various projects with other geologists at NGU.

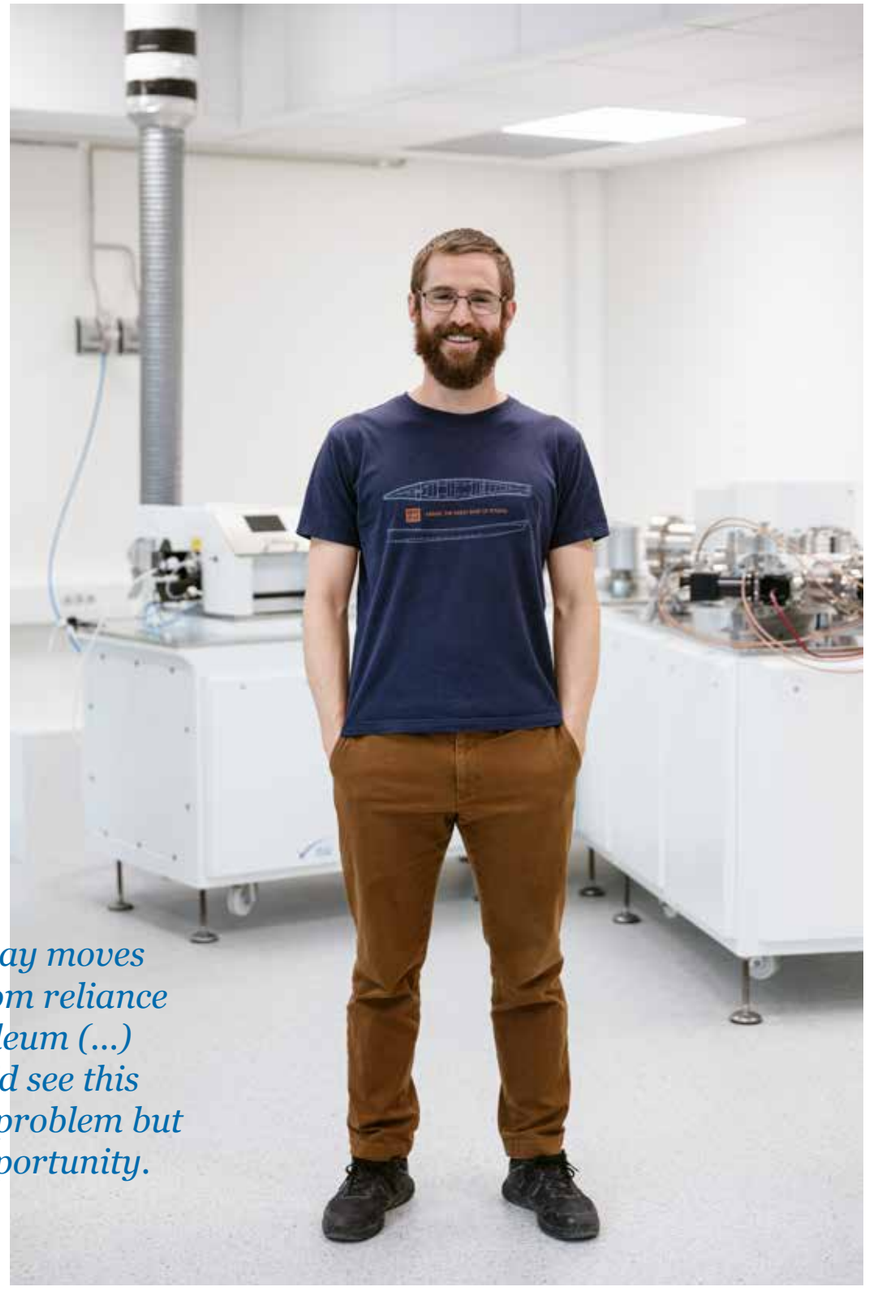
Regardless, nature is never far away in Norway.

Norway is a prosperous nation, largely due to a geological resource: petroleum. I appreciate that Norway shares the revenue from this, and other resources, broadly among its inhabitants, although I believe that this aspect can still be improved. As Norway moves away from reliance on petroleum as natural resources, which it must along with the rest of the world, for the sake of our children and future generations, we should see this not as a detriment but an opportunity.

Norway, in addition to having an advanced technological sector, with a highly educated workforce, has other important geological resources such as minerals which are integral to "green-energy" technologies, such as wind turbines, solar cells, and batteries. With stringent regulation, we have an opportunity to manage and utilize these resources in an environmentally and socially responsible manner.

In addition to managing natural resources, it is also crucial to understand and mitigate the geological hazards which we face in Norway, such as, for example, landslides and liquefaction of "quick-clays". It is important to understand the planet on which we live, and the processes which shape it over time.

Even though the time- and spatial-scales of these processes make them difficult to conceptualize, they clearly impact our everyday lives and the course of our society.



> *"As Norway moves away from reliance on petroleum (...) we should see this not as a problem but as an opportunity.*

Cash accounts: income and expenditures 2017-2019 (MNOK)

	2017	2018	2019
Income			
Annual Grant	169.1	179.4	181,4
Income from allocations and transfers	45.0	63.4	43,7
Sales and rental income	32.6	24.4	28,4
Total Income	246.7	267,2	253,5
267.2			
253,5			
Expenses			
Salaries and related costs	152.7	156.5	157,7
Depreciation	9.2	9.5	10,6
Other expenses	84.8	101.1	85,2
Total costs	246.7	267.1	0
253,5			
Total result	0	0	0

NGU's Overall production of reports, publications, presentations and maps 2017-2019

Product Type	2017	2018	2019
NGU reports	37	32	37
Articles in scientific journals and books	127	138	102
Articles in other publications	47	65	50
Presentations and lectures for students	383	330	319
Forskning.no	12	20	13
Bedrock and Quaternary maps	7	25	15

NGU Employee statistics

	2017	2018	2019
Total staff	203	196	197
With university degrees	148	143	146
With PhD degrees	70	64	64
Non-Norwegian employees	72	73	75

ANNUAL REPORT 2019 / WHAT THE STATISTICS TELL US

What the Numbers Tell Us

NGU continued, in 2019, to work in accordance with the guidelines embodied its Strategic Plan 2017-2020, as well as the major targets and tasks defined in Prop. 1 S (2017-2018) and in the 2019 allocation letter from the Ministry of Industry and Fisheries (NFD). NGU has, in principle, reached its targets and fulfilled the requirements and guidelines which are defined in the allocation letter and has remained within the given budgetary framework and financial guidelines.

NGU runs on a balanced budget. About 70% of NGU's financing consists of direct government grants.

NGU began, as of January 1, 2016, to operate under the accrual basis of accounting. The accounts overview displays figures for 2017 -2019, based on accrual methods.

NGU received, in 2019, a total allocation of 181.4 MNOK towards expenditures. This includes the grant from NFD, and a debit authorization of o.7 MNOK from the Norwegian Environmental Agency. The NFD allocation includes a grant of ca. 29 MNOK ear-marked for the MAREANO Mapping Programme.

NGU's databases are accessible through our website www.ngu.no. In addition to the databases, information about are activities is disseminated in the forms of reports, scientific journals and lectures for various audiences. The volume of scientific publications from NGU is high compared to the output from similar institutions, both domestically and internationally.

NGU's overall sickness absence rate in 2019 was 5%.

For more details and key statistics, please refer to the NGU annual report to the Ministry of Trade, Industry and Fisheries (NFD), available on the NFD website and ngu.no.

NGU's main goals:

- Increase the mapping of geological resources.
- ncrease the availability of geological knowledge for land-use planning and construction activities.
- Increase knowledge of the geological structure of Norway and of the geological processes which formed the country.
- Ensure good management and user-adapted geological knowledge.
- Strengthen communication and dissemination of geological knowledge.

GEOLOGICAL
SURVEY OF
NORWAY

- NGU -