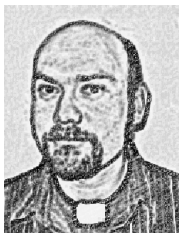
ANNUAL REPORT 2016

Department of Geology and Mineral Resources Engineering

NTNU
Norwegian University of Science and Technology

Management

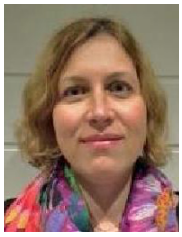
Mai Britt Mørk
Head of Department,
Geology Group



Rolf Arne Kleiv
Mineral Production
and HSE Group

Bjørn Nilsen
Ingenieering Geology
and Rock Mecanics
Group

Front page:
Kristian Drivenes in the field
(Photo: Øystein Gjermshusengen)



Marzena Ewa Grindal
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Scientific staff

Professors
Bjørge Brattli, Rolf Arne Kleiv, Hanumantha Rao Kota, Allan George Krill, Rune Berg-Edland Larsen, Charlie Chunlin Li, Stephen John Lippard, Suzanne McEnroe, Mai Britt E. Mørk, Bjørn Nilsen

Associate Professors
Terje Harald Bargel, Kristian Drivenes, Steinar Løve Ellefmo, Maarten Felix, Erik Stabell Ludvigsen, Krishna Kanta Panthi, Randi Kalskin Ramstad, Bjørn Eske Sørensen, Maria Thornhill, Kurt Aasly

Adjunct Faculty
Christine Fichler, Solveig Føreland, Eivind Grøv, Sunniva Haugen, Reginald Hermanns, Atle Mørk, Arve Næss, Quoc Nghia Trinh, Børge Johannes Wigum

Temporary scientific staff

Postdoctoral fellows and researchers
Nathan Church, Harald Gether, Thomas Grant, Helge Rushfeldt

Doctoral candidates
Chhatra Bahadur Basnet, Liyuan Chi, Øyvind Dammyr, Priyanka Dhar, Justin Olabode Fadipe, Marit Fladvad, Sondre Gjengedal, Anette Utgården Granseth, Are Håvard Høien, Cyril Jerome Juliani, Hanne Kvitsand, Aleksandra Lang, Alexander Michels, Benedicte Eikeland Nilssen, Øystein Lid Opsal, Mario Orlando Morales Cardenas, Zeudia Pastore, Anna Pryadunenko, Ida Johanne Svendsen Røisi, Camilo Andrés Silva, Veena Sajith Vezhapparambu, Helene Strømsvik, Marte Kristine Tøgersen, Solveig Vassenden, Geertruida Wilhelmina ter Maat

Dmitrii Tkalich and Krzysztof Jan Zieba completed their PhD theses in 2016

Technical and administrative staff

Administrative Staff
Wenche Wilhelmsen Finseth, Øystein Gjermshusengen, Marzena Ewa Grindal, Anne-Irene Johannessen, Aina Myrvold, Knut Olav Solem, Thor Haldor Thoresen

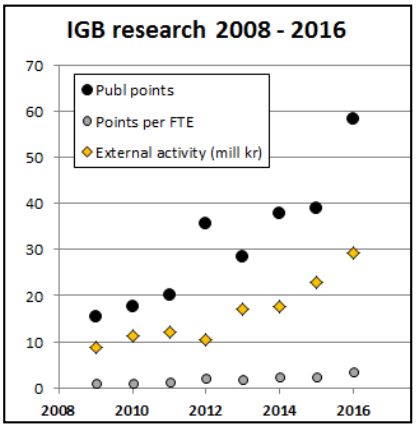
Technical Staff
Kristin Bergseth Aure, Torkjell Breivik, Odd Corneliussen, Kjetil Eriksen, Erik Larsen, Arild Edin Monsøy, Torill Sørløkk, Laurentius Tijhuis, Gunnar Vistnes

2016 in summary, by IGB-Department leader

IGB *Institutt for geologi og bergteknikk* originated from the former NTH departments *Geology*, *Mineral production*, and *Mining* in 1989, and has been localized in the *"Berg – Oppredningen"* building complex at Gløshaugen since 2002. Our strategic goals involve *"research and education for sustainable management of the Earth's geological resources"* – now even more relevant than ever, and bridging the department's research groups: Geology; Engineering geology and rock mechanics; and Mineral production and HES. Fieldwork and laboratory work is integrated in our research, with unique laboratory facilities ranging from pilot scale mineral dressing, flotation, rock mechanics and engineering, to small scale advanced chemical, mineralogical and magneto-mineralogical laboratories.

Sharing of infrastructure with SINTEF Byggforsk in our engineering geology and rock mechanics laboratory has been successful through several years, and a new and revised contract was signed in 2016. We also signed an agreement with NGU, CAMOC, in advanced mineral- and ore characterization, to collaborate promoting new infrastructures in Mineral research. EM-lab collaboration with Material Science resulted in a common huge infrastructure application to NFR for continuing being upfront in advanced electron microscope facilities.

2016 was a successful year in terms of *production* in education and research. 51 master candidates graduated in the 5-year and 2-year master programs in Geotechnology and Geology, and 18 candidates graduated as Bachelor in Geology. We are also pleased with the recruitment of new students to our Bachelor and Geotechnology programs with ≥ 2.2 applicants per position, in spite of the declines for geoscience elsewhere due to low oil prices. Notably we have seen a growing interest toward specialization in engineering geology, reaching an all-time high in 2016. In research measures we saw a long predicted increase in number of publication points as well as in externally funded research activity (Figure).



Publication points and external activityfrom 2008 to 2016.

During 2016 our PhD staff increased to 30, and we are also proud of seeing a good international profile with candidates from 13 different countries represented, and close to 50/50 gender balance.

Three new scientific employees were welcomed in 2016: Randi Kalskin Ramstad as associate professor in engineering geology soils, and Solveig Førland as adjunct associate professor in mineral production and HES. Randi's expertise and initiatives already provided a PhD project in geothermal energy, and she is also the department's representative in ground water issues. Solveig's main expertise is within health, safety and environments, which is crucial in our education in mining and mineral production. Dr. Richard Harrison, Cambridge University, was appointed one of NTNU's temporary international chair positions to promote excellent research in geomagnetometry in collaboration with Professor Suzanne McEnroe.

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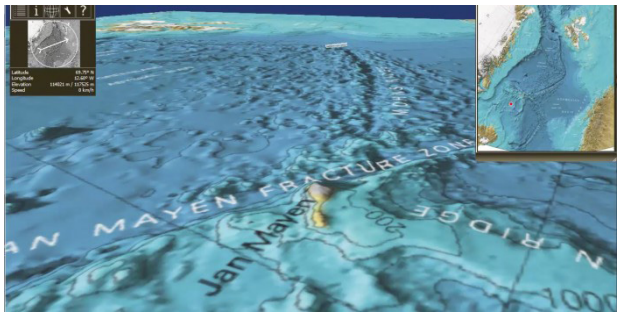
The department is presently involved in developing three of four new focus areas of the IV-Faculty's new research strategy: "Safer, cleaner and efficient energy", "Mineral resources" and "Ocean space", and already played a role in establishing HydroCen - Centre for Hydropower Technology through our expertise in engineering geology and tunneling with Professor Bjørn Nilsen and Associate professor Krishna Panthi.

Initiation of a new strategic Faculty program in mineral resources is coordinated by Professor Rolf Arne Kleiv. Our focus on mineral resources and mineral production over the last years has resulted in several new PhD research projects and new combination of disciplines such as in Geometallurgy, and methodology for exploration and mineral production of deep sea minerals (massive sulfides related to Mid Oceanic ridge areas). We have also experienced increased success in gaining NFR-funded research projects in collaboration with industry partners (e.g. MarMine), and participation in EU projects (e.g. InRec, Blue Mining, Blue Nodule, Nykos). Associate Professor Maria Thornhill is representing NTNU at the European Technology platform on sustainable mineral resources.

In August 2016 associate professors Kurt Aasly and Steinar Ellefmo participated in the MarMine research cruise to the Mohn´s Ridge north of Jan Mayen. This was a multidisciplinary research cruise organized by NTNU and NIVA and several collaborating partners. The successful results of the cruise provided a huge amount of rock samples and data for further research within the MarMine and associated projects.

Looking back, I am extremely proud to have been the head of this unique department of geology and mineral resources engineering!

With compliments to all staff and students,
MAI BRITT E. MØRK
Trondheim 9/6-2017



Marmine sampling area north of Jan Mayen.

Part of the Marmine team on board Polar King.

Contents

Engineering Geology and Rock Mechanics

Our research group is multidisciplinary, with teaching and research activities on a large variety of issues related to engineering geology of rocks, rock mechanics and engineering geology of soils. In Engineering geology of rocks main focus is on investigation, design, stability analysis and constructional aspects of underground projects for important purposes such as road- and railway tunnels, hydropower plants, caverns for various purposes (storage of oil, gas, drinking water, freeze storage, sports halls, and much more). In Rock mechanics, main focus is on rock testing and characterization and on stability/ rock support. In Engineering geology of soils, main focus is on sustainable use of soil and ground water resources. Our research group also has considerable research activities connected to slope stability, including impacts of climatic change.

Group members

Bjørge Brattli
Professor

Charlie Chunlin Li
Professor

Bjørn Nilsen
Professor

Krishna Kanta Panthi
Associate Professor

Randi Kalskin Ramstad
Associate Professor

Adjunct Faculty:
Terje Harald Bargel, Eivind Grøv, Reginald Hermanns, Karl Gunnar Holter, Nghia Trinh

PhD candidates:
Chhatra Basnet, Liyuan Chi, Øyvind Dammyr, Sondre Gjengedal, Are Håvard Høien, Hanne Kvitsand, Mario Morales, Øystein Lid Opsal, Helene Strømsvik, Dmitrii Tkalich, Solveig Vassenden

Ongoing external funded projects

Project title	Responsible
DePOPS (NFR, Industry/Titania)	K. Panthi/B. Nilsen
FastTunn (NFR, Industry)	E. Grøv
HydroCen (NFR, Industry)	B. Nilsen/K. Panthi
NextDrill (NFR, Industry)	C. Li
ORMEL (RFFMN, Public authorities)	R.K. Ramstad
Stability and rock support of road and railway tunnels (Industry/SVV)	B. Nilsen
TIGHT (NFR, Industry)	E. Grøv/B. Nilsen

Communication tunnels (road and railway)

Engineering geological knowhow is of great importance for planning, excavation and support of all kinds of tunnels and underground excavations. Particularly this is the case for road and railway tunnels, which to a greater extent today are being built in urban areas, with very strict requirements regarding stability, deformation and ground water lowering. Also, tunnels are being planned and built for crossing deeper and deeper below fjords and straits, involving increased requirement for stability control, rock support and sealing. A new trend in Norway is that TBM (Tunnel Boring Machines) are taken into use for excavation of large (railway) tunnels, representing "new" challenges also related to engineering geology. Research projects on these issues have been going on for more than three decades at our institute, representing a very solid database for further evaluation and research in this field. The most recent years, research in this field has to a great extent been focused on water inflow and sealing, including NFR-research projects on sprayed membrane lining and high pressure grouting (TIGHT).

For further research on the feasibility of sprayed membrane lining, an adjunct professorship financed by the National railway authorities was established in December 2016 (KG Holter). Two PhDs have been directly linked with this research activity.

Rock support during TBM-excavation of railway tunnel (Ulriken, Bergen).

Geothermal energy

Geothermal energy is a renewable energy source which is more and more used for heating and cooling purposes in Norway and worldwide. To utilize the ground for heating and cooling it is vital to know the thermal properties and the physical and thermal behaviour of the ground for optimal design and operation of different types of geothermal energy plants. The main research focus is on utilizing shallow geothermal energy both on open systems (groundwater) in sand and gravel deposits and closed loop systems in bedrock. In the recent years, utilizing deep systems ranging from 800 metres to several kilometres deep boreholes, has gained more focus due to the lack of area in urban areas.

Our research group is leading the research project ORMEL which focuses on optimizing the utilization of groundwater pumped from filter wells established in sand and gravel deposits in the centres of Melhus and Elverum. One PhD-student is connected to the ORMEL-project.

The research group cooperates extensively with industrial partners, national and foreign research partners. Among these are KTH in Sweden which is one of the leading research groups within research on shallow geothermal energy. National research partners are the Geological Survey of Norway (NGU), SINTEF Energy and SINTEF Byggforsk, Christian Michelsens Research (CMR) in Bergen, and other departments at NTNU, especially NTNU EPT. The research group will also participate together with SINTEF Byggforsk in the FME centre ZEN – Zero Emission Neighbourhoods.

Water flushing from the groundwater well in the centre of Melhus. The capacity of the well is around 20 liters/second.

Hydropower tunnelling

As a consequence of the increased demand for green energy, a Centre for Hydropower Technology (HydroCen) was established by NFR in May 2016 as one of the 8 new FMEs (Centre for Environment-friendly Energy Research). Our research group is involved in this 8-year research project from the start with 3 PhD-projects focusing on aspects related to hydropower tunnel stability, support and design. Issues particular for the special conditions of water tunnels, i.e. effects of swelling clay, peaking operation and transition lined/unlined tunnel, will be in focus during the initial part of this research which will involve extensive cooperation with other NTNU research groups, industrial partners and foreign research partners. Research related to HydroCen will be a main research activity for our research group in the years to come, with several PhD projects, and will also include an adjunct professorship financed by Statkraft and NGI through HydroCen.

Mapping complex geology of access tunnel to Bratsberg hydropower plant.

Rock mechanics

The scope of rock mechanics is the mechanical behaviour of rock and rock masses related to engineering excavations, theory and methodology of rock support and applications of rock mechanical principles in excavation design. Research focuses are on rockburst, failure mechanics of rock, methodology of underground rock support and dynamic rock support. Rockburst is associated with rock stresses as well as rock types. It has become a big issue in TBM tunnelling because of its unpredictability and serious threats to workers and facilities. Failure mechanics of rock is a basic research topic aiming to understand the transition of failure modes when the rock condition is changed. Methodology of underground rock support deals with principles and methods of rock support in different rock conditions. It involves both theoretical analyses and on-site work in monitoring, observation and verification. Dynamic rock support is a topic aiming for methodology of rock support in burst-prone rock masses as well as studies on the dynamic performance of individual support devices like rock bolts. NTNU is on the frontline of research on the topic of dynamic rock support. The Laboratory of Rock Mechanics at NTNU is one of the most advanced laboratories in rock mechanics in Europe. It is aimed to develop the laboratory to a main center for rock mechanics tests in the world.

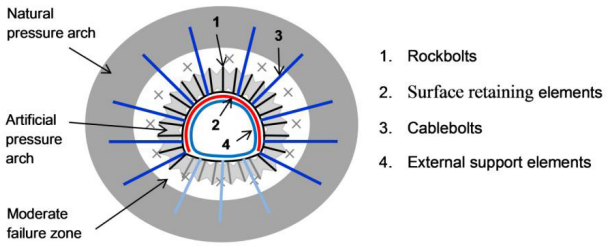


Figure: Methodology of underground rock support.

Slope stability and landslides

Research related to stability of natural slopes and excavated cuts in rock and soil has a long tradition in our research group. As part of this activity, our research group participated in NFR-SFF International Centre for Geohazards (IGG – completed 2012), and in this connection and later organized several PhD-projects on slope stability. Recent research has also included PhD-projects (i.e. NFR-DePOPS) and applied research connected to open pit mining. The research on slope stability and landslides has become increasingly important as a result of climate change with increased rainfall and milder climate causing stability reduction as well as landslides associated to earthquakes. Research in this field has been intensified during the last 5-10 years by establishment of adjunct professorships in cooperation with NGU and NVE. To further strengthen the capacity, expertise in slope stability/landslides will be one of the main requirements in the hiring of new professor in Engineering geology, which is to take place in 2017 due to retirement. Further cooperation with national key organizations like NGU and NVE, as well as international organizations in this field, will be a main priority of our research group in the future.

Jure landslide in 2014 in the Sunkoshi river, Nepal caused by continuous rainfall for many days.

The geology group is responsible for education and research in basic geology disciplines, as well as more applied ones. Our research activities aim to improve understanding of fundamental geological processes with particular focus on the formation and distribution of geological resources. To cover this we specialize in advanced mineral characterization, mineral deposit geology/ore geology, and sedimentary and Arctic geology. Structural geology, basin analysis and geophysics are likewise fundamental parts of the research and important in solving regional geological problems.

Group members

Rune Berg-Edland Larsen
Professor

Allan George Krill
Professor

Stephen John Lippard
Professor

Suzanne McEnroe
Professor

Mai Britt Mørk
Professor

Maarten Felix
Associate Professor

Bjørn Eske Sørensen
Associate Professor

Adjunct Faculty:
Christine Fichler, Atle Mørk, Arve Næss

Postdoctoral fellows:
Nathan Church, Thomas Grant

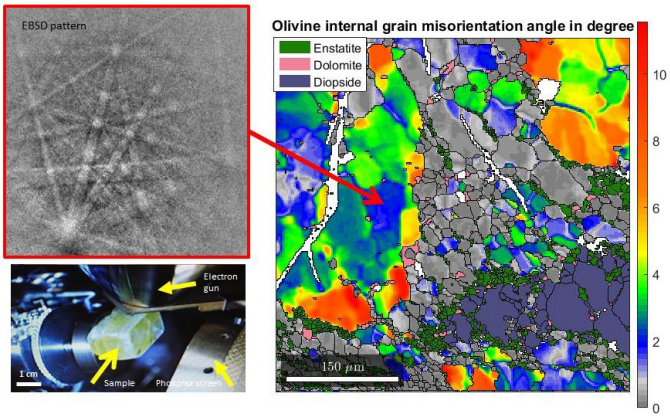
PhD candidates:
Justin Olabode Fadipe, Anette Utgården Granseth, Daniel Luis Ibraimo, Emily Barnabas Kiswaka, Gareth Steven Lord, Alexander Michels, Zeudia Pastore, Anna Pryadunenko, Geertruida Wilhelmina ter Maat, Krzysztof Jan Zieba

Ongoing external funded projects

Project title	Responsible
SWARM (NFR)	Suzanne McEnroe
RBE – Platinum Probe (NorMin)	Rune Berg-Edland Larsen
ABYSS (FP7)	Suzanne McEnroe
MATERA ERA-Net: Coordinator Novel Nanomagnetic Oxide Composites (ERA-Net)	Suzanne McEnroe
Glacialimpact of sedimentary basins, numerical methods (SINTEF/oil companies)	Stephen Lippard
Triassic successions Svalbard – N. Barents Sea (NPD)	Atle Mørk
Organic carbon distribution, Norwegian shelf (Statoil)	Maarten Felix
Permian-Triassic depositional systems, Norwegian Sea (ANTHEI programme)	Maarten Felix

Advanced mineral characterization

Advanced mineral and rock characterization is an integral part of research and education in most sub-topics in the group, within igneous, metamorphic and sedimentary petrology, ore petrogenesis, detailed reservoir characterization, and for understanding deformation mechanisms and magnetic properties. In addition to fundamental laboratories for chemical and mineral analysis, we have considerable use of electron microscopy facilities, and valuable collaboration with the Institute of Material Science. In particular we emphasize our research interests in state of the art SEM EBSD (electron backscatter diffraction) analysis. Mineral indexing and phase discrimination between complicated low symmetry geological materials has been improved by Bjørn Eske Sørensen. Our infrastructure in magnetometry is recently upgraded with new groundbreaking instrumentation that can map magnetic anomalies at the µm scale of individual mineral. This instrument was designed and built by Nathan Church. This enhances to an unprecedented level our interpretation skills in ground, airborne and satellite surveys.



a) Sample placed in the instrument for SEM EBSD analysis and
b) the resulting EBSD pattern in one pixel scale.
c) EBSD map of dunite – mineral and orientation determined from pattern in each pixel. The image visualizes internal deformation by differentiating old deformed olivine grains (vivid colors) from new recrystallized olivine (grey). Other minerals explained in inset.

Image from B.E. Sørensen et al. (in prep.)

Ore-Deposit Geology

Future technologies depend on the access of economic ore and mineral deposits of essential metals and minerals. Our basic idea is to study the processes that distinguish ore-forming geological systems from comparable settings that are not fertile. During the last years we have succeeded in developing successful research collaboration between ore geology/advanced mineral characterization and magnetometry/mineral physics. The Seiland project in north Norway provided a successful combination of ore-forming geochemistry, thermodynamic modelling of mineral assemblages and geophysics both in regional and mineral scale to better understand the genesis of large fertile geological provinces.

Currently, we are applying this approach to three magmatic systems:
Transfer of ore-forming ultramafic melts from the deep mantle to the shallow crust: The Seiland igneous province comprises the most fertile melt types known, which form world class Cu-Ni-Cr-Co-PGE-Au deposits. Our models for the ore formation rely on study of igneous processes in combination with volatile fluxing of sulphur, CO_2 and H_2O, magmatic mixing and contamination.

Photo: Seiland workshop (2015) by professors Rune Berg-Edland Larsen and Suzanne McEnroe, Post docs, PhD- and master students, research partners from the University of Copenhagen, and Nordic Mining.

Formation of batholith-size ore-forming granitic systems: In Cornwall we are studying the Cornubian Batholith that covers an area of c. 2000 km² and is associated with world class Sn-W and Cu deposits. Excellent coastal exposures allow detailed investigation of the granitic-hydrothermal transition where granitic melts have evolved to extremely metal-rich brines. We study in detail the conditions that control the transfer of economic elements from the melts to the hydrothermal fluids.

Importance of melt history for the formation of Seabed Massive Sulphide deposits (SMS). Mining of offshore Seabed Massive Sulphide Deposits at kilometres water depth may take over as the most important source of Cu, Zn and Co when easy accessible onshore deposits are depleted. The aim is to understand the character of partial mantle melting that is required to generate fertile oceanic crust which is the source-rock for SMS deposits. Amongst other places we are studying oceanic mantle in Cornwall, Røros, Leka and Newfoundland to understand better the importance of tectonic setting for the formation of fertile oceanic crust.

Sedimentary geology and basin analysis

Sedimentology and basin analysis are topics in education for petroleum geologists, and we perform relevant research for exploration and reservoir characterization, including CO_2 sequestration.

Modelling of sedimentary processes in terms of fluid mechanics and basin fill aims to understand the sediment transport processes and how they influence the spatial (and temporal) distribution of the different types of sediments. This is done through a combination of mathematical modelling with core and outcrop description, at present through ongoing PhD. projects focusing on organic carbon distribution on the Norwegian shelf. The aim is to expand the research area through multidisciplinary collaboration with partners at NTNU (e.g. the structural/basin geologist to be hired), in Norway (e.g. NGU, NGI), and abroad (e.g. the Universities of Leeds and Edinburgh).

Structural geology and basin analysis provides a framework for understanding the structural dynamics and formation and nature's allocation of geological resources such as hydrocarbons in the crust. A PhD project in collaboration with SINTEF focused on uplift in the Barents Sea using numerical methods. Expertise in structural geology and basin analysis provides a bridge to other disciplines at IGP in crustal dynamics. As the professor (Lippard) is retiring in August 2017 it is now becoming urgent to fill the position.

Sedimentary geology studies in Arctic areas focus on sedimentary environments, provenance and diagenesis involving field work and core study of Mesozoic deposits in Svalbard and the Barents Sea. The field work 2016 concentrated on the Triassic De Geerdalen Formation on central Spitsbergen including one PhD student and three master students, supported by NFR Arctic Field Grants and collaboration with UNIS and NPD. One of the aims is to improve our models for deposition and distribution of Triassic reservoir rocks. This is also a framework topic for a new PhD project on mineral and isotopic methodologies for provenance in collaboration with NGU starting in 2017.

Fossil sampling and logging of Triassic rocks of the Botneheia Fm, Central-Spitsbergen for master thesis work in Arctic geology. Background: Marhøgda and Diabasodden. Photo: Nina Bakke 2016.

Mineral production and HSE

The Research Group's main focus is on methods and technologies for extracting minerals and metals from primary and secondary sources to provide essential and valuable raw materials for today's and tomorrow's society. This covers the entire value chain from the geological resources to the final mineral products and includes modelling and evaluation of mineral deposits, mine planning, process mineralogy and mineral processing as well as product development, tailings management and remediation. Mineral resources are non-renewable and their extraction carries with it a strong social and environmental obligation. As NTNU is the only University in Norway focusing on mineral production, the Mineral Production and HSE Research Group at IGP has a national responsibility to maintain and develop the required competence within this field.

Group members

Rolf Arne Kleiv
Professor

Hanumantha Rao Kota
Professor

Kurt Aasly
Associate Professor

Steinar Løve Ellefmo
Associate Professor

Maria Thornhill
Associate Professor

Erik Stabell Ludvigsen
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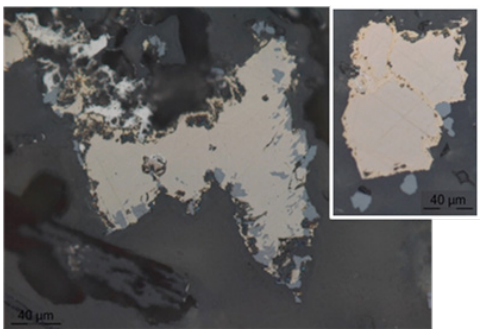
Ongoing external funded projects

Project title	Responsible
New Knowledge on Sea Disposal (NYKOS) – NRC/industry	R. A. Kleiv
Geometallurgy Applied to Industrial Minerals Applications (InRec) – NRC/industry	S.L. Ellefmo
Exploitation techn. for marine minerals on the ext. Norw. cont. shelf (MarMine) – NRC/Industry	K. Aasly
Blue Mining – EU/Industry	S.L. Ellefmo
Blue Nodules – EU/Industry	K. Aasly
+ three industrial PhD projects and a large number of projects at the Mineral Processing Lab	

The MarMine project

As part of the NRC-funded MarMine project, researchers from IGB together with colleagues from other NTNU departments as well as external research and industry partners went on a research cruise to the Arctic Mid Ocen Ridge between Jan Mayen and Svalbard. The cruise took place during three weeks of August and September 2016 and included 25 researchers and technical personnel on board the vessel Polar King. The aim of the cruise was to visit several locations on the northern part of the so called Mohn´s Ridge, including a known hydrothermal vent system, Loki´s Castle in order to collect data and samples for use in the research related to the MarMine project.



Relatively coarse grains of isocubanite (pinkish) occur with alteration rims/fractures and exsolutions of chalcopyrite (yellow), and are variably intergrown with sphalerite (grey) and pyrite (white). Photomicrograph: Ben Snook NTNU/ MarMine.

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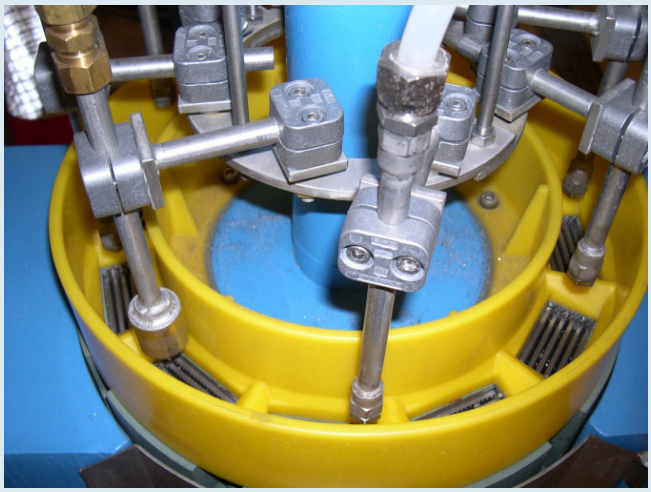
The Mineral Processing Laboratory

Research and education at the nationally unique Mineral Processing Laboratory at NTNU provide vital knowledge on sustainable processing of ores and minerals, as well as on recovery of valuable components from industrial waste.

At the Mineral Processing Laboratory, ores and mineral based raw materials can be crushed and ground in order to liberate the individual phases. These particles can then be separated to recover valuable minerals, remove contaminating components or divide the material into different size fractions. The separation is based on differences in the physical and chemical properties of the particles, and could be based on density, magnetism, surface chemistry, particle size, mechanical strength, electrical conductivity or colour/appearance. The equipment consists of modular units, which allow unit operations to be run either separately or combined in continuous circuits. The laboratory can also produce user specified micronized mineral products.

In 2016, the bulk of the Research Group's scientific output originated from the Mineral Processing Laboratory with level II publications on both innovative flotation and mechanical activation. Both these research areas have been strengthen with respect to project activities, infrastructure and functionality. The flotation laboratory has acquired a new tensiometer and its first pneumatic flotation cell. The general activity in the laboratory was high. A large number of both industry funded and NRC funded projects were conducted - spanning from simple crushing jobs to extensive pilot work and circuit development.



Wet High Intensity Magnetic Separation (WHIMS). Close-up of the matrix boxes of the Jones P40 pilot scale separator. Photo: Oppredningslaboratoriet.

Strategic work, sustainability and networking

In 2016, the Research Group has had a particular focus on strategic work. As a result, 'Sustainable mineral production' has secured a more prominent place in the Faculty's revised Research Strategy, going from being one of 16 Strategic Research Areas to one of five overarching Social Objectives. This is a reflection of the crucial importance of mineral commodities. Global population growth, increased industrialization and the need for new green technologies has resulted in a fast growing demand for minerals and metals. An expanding mining industry is a prerequisite for implementing the green shift. Based on its large land-based and offshore mineral resources, Norway has the potential for becoming a major supplier of mineral products to a green global economy.

In addition to the internal strategy processes, the Research Group has devoted a lot of time and resources on interacting and cooperating with industry, governmental authorities and media. This includes technical assistance, professional training, committees work, promotion and public information. At the same time, the Research Group has worked actively to strengthen and expand the research networks develop through existing NRC and EU projects and to build a long-term strategic interface towards the relevant EU Research Mechanisms. The Research Group represents NTNU on European Innovation Partnership on Raw Materials (EIP-RM) and on The European Technology Platform on Sustainable Mineral Resources (ETP-SMR).

Sustainable Mineral Production. Every deposit is unique – there are few turn-key solutions.Photo: R.A. Kleiv

Samples and data from the areas were collected by using remotely operated vehicles (ROVs) and autonomous operated vehicles (AUVs).

In total nearly one ton of mineralized rock samples were collected from Loki´s Castle. Additionally, push core sample and gravity cores from this and other sites on the ridge were collected. An ROV mounted drill rig developed for the project was successfully tested in the pillow lava basalt and a UHI camera mounted on the AUV was tested for the first time. Samples and data collected during the cruise will be further used to fulfill the goals of the MarMine project, which is to assess and develop new knowledge about exploitation technologies for typical seafloor marine mineral deposits, including mining technology and mineral processing solutions and characterization (See photo).

Field courses and excursions

Field courses and excursions spring 2016			
Subject heading	**Date**	**Destination**	**Course coordinator**
Gruvedrift VK	February/March	Sverige	Sunniva Haugen
Hydrogeologi	When free of snow	Kaldvella i Melhus, Moodden Nidelva	Bjørge Brattli
Bergmek og geotek	March	Børsa E39, tunnel	Charlie Li
Ingeniørgeologi Berg VK	March	Strindheimtunellen	Bjørn Nilsen
GIS for mineraler VK		Rana Gruber	Erik Ludvigsen
Sedimentologi og stratigrafi	April	Storvika, Blekkpynten	Maarten Felix
Prosessmineralogi	April	Titania	Kurt Aasly
HMS i tungindustrien	06.04.	Bedriftsbesøk	Solveig Føreland
Bergmekanikk VK	12.04. – 13.04.	Mo I Rana, Rana Gruber	Charlie Li
Norges geologi og georessurser	12.04, 13.04 og 14.04.	Gauldalen	Terje Bargel
Ingeniørgeologi og tunneldrift, GK	15.04.	Strindheimtunellen	Krishna Panthi
Petrologi og geokjemi	17.04.	Bymarka	Bjørn E. Sørensen
Prospektering, malm	18.04. – 25.04.	Cornwall	Rune Berg-Edland
Petrologi og geokjemi	19.04. - 21.04.	Leka	Bjørn E. Sørensen
Sedimentologi og stratigrafi	21.04. – 27.04.	Yorkshire	Maarten Felix
Norges geologi og georessurser	25.04. – 26.04.	Oslofeltet	Atle Mørk
Produksjon av tilslagsmaterialer	Mai	Lia og Vassfjell Pukkverk	Børge Wigum
Prospektering, malm	Mai	Fosen	Rune Berg-Edland
Ingeniørgeologi Berg VK	02.05. – 03.05.	Vestlandet	Bjørn Nilsen
Ingeniørgeologi Løsmasser VK	04.05. – 05.05.	Nordvestlandet	Terje Bargel
Historisk geologi og peleontologi	28.05. – 30.05.	Oslo	Atle Mørk
Strukturgeologi	09.06. – 19.06.	Alta	Stephen Lippard

Field courses and excursions autumn 2016			
Subject heading	**Date**	**Destination**	**Course coordinator**
Fordypningsemne	10.08. – 14.08.	Kvam – Snåsaområdet	Bjørge Brattli
GIS for mineraler GK	21.08. – 23.08.	Røros	Erik Ludvigsen
Mineralproduksjon	31.08.	Rana Gruber	Steinar L. Ellefmo
Geologi innføring	30.08., 31.08. og 02.09.	Gaudalen	Allan Krill
Rock Engineering	05.09. – 07.09.	Bogna	Bjørn Nilsen
Geologi innføring	13.09., 14.09. og 16.09.	Tautra	Allan Krill
Ingeniørgeologi	20.09.	Vassfjellet rundt	Bjørge Brattli
Ingeniørgeologi	21.09.	Vassfjellet rundt	Bjørge Brattli
Ingeniørgeologi	22.09. – 23.09.	Leirfossen – Bynesveien	Bjørn Nilsen
Skredprosesser	25.09. – 26.09.	Oppdal – Surnadal	Reginald Hermanns
Rock Engineering	27.09.	Strindheimtunnel	Krishna Panthi
Mineralforekomstgeologi	27.09. – 30.09.	Røros	Rune Berg-Edland
Geologi og miljøet (perspektivemne)	03.10. og 07.10.	Vassfjellet Gaudalen	Bjørge Brattli
GIS for mineraler GK	04.10.	Bedriftsbesøk, Lade	Erik Ludvigsen
Strukturgeologi, videregående kurs	12.10. – 22.10.	Isola d'Elba, Italia	Giulio Viola
Geologi innføring	18.10., 19.10. og 21.10.	Vestranden, Trondheimsfjorden	Allan Krill
Produksjon av tilslagsmaterialer	Mai	Lia og Vassfjell Pukkverk	Børge Wigum
Prospektering, malm	Mai	Fosen	Rune Berg-Edland
Ingeniørgeologi Berg VK	02.05. – 03.05.	Vestlandet	Bjørn Nilsen
Ingeniørgeologi Løsmasser VK	04.05. – 05.05.	Nordvestlandet	Terje Bargel
Historisk geologi og peleontologi	28.05. – 30.05.	Oslo	Atle Mørk
Strukturgeologi	09.06. – 19.06.	Alta	Stephen Lippard

Student excursion to Nevada, Arizona (Grand Canyon), California (Death Valley)

Annual spring field trip for the graduating class of bachelor and master students in geology, March 11-18. There were 22 students, including some beginning master students, and two NTNU professors, Allan Krill and Stephen Lippard. They visited classic geological sites in Grand Canyon (Arizona), Las Vegas (Nevada), and Death Valley (California), where it is possible to observe and interpret dramatic and challenging geological relationships. Field locations were selected by Professor Stephen Rowland, Univ. of Nevada, Las Vegas (UNLV), who led one day of the trip.

Photo shows NTNU students in Red Rock Canyon, Las Vegas.
Photo: Stephen Lippard

Student excursion to Chile

In March 2016 a one week «Main excursion» to Chile was organized for 4th and 5th years students of Engineering geology/ Geotechnology. A group of 10 students participated, with professor Bjørn Nilsen as excursion leader. With Santiago as main base, technical visits were organized to construction sites for extension of Santiago metro (see photo), Andina copper mine (underground part), Alto Maipo hydropower project (including TBM tunnels and sections with severe water flow and rock stress problems) and offices of Normet (manufacturer of shotcrete rigs, etc) and Arcadia (main consulting company.

Excursion participants and local guides at face of metro tunnel under excavation in soil (moraine).

Cornwall, England

In the first year of the MSc studies, students specialising in hard-rock and resource geology are offered an opportunity to specialise in ore-deposit geology. In both the basic and advanced course the students study the formation of basic raw material such as copper, platinum and silicon. A crucial part of this specialization is hands on studies of deposits in the field in either Røros where we study the formation of volcanic hosted ore-deposits or in Cornwall where we study tin-copper-tungsten-kaolinte deposits in granitic settings. The images display a group of students in front of, and a close up of the world heritage Cligga Head tin and tungsten deposit in Cornwall.

Photo: Kristian Drivenes

Photo: Kristian Drivenes

Yorkshire, England

The annual Yorkshire field course is part of the basic sedimentology course for Bachelor in Geology and Master in Petroleum geoscience (3rd year). The well exposed coastal outcrops are excellent for learning sedimentary facies and structures, detailed logging and interpretation of fluvial and marine Jurassic and Upper Cretaceous paleo-environments analogous to exploration areas in the North Sa. Since 2016 the field course has been extended by Maarten Felix to include Upper Palaeozoic turbidites and limestones in the Peak District. 31 students participated in 2016, supervised by Maarten Felix, Mai Britt E. Mørk and Arve Næss.

Photo: Mai Britt Mørk

Oslofeltet

Historical geology and paleontology, each year has a three day field excursion in the Oslo Region studying the Cambrosilurian succession. Alum shale at Slemmestad, trilobites and cephalopods at Bjørkåsholmen and nodular limestone and the Ordovician-Silurian boundary beds at Hovedøya (photo). On the second day at Ringerike we study the transition from shallow marine clastics to carbonate brachiopod limestones, with coral reefs on top. On the last day at Malmøya we study the transition from marine shales crowded by brachiopods to nodular limestones with corals and stromatoporoids before that succession is covered by a dark graptolite shale. The excursions ends with a visit to the dinosaur skeletons at the Geological Museum.

Photo: Atle Mørk

Alta

48 students in two groups travelled to Finnmark in the period 9th-19th June to do geological mapping and make measurements and observations in the area of Lille Raipas in the vicinity of Alta. The mapping area comprises a variety of Proterozoic (middle and late Precambrian) metasedimentary rocks that show a range of tectonic and sedimentary structures. From their measurements and observations, the students make geological maps and cross-sections, construct and interpret stereographic projections, and write a final report that has to be submitted at the end of the field course.

Students mapping and taking structural measurements in the field. Photo: Allan Krill

Elba, Italia

The 12th of October, 18 students, 4 teaching assistants and one course leader travelled down to the island of Elba on the coast of Toscana, Italy. This field trip is part of the Advanced Structural Geology course. It consisted of a three-day excursion around the island, and seven days of geological mapping on the eastern coast of Elba. The students were divided into groups of two, and assigned an area of about 5x1 km each, where they mapped structures and lithologies. During this field course, the students learned to be independent field mappers, to describe and interpret the many spectacular structures, and to put all the individual observations together in order to understand the overall geological history. The accommodation at Elba is very near the mapping area, so little time is spent on transportation, and much time is spent in the field! At the end, all students have to hand in individual reports, maps and cross section.

Photo: Eric Ryan

Photo: Eric Ryan

Doctoral graduates

Dmitrii Tkalich
An experimental and multiscale numerical study of mechanical and tribological behavior of cemented tungsten carbides and hard rocks in percussive drilling.

Krzysztof Jan Zieba
Towards understanding the glacial impact on sedimentary basins using numerical methods.

Ongoing PhD Theses

Chhatra Bahadur,Basnet
Applicability of Unlined/Shotcrete Lined High Pressure Tunnels for Hydropower Projects in the Himalaya

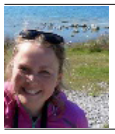
Øyvind **Braamann, Dammyr**
The use of TBM in future Norwegian Infrastructure Projects

Priyanka, Dhar
Novel Reagent Systems in Flotation Separation of Industrial Minerals

Justin Olabode, Fadipe
Determination of Palaeoenvironmental Conditions for the Distribution or Organic Carbon on the Norwegian Shelf during the Late Jurassic

Marit, Fladvad
Optimal Utilization of Unbound Crushed Aggregates for Road Construction

Sondre, Gjengedal
Investigation of ground Water Aquifers for Optimizing Water Extraction for Heating and Cooling Purposes. Examples from the Municipalities of Melhus and Elverum in Norway



Anette Utgården, Granseth
Formation of the Knaben Mo- and Flåt Ni-mineralisations and their Relationship of the Magmatic Evolution of the Late Mesoproterozoic Sveconorwegian Province in SW Norway

Are Håvard, Høien
Applicability of reinforced ribs of sprayed concrete in poor quality, swelling rock mass

Daniel Luis, Ibraimo
Combined Geological and Geophysical Interpretations and Modeling to Understand the Evolution and Regional Implications of the Atchiza Suite, Tete Province, Mozambique

Cyril Jerome, Juliani
Assessment of the Resource Potential on the Norwegian mainland and on the Mid-Atlantic under Norwegian Jurisdiction

Emily Barnabas, Kiswaka
Permian-Triassic Depositional Systems in the Norwegian Sea Area

Aleksandra, Lang
Geometallurgical flowsheet development and specification at Verdalskalk AS

Chi, Liyuan
An Experimental Study on Stress Waves and Rock Fracture Clise to Borehole

Gareth Steven, Lord
Facies Distribution of the Triassic Succession of Svalbard and the Northen Barents Sea

Camilo Andrés, Mena Silva
Effective Sampling and Mineral Characterization

Alexander, Michels
Determining the Contributions from Remanent Magnetization and Susceptibility to Magnetic Anomalies over Exposed Mantle Ophiolites, and Granulite Facies Rocks in Norway

Benedicte Eikeland, Nilssen
Si quality and milling technology parameters effect on resulting Si powder properties, for various applications with focus on Li-ion battery

Øystein Lid, Opsal
Shear strength of Norwegian tills

Mario, Orlando Morales Cardenas
Decisive Parameters for Open Pit Slopes (DePOPS)

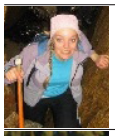
Zeudia, Pastore
Geophysical Expressions of Serpentinites: Mapping the Reactions the Produce Magnetic Minerals and Developing Exploration Tools for Potential Economic Deposits

Anna, Pryadunenko
Importance of Mantle Properties upon the Formation of Volcanic Hosted Massive Sulfide Deposits

Ida Johanne Svendsen, Røisi
Development of process mineralogical understanding of Norwegian REE deposits and development of methodology

Veena, Sajith Vezhapparambu,
Increased Geometallurgical Performance in Industrial Mineral Operations through Multivariate Analysis of MWD-Data

Helene, Strømsvik
Studies in High Pressure Rock Mass Grouting



Marte Kristine, Tøgersen
Increased Recovery of Iron from the Storforsheid Iron Formation

Geertruida Wilhelmina, ter Maat
Crustal Magnetism and Magnetic Anomalies

Solveig, Vassenden
Studies of mechanical properties of geological material influencing abrasion of cutter steel for TBM boring

Geology – 2016

Allaart, Lis
Combining terrestrial and marine glacial archives: A geomorphological map of the Nordenskiöldbreen forefield, Svalbard.
Supervisor: Schomacker, Anders

Alvestad, Erlend
Analyse av faren for fjellskred/ steinsprang langs Fv 715 Trolla-Flakk (Bynesveien).
Supervisor: Nilsen, Bjørn

Björklund, Carl Erik Robert
Distribution of porosity and permeability in dolomite and non-dolomitized carbonate facies-analysis with a Minipermeameter.
Supervisor: Mørk, Mai Britt E.

Fagerheim, Rune
Analyse av ingeniørgeologiske forhold for sjakter i forbindelse med kraftutbyggingen i Tosbotn.
Supervisor: Nilsen, Bjørn

Fossan-Waage, Oda Dagsland
A sedimentological study of black shales from the Spekk Formation, Norwegian Sea.
Supervisor: Felix, Maarten

Gjørva, Marit Bakken
Samanhengen mellom skogsvegar, skogsdrift og skredfare.
Supervisor: Bargel, Terje H.

Grannes, Kim Rune Bragstad
Cryptic Variations of Olivene and Clinopyroxene in the RF-4 Drill-Core.
Supervisor: Larsen, Rune Berg

Harstad, Trond Svånå
Sandstone Provenance of the De Geerdalen Formation, Svalbard.
Supervisor: Mørk, Mai Britt E.

Haugen, Turid
A Sedimentological Study of the De Geerdalen Formation with Focus on the Isfjorden Member and Palaeosols.
Supervisor: Mørk, Atle

Hestnes, Åse
Lithological and structural analysis of the Rødberget-Rørvika-Varpneset transect, Mid Norwegian Caledonides.
Supervisor: Krill, Allan G.

Høyen, Anne Bruland
Within plate gabbroic intrusion at 565 Ma in the Uppermost Allochthon.
Supervisor: Krill, Allan G.

Jordet, Hilde Dalen
Skråningsstabilitet og jordskredfare ved Ljøsegga, Soknedal.
Supervisor: Brattli, Bjørge

Langeland, Jørgen Mathias
Lausmasseskred i finkorna avsetningar: Kartlegging av fare for jord- og flaumskred i Soknedal, Midtre Gauldal kommune.
Supervisor: Bargel, Terje H.

Moe, Stine Merete Hvoslef
Hydraulisk jekking ved høytrykksinjeksjon av berg.
Supervisor: Grøv, Eivind

Nash, Victoria Engelschiøn
Large-sized Ichthyosaurs from the Lower Saurian Bone Bed (Early Triassic) of the Vikinghøgda Fm., Marmierfjellet, Spitsbergen.
Supervisor: Mørk, Atle

Nikolaisen, Even
Platinum Group Elements in the Reinfjord Ultramafic Complex.
Supervisor: Larsen, Rune Berg

Rem, Øyvind Bertinussen
The Rock Slope Instability at Tytefjell in Vindafjord, Rogaland.
Supervisor: Hermanns, Reginald

Sandbakken, Marit Eline
3-dimensjonal visualisering av grunnvannsmagasinet i Elverum sentrum.
Supervisor: Brattli, Bjørge

Slenes, Tonje Moen
Metamorfose og metasomatiske prosesser i tonalittiske og mafiske gangbergarter på Klemetsaunet, Trondheim.
Supervisor: Sørensen, Bjørn E.

Stange, Marianne Floen
The Magnetic and Mineralogical Properties of the Stardalur Volcano, Iceland.
Supervisor: McEnroe, Suzanne

Stemland, Marte Bakka
Skredfarekartlegging på Frøset, Midtre Gauldal kommune.
Supervisor: Bargel, Terje H.

Støen, Simen Jenvin
Late Triassic sedimentology and diagenesis of Barentsøya, Wilhelmøya and eastern Spitsbergen.
Supervisor: Mørk, Atle

Vatne, Brit
Evaluering av lekkasje fra tilløpstunnel ved Holsbru kraftverk.
Supervisor: Panthi, Krishna K.

Winje, Cathrine Røkkum
Depositional Environment and the Diagenetic Influence on the Pressure Solution Seam Behavior and Distribution in Carbonate Sediments.
Supervisor: Mørk, Mai Britt E.

Geotechnology – 2016

Baghirov, Teymur
Geometrical analysis of deltaic clinoforms and their implication for sediment infill and sea-level conditions in Sørvestsnaget Basin, southwestern Barents Sea.
Supervisor: Mørk, Mai Britt E.

Basnet, Nabin
Earthquake and Monsoon Induced Slope Failure Effects on Hydropower Projects - An Analysis Along the Sunkoshi Valley, Nepal.
Supervisor: Panthi, Krishna K.

Bérdi, Laura
Comparison of methods for calculation of immature organic carbon values and initial hydrocarbon potential from mature organic carbon measurements.
Supervisor: Felix, Maarten

Birkeland, Jardar
Integrated interpretation of seismic and potential field data on the Frøya High, Mid Norway.
Supervisor: Fichler, Christine

Bjørnsrud, Håkon Walter
Forankring av kunstig sjøbunn.
Supervisor: Li, Charlie Chunlin

Bones, Mette Nordmark
Boring av 800 meter dype energibrønner i Asker - Uttesting av boreteknologi og laboratoriemetoder for boreslitasje.
Supervisor: Ramstad, Randi K.

Fosseide, Julie Christine
Laboratory Testing of Online Extraction of Organic Contaminants from Water.
Supervisor: Brattli, Bjørge

Haugen, Thomas
Estimering og sammenligning av hydraulisk ledningsevne ved hjelp av kornfordelingsanalyser, permeametertester og feltmåling.
Supervisor: Brattli, Bjørge

Havskjold, Håkon Engum
Development Towards a New Test Procedure for Flotation at Brønnøy Kalk.
Supervisor: Kleiv, Rolf Arne

Holter, Martin
Analyse av problemstillinger knyttet til realistisk kvantifisering av svelletrykk på sikringskonstruksjoner i tunneler.
Supervisor: Nilsen, Bjørn

Jackson, Eunice
2D Petroleum System Modelling in Northern Viking Graben.
Supervisor: Lippard, Stephen John

Jakobsen, Vegard Utstøl
An empirical approach for determining the evolution and behavior of rockslide dams.
Supervisor: Hermanns, Reginald

Johansen, Sondre Krogh
Sedimentology and facies distribution of the Upper Triassic De Geerdalen Formation in the Storfjorden area and Wilhelmøya, eastern Svalbard.
Supervisor: Mørk, Atle

Kolden, Hilde Lund
Analyse av vibrasjonsmålinger fra Eiganestunnelen og numerisk modellering av internkrysning ved E39 Rådal-Nordås-Flyplassvegen og krysning av Folldalstunnelen.
Supervisor: Li, Charlie Chunlin

K.C., Ramesh Kumar
Assessment on the potential use of shotcrete lined high pressure tunnel at rasuwagadhi hydroelectric project, nepal.
Supervisor: Panthi, Krishna K.

Lorentzen, Andreas P.
Romlig mineralogisk og geofysisk karakterisering av Nabberen nefelinsyenittforekomst.
Supervisor: Ellefmo, Steinar L.

Mchomvu, Iddy Mussa
2D seismic interpretation and 2D basin modeling of hyrocarbon generation, migration and entrapment in the north viking graben.
Supervisor: Lippard, Stephen John

Nørsett, Silje Marie
Geometric and Qualimetric Modelling of the Hessjø deposit.
Supervisor: Ellefmo, Steinar L.

Pettersen, Sølve Utstøl
Injeksjon på Bodøtunnelen.
Supervisor: Grøv, Eivind

Qasim, Hasnain
Reservoir characterization and impacts of diagenesis on Upper Cretaceous sandstone formations in the Norwegian Sea, well 6707/10-1.
Supervisor: Mørk, Mai Britt E.

Rathore, Ajender
Stability assessment of the underground powerhouse cavern for the Sach Khas hydroelectric project in Himachal, India.
Supervisor: Panthi, Krishna K.

Rødal, Håkon Kjøde
Nytteverdi av styrt kjerneboring for planlegging av E39 i tunnel under Romsdalsfjorden.
Supervisor: Nilsen, Bjørn

Sagen, Ina Cathrine
Spatial reservoir characterisation with focus on distribution of porosity and permeability properties.
Supervisor: Ellefmo, Steinar L.

Sohaib, Muhammad
On Regional Distribution and Characterization of The Klippfisk Formation Limestone.
Supervisor: Mørk, Atle

Stein, Eivind
Evaluation on the Stress Induced Brittle Failure along the Headrace Tunnels of Neelum Jhelum HPP, Pakistan.
Supervisor: Panthi, Krishna K.

Zervas, Ioannis
Fault Growth, Segmentation, Reactivation and Inversion along a part of the Troms-Finnmark Fault Complex, SW Barents Sea.
Supervisor: Lippard, Stephen John

Ølnes**, Eirik**
Kombiløsning mellom utvidelse hos Forset Grus AS og fremtidig jernbane/ godsterminal.
Supervisor: Grøv, Eivind

Journal publication

1. **Bernardis, Sarah; Fakra, Sirine C.; Dal Martello, Elena; B. Larsen, Rune; Newman, Bonna K.; Fenning, David P.; Di Sabatino Lundberg, Marisa; Buonassisi, Tonio.** X-ray Microprobe Investigation of Iron during a Simulated Silicon Feedstock Extraction Process. Metallurgical and materials transactions. B, process metallurgy and materials processing science 2016 ;Volume 47.(6) p. 3565-3574 NTNU
Biedermann, Andrea Regina; Heidelbach, F; Jackson, Mike; Bilardello, Dario; McEnroe, Suzanne. Magnetic fabrics in the Bjerkreim Sokndal Layered Intrusion, Rogaland, Southern Norway. Tectonophysics 2016 ;Volume 688. p. 101-118 NTNU
2. **Broch, Einar.** Planning and utilization of rock caverns and tunnels in Norway. Tunnelling and Underground Space Technology 2016 ;Volume 55. p. 329-338NTNU
3. **Broch, Einar.** Utilization of Rock Caverns in Norway. Publication (Norsk forening for fjellsprengningsteknikk) 2016 (25) p. 9-16 NTNU
4. **Broch, Einar; Edvardsson, Sverre.** The Development of Underground Hydropower Plants in Norway. Publication (Norsk forening for fjellsprengningsteknikk) 2016 (25) p. 101-106 NTNU
5. **Broch, Einar; Grasbakken, Elisabeth M; Engelstad, Øyvind; Gjæringen, Gunnar.** Foreword. Publication (Norsk forening for fjellsprengningsteknikk) 2016 (25) p. 3-3 NTNU
6. **Church, Nathan Stewart; Fabian, Karl; McEnroe, Suzanne.** Nonlinear Preisach maps: Detecting and characterizing separate remanent magnetic fractions in complex natural samples. Journal of Geophysical Research - Solid Earth 2016 ;Volume 121.(12) p. 8373-8395 NTNU UiT
7. **Dammyr, Øyvind Braamann.** Prediction of Brittle Failure for TBM Tunnels in Anisotropic Rock: A Case Study from Northern Norway. Rock Mechanics and Rock Engineering 2016 ;Volume 49.(6) p. 2131-2153 NTNU
8. **Drivenes, Kristian; B. Larsen, Rune; Müller, Axel Bernd; Sørensen, Bjørn Eske.** Crystallization and uplift path of late Variscan granites evidenced by quartz chemistry and fluid inclusions: Example from the Land's End granite, SW England. Lithos 2016 ;Volume 252-253. p. 57-75 NTNU UiO
9. **Drivenes, Kristian; Sørensen, Bjørn Eske; B. Larsen, Rune.** Orogenic degassing, scapolitization and K-metasomatism during Caledonian exhumation, Helgeland, Norway. Norsk Geologisk Tidsskrift 2016 ;Volume 96.(3) p. - NTNU
10. **Fichler, Christine.** Gravity for hydrocarbon exploration. GeoExpro 2016 ;Volume 13.(2) p. 60-62 NTNU
11. **Fichler, Christine.** Magnetics for hydrocarbon exploration. GeoExpro 2016 ;Volume 13.(6) p. 54-57 NTNU
12. **Grant, Thomas; B. Larsen, Rune; Anker-Rasch, Lars; Grannes, Kim Rune Bragstad; Iljina, Markku; McEnroe, Suzanne; Nikolaisen, Even; Schanche, Mona; Øen, Endre.** Anatomy of a deep crustal volcanic conduit system; The Reinfjord Ultramafic Complex, Seiland Igneous Province, Northern Norway. Lithos 2016 ;Volume 252-253. p. 200-215 NTNU
13. **Grant, Thomas; Harlov, Daniel E.; Rhede, Dieter.** Experimental formation of pyroxenite veins by reactions between olivine and Si, Al, Ca, Na, and Cl-rich fluids at 800 ºC and 800 MPa: Implications for fluid metasomatism in the mantle wedge. American Mineralogist 2016 ;Volume 101.(4) p. 808-818 NTNU
14. **Hokka, Mikko; Black, J. H.; Tkalich, Dmitry; Fourmeau, Marion; Kane, Pascal-Alexandre; Hoang, Nguyen-Hieu; Li, Charlie Chunlin; Chen, W.W.; Kuokkala, V.T..** Effects of strain rate and confining pressure on the compressive behavior of Kuru Granite. International Journal of Impact Engineering 2016 ;Volume 91. p. 183-193 NTNU SINTEF
15. **Holter, Karl Gunnar.** Performance of EVA-Based Membranes for SCL in Hard Rock. Rock Mechanics and Rock Engineering 2016 ;Volume 49.(4) p. 1329-1358 NTNU
16. **Holter, Karl Gunnar; Geving, Stig.** Moisture Transport Through Sprayed Concrete Tunnel Linings. Rock Mechanics and Rock Engineering 2016 ;Volume 49.(1) p. 243-272 NTNU
17. **Holter, Karl Gunnar; Smeplass, Sverre; Jacobsen, Stefan.** Freeze–thaw resistance of sprayed concrete in tunnel linings. Materials and Structures 2016 ;Volume 49.(8) p. 3075-3093 NTNU
18. **Ingólfsson, Ólafur; Benediktsson, Ívar Örn; Schomacker, Anders; Kjær, Kurt H.; Brynjólfsson, Skafti; Jónsson, Sverrir A.; Korsgaard, Niels Jákup; Johnson, Mark D.** Glacial geological studies of surge-type glaciers in Iceland - Research status and future challenges. Earth-Science Reviews 2016 ;Volume 152. p. 37-69 NTNU UNIS
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