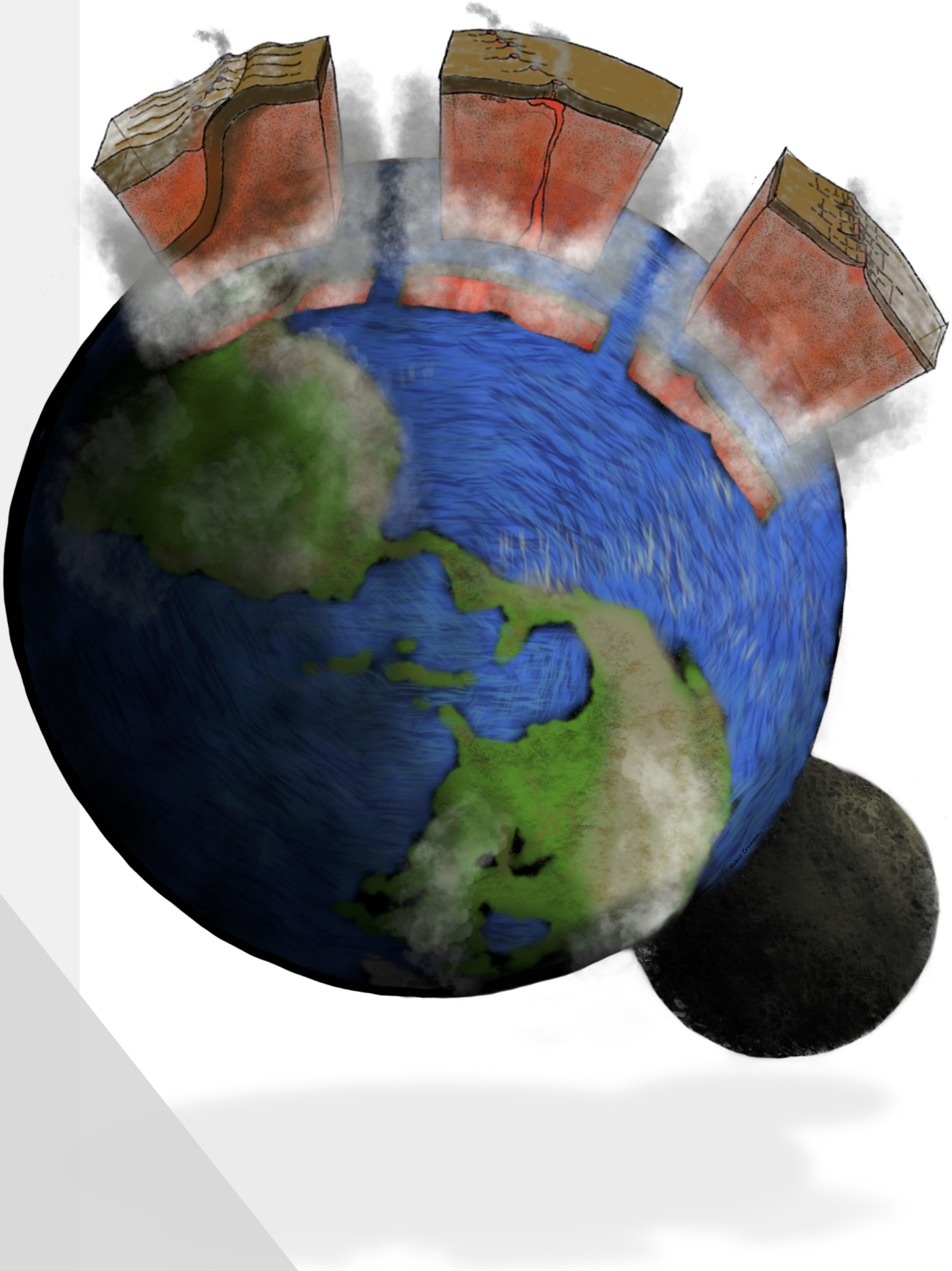
CEED ANNUAL REPORT 2018



UiO : The Centre for Earth Evolution and Dynamics
University of Oslo

Above: *From the official opening of the Stable Isotope Biogeochemistry Lab in Christine Bonnevies Hus; the University of Oslo the 24th of April. Photos: T-L. K. Gørbitz*

Front cover: *Ocean-Plate Tectonics: A concept to describe the formation, cooling and destruction of an oceanic plate as intimate parts in the convective overturn of the Earth's mantle, see page 20. By Fabio Crameri, CEED*

Back cover from the top:

1: From the Oslo rift excursion at Krokskogen, 20th of June

2: The symposium «CEED—no longer a teenager» in the University Aula, 1st of March

3: The first Else-Ragnhild Neumann award was shhared between Anja Røyne, PGP-UiO (left) and Grace Shephard, CEED-UiO (right); In the middle: Professor Emerita Else-Ragnhild Neumann, the Academy of Science the 7th of December

All photos: T-L. K. Gørbitz

PRIMARY OBJECTIVE:

Develop an Earth model that explains how mantle processes drive plate tectonics and trigger massive volcanism and associated environmental and climate changes throughout Earth history

SECONDARY OBJECTIVES:

(1) Build a consistent global plate tectonic model for the past 1100 Ma

(2) Explore how palaeogeography and True Polar Wander have influenced the long-term climate system

(3) Develop models that link surface volcanism with processes in the deepest mantle

(4) Develop models that link subduction processes in arcs and collision orogens with the mantle

(5) Understand the role of voluminous intrusive and extrusive volcanism on global climate changes and extinctions in Earth history

(6) Develop models for mantle structure, composition and material properties

(7) Understand similarities and differences between the Earth and the other terrestrial planets

(8) Develop tools and databases that integrate plate reconstructions with geodynamic and climate modelling

CEED is dedicated to research of fundamental importance to the understanding of our planet, that embraces the dynamics of the plates, the origin of large scale volcanism, the evolution of climates and the abrupt demise of life forms.

This ambitious venture shall result in a new model that explains how mantle processes interact with plate tectonics and trigger massive volcanism and associated environmental and climate changes throughout Earth history.

Deep Earth | Earth Modelling | Dynamic Earth | Earth's Crises | Earth and Beyond | Earth Laboratory

The new CEED logos design by Fabio Crameri, CEED

ACHIEVEMENTS IN 2018

CEED produced **129** publications in international journals. This includes six papers in **high-impact journals**; three of these had a young CEED researcher as the first author.

CEED researchers authored six books or book chapters.

Three PhD students at CEED sucessfully defended their PhD projects: **Nils C. Prieur, Ping-chuan Tan** and **Thea H. Heimdal**

The Young Outstanding Scientist project *Platonic*, started in November, with P.I. **Tobias Rolf**

Mathew Domeier was awarded the 2018 *Reusch Medal* from the Norwegian Geological Society

Adjunct Professor **Juan Carlos Afonso** received the *Early Career Scientist Award* from The International Union of Geodesy and Geophysics.

Anne Hope Jahren was elected as a *member of the Norwegian Academy of Science and Letters.*

Trond H. Torsvik and Robin Cocks received *the Prose award* for their book *Earth History and Paleogeography.*

Grace Shephard received the first *Else Raghild Neuman award for young female scientists* (shared with Anja Røyne, PGP-UiO)

Thea Heimdal received the CEED prize for young scientists.

International conference organized by CEED

CEED – No longer a teenager. The University Aula on the 1st of March, with international participants, organizers: C. Gaina and T-L. K. Gørbitz.

New Frontiers in Palaeogeography and Biogeography. 21st of September, the Geological Society, Burlington House, London. Organized by Conall Mac Niocaill (Oxford University), **Trond Torsvik** (University of Oslo) and David Harper (Durham University).

A **symposium to honour Else-Ragnhild Neumann**, the first female Professor in Geosciences in Norway. The Academy of Sciences, the 5th of December. Organizers: H. Svensen, C. Gaina and T-L. K. Gørbitz

Young CEED workshop: 14 inter-disciplinary early-career scientists from 12 nationalities and 8 university affiliations, Drøbak Norway 5-12 November. Organizers: F. Crameri, V. Magni, G. Shephard and M. Domeier,

CEED organization

Advisory Board

Professor **Anny Cazenave**, LEGOS-CNES Toulouse, France

Professor **Claudio Faccenna**, Università Roma TRE, Italy

Professor **Per Barth Lilje**, Department of Astrophysics, UiO

Centre for Earth Evolution and Dynamics (CEED) was officially opened on the 1st of March 2013. Our research includes the dynamics of tectonic plates and Earth history, convection in the mantle, structure of the deep Earth and the origin of mantle plumes and possible connections with large scale volcanism, climate changes through geological time, mass extinctions, and research on planets from our Solar System. To ensure that our scientific vision is effectively met, 2018 activities have been carried out mainly within six research themes, each lead by a Team leader :

The Deep Earth (Team leader Reidar Trønnes)

Earth Modelling (Team leader Clint Conrad)

The Dynamic Earth (Team leader Trond H. Torsvik)

Earth Crises (Team leader Henrik Svensen)

Earth and Beyond (Team leader Stephanie Werner)

Earth Laboratory (Team leader Pavel Doubrovine)

CEED members

37 Professors, Adjunct Professors, Researchers and Research Associates

19 Postdocs

12 PhD fellows

8 Technical-administrative staff members

8 Master students

1 Professor emerita

In total:

76 paid staff members and 51,7 man-years representing 16 nationalities

*Above: **Mathew Domeier** is awarded the Reusch Medal 2018 by Øystein Nordgulen at NGF's Winter meeting, Bergen 8.1.2019. Photo: Gudmund Løvø/NGU*

*Right: **Stephanie C. Werner** became a full Professor and a permanent staff member at the Department of Geosciences in June 2018.*

GEO-DEEP9500 course in Svalbard - August 2018, safety instructions.

*The intensive course on **Arctic tectonics, volcanism and climate** was initiated by the RCN INTPART project NOR-R-AM (PI. C. Gaina), which brings together Arctic researchers from Norway, Russia, Canada and USA. The course was organized under CEED`s National Research School DEEP`s auspices.* *(See more on page 70).* *Photo: Eivind O. Strume*

Table of contents

From the Director

On March 1st 2018 we have declared that CEED is no longer a teenager. Our research now is finding answers to some of the big questions we have asked back in 2011, when the SFF proposal was written. In the following, I will briefly present few examples from published and on-going CEED "break-through" research. The interested reader will find more in the present report and respective papers.

One of our fundamental questions is "Are the Large Low Velocity Provinces (**LLVP**) at the core mantle-boundary long-lasting features?" The Deep Earth team suggests that the two present-day topographic piles located antipodal on the core-mantle boundary under Africa and the Pacific, respectively, have formed before the final Basal Magma Ocean (BMO) solidification. Based on their recent silicate melts studies the team reached the conclusion that the spherical harmonics degree-2 convection pattern, characterizing the present Earth, was established well before the final BMO solidification, which allowed the dense cumulate material to have been swept into piles or layers at the root zones of the LLVPs (*Trønnes et al., 2018*)-see page 13. To shed more light on this issue, the Earth Modelling team investigated the LLVP material properties that will allow these piles to survive Giga years of mantle convection (*Heyn et al., 2018*). They showed that a viscosity increase related to composition can stabilize the piles and increase the mass retained in the structures. The potential increase in viscosity most likely results from interaction between the core and the Earth's mantle during the magma ocean stage, which enriched the dense material in bridgmanite (*Trønnes et al., 2018*). CEED PhD student Heyn also shows that the pile edge changes its properties during interaction with subducted material, which can lead to the LLVP lateral move (few tens of kilometres) along the core-mantle boundary (CMB). The lateral extension of the pile causes a new plume to rise at the pile edge (page 25).

From Mesoproterozoic and Neoproterozoic paleogeographic reconstructions of Laurentia and Baltica (page 60), to the early Late Ordovician Iapetus Ocean (page 37), and to Eocene (page 34) and Miocene to Present-day examples (page 24) **SUBDUCTION** is a running theme through CEED's 2018 activities and tackled by three CEED teams: Earth Laboratory, Dynamic Earth and Earth Modelling. Temporal fluctuations in subducted material along specific continental margins has been elegantly linked by *Domeier et al. (2018)* to changes in arc magmatism along those margins, by using the estimated zircon age frequencies. This study has been published in Nature Scientific Reports. *Hounslow, Domeier, and Biggin (2018)* have also found that changes in the global rate of subduction are linked with subsequent changes in the rate of geomagnetic reversals (page 59). These remarkable findings built upon several years spent by CEED researchers to diligently build a comprehensive Earth Model, and indeed they fulfill CEED's ultimate goal to "demonstrate how mantle processes drive plate tectonics and trigger massive volcanism and associated environmental and climate changes throughout Earth history".

Tackling the "climate change through Earth's history, PhD Thea Heimdal (Earth Crises team) completed her doctoral dissertation in December 2018 on a topic linked to causes and consequences of one of the largest Large Igneous Province (**LIP**) – the Jurassic Central American Magmatic Province-CAMP. *Heimdal et al. (2018 and 2019)* findings support the hypothesis that sill-evaporite interactions increased volatile release during the CAMP emplacement and suggests that also the sub-volcanic part of a LIP can be of major importance in driving climate change and mass extinctions (page 42).

Switching gears from Earth's climate to planetary climates, the Earth and Beyond team brings now compelling evidences that Mars's climate was warmer in its past. They have used numerical methods, experimental and remote sensing techniques to study the weathering profiles of Noachian surface of Mars (*Bultel et al., 2019* and *Krzesinska, A.M. et al, 2018*-see pages 49-50).

And as Water is the magic ingredient for having plate tectonics, climate and life on Earth and possibly on other planets, CEED is proudly introducing the **Water Planet** umbrella project that explores and develops water-related linkages among the CEED teams (page 62 and waterplanet.no). And to boost even more the CEED internal and external network, in 2018 we have established the **YoungCEED** "club" which conducted their first international workshop, on a theme dear to our center: Subduction Initiation (page 66).

Last, but not least, CEED established a Norwegian award for Early Career women in Geosciences. **The Else-Ragnhild Neumann award** honours the scientific contribution of Professor Else-Ragnhild Neumann who, in 1981, became the first female professor in Geosciences in Norway. Professor Emerita at CEED, Neumann, who turned 80 on 7th of December 2018, is still active and continues to publish about volcanism and links to mantle processes. We are proud that one of CEED researcher, Grace Shephard, has received the inaugural award together with Anja Røyne, a physicist and geoscientist from University of Oslo (pages 64-65).

I congratulate all my colleagues on their excellent 2018 activities and results! There are new exciting projects to be started in 2019: CEED will go to Greenland (the MAGPIE project), to Lake Baikal (the HOTMUD project), and virtually, to Europa, one of Jupiter's icy moons (the PLATONICS project). Looking forward to a great 2019!

2018 papers in high impact journals
Bold: CEED researcher, CEED young researcher*

*__Domeier, Mathew; Magni, Valentina;__ Hounslow, Mark W; **Torsvik, Trond**. H. Episodic zircon age distributions mimic fluctuations in subduction. Scientific Reports 2018, 8, Article number: 17471.

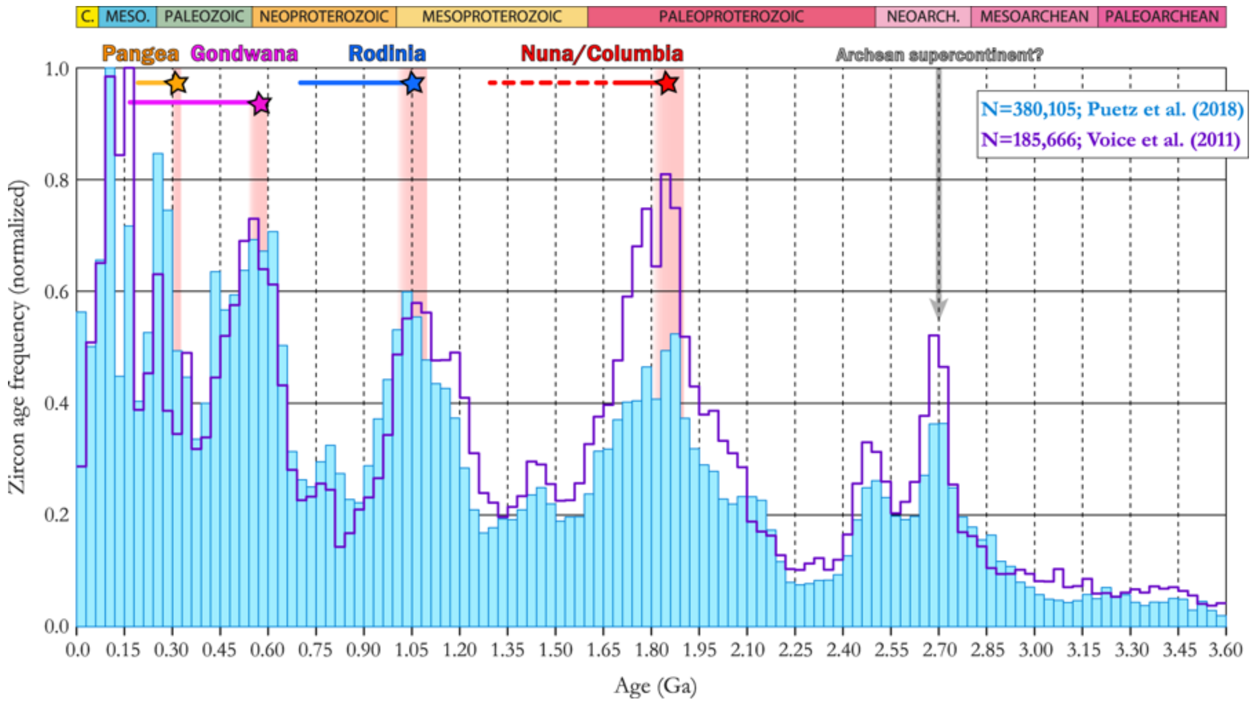
*__Heimdal, Thea Hatlen; Svensen, Henrik__; Ramezani, Jahandar; Iyer, Karthik Herman; Pereira, Egberto; Rodrigues, René; **Jones, Morgan Thomas; Callegaro, Sara**. Large-scale sill emplacement in Brazil as a trigger for the end-Triassic crisis. Scientific Reports 2018 ; 8 (1), 141.

*Jamtveit, Bjørn; Moulas, Evangelos; **Andersen, Torgeir Bjørge**; Austrheim, Håkon Olaf; Corfu, Fernando; Petley-Ragan, Arianne Juliette; Schmalholz, Stefan Markus. High Pressure Metamorphism Caused by Fluid Induced Weakening of Deep ontinental Crust. Scientific Reports 2018 ; 8. s. –

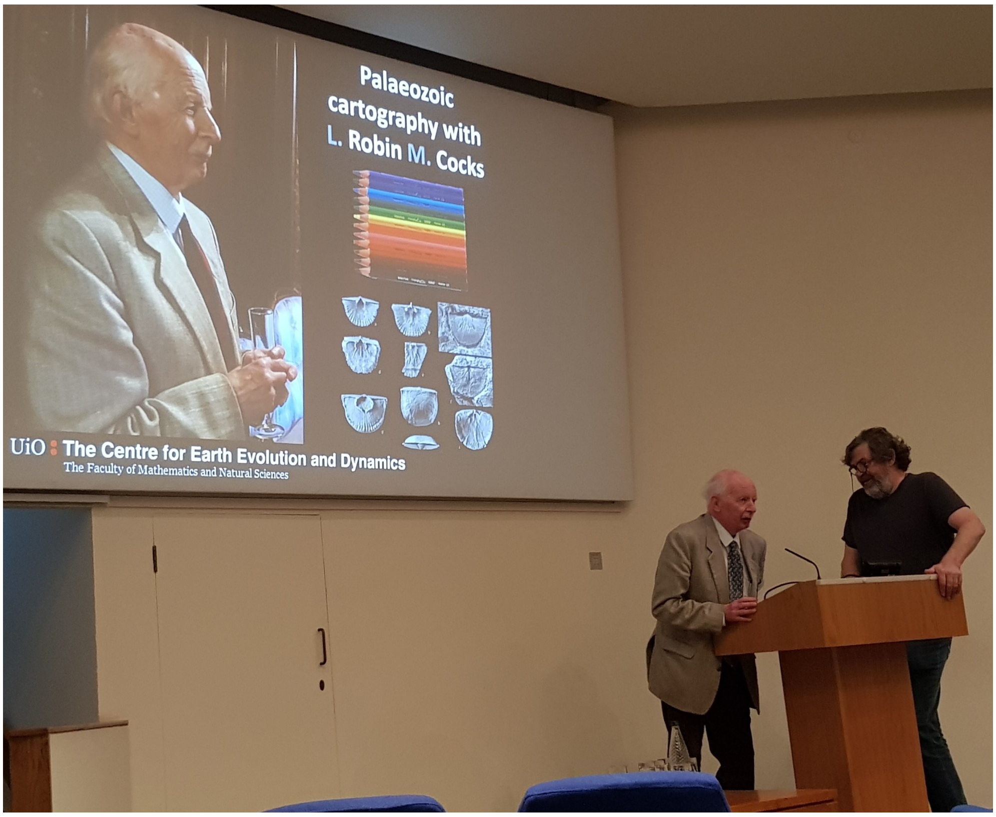
Karstens, Jens; Haflidason, Haflidi; Becker, Lukas; Berndt, Christian; Rüpke, Lars Helmuth; **Planke, Sverre**; Liebetrau, Volker; Schmidt, Mark; Mienert, Jurgen. Correction: Glacigenic sedimentation pulses triggered post-glacial gas hydrate dissociation. Nature Communications, 2018; 9.(1).

Konrad, Kevin; Koppers, Anthony A.P.; **Steinberger, Bernhard**; Finlayson, Valerie A.; Konter, Jasper G.; Jackson, Matthew G.. On the relative motions of long-lived Pacific mantle plumes. Nature Communications 2018; 9.

*__Spakman, Wim__; Chertova, Mariya V., Van Den Berg, Arie; van Hinsbergen, Douwe J J. Puzzling features of western Mediterranean tectonics explained by slab dragging. Nature Geoscience 2018 ; 11.(3) s. 211-216



Episodic age distribution of zircons since 3.6 Ga. Blue (purple) histogram shows the age distribution of zircons in 30 Ma bins. Pink bars mark the estimated age of major supercontinent assembly events[44,45], and the duration of those continents is shown by the colored horizontal bars along the top of the panel. From ***Domeier, Mathew; Magni, Valentina;*** *Hounslow, Mark W;* ***Torsvik, Trond****. H. Episodic zircon age distributions mimic fluctuations in subduction. Scientific Reports 2018, 8.*



From the conference «New Frontiers in Palaeogeography and Biogeography", honouring Robin Cocks (left) - a long term collaborator of CEED), on the 21st of September, the Geological Society, Burlington House, London. Co-organized by Trond H. Torsvik (right).

1. Deep Earth: Materials, structure and dynamics

The Deep Earth Team continued in 2018 to explore the materials and structure of the outermost core and lowermost mantle. The recent realisation that the more compressible silicate melts become denser than the lower mantle minerals at pressures above 70-80 GPa, implies that such melts early would accumulate in the lower third of the mantle. Because the solidus (= temperature of initial partial melting) of peridotitic and basaltic mantle rocks are only 100-300 K above the present temperature of the outermost core, and because the mantle has cooled by less than 200-300 K during the last 3 Gy, the complete solidification of such a basal magma ocean (BMO) is likely to have taken at least 1-2 billion years. Chemical exchange between the metallic core and the BMO during the first 30-60 % of Earth's lifetime probably led to the current structure and dynamics of the core and the lower mantle. The efforts of the Deep Earth group are focussed on decoding various aspects of this exchange.

Terrestrial planet formation and core composition

The oxygen content of terrestrial (Earth-like) planetary bodies is too low to fully oxidise all of the other major elements. The abundant element iron, which may easily assume three main valence states, is the major component of the metallic cores of Mercury, Venus, Earth, Moon, Mars and Vesta (*Trønnes et al. 2018*). Figure 1.1 shows that the core fraction and the FeO^{mantle} content are inversely related. The FeO^{mantle} and oxygen fugacity increase with heliocentric distance from Mercury to Vesta. The metal separation and core segregation processes, as well as the resulting core composition, are governed by pressure, temperature and oxygen fugacity (oxygen activity). At high O-fugacity, S becomes increasingly siderophile (iron-loving) and at pressures below 15 GPa, corresponding to the early melting of the planetary embryo Mars and planetsimal Vesta, the ternary eutectics in the system Fe-O-S are close to the Fe-S join. Mars and Vesta have therefore S-rich cores (*Trønnes et al., 2018*).

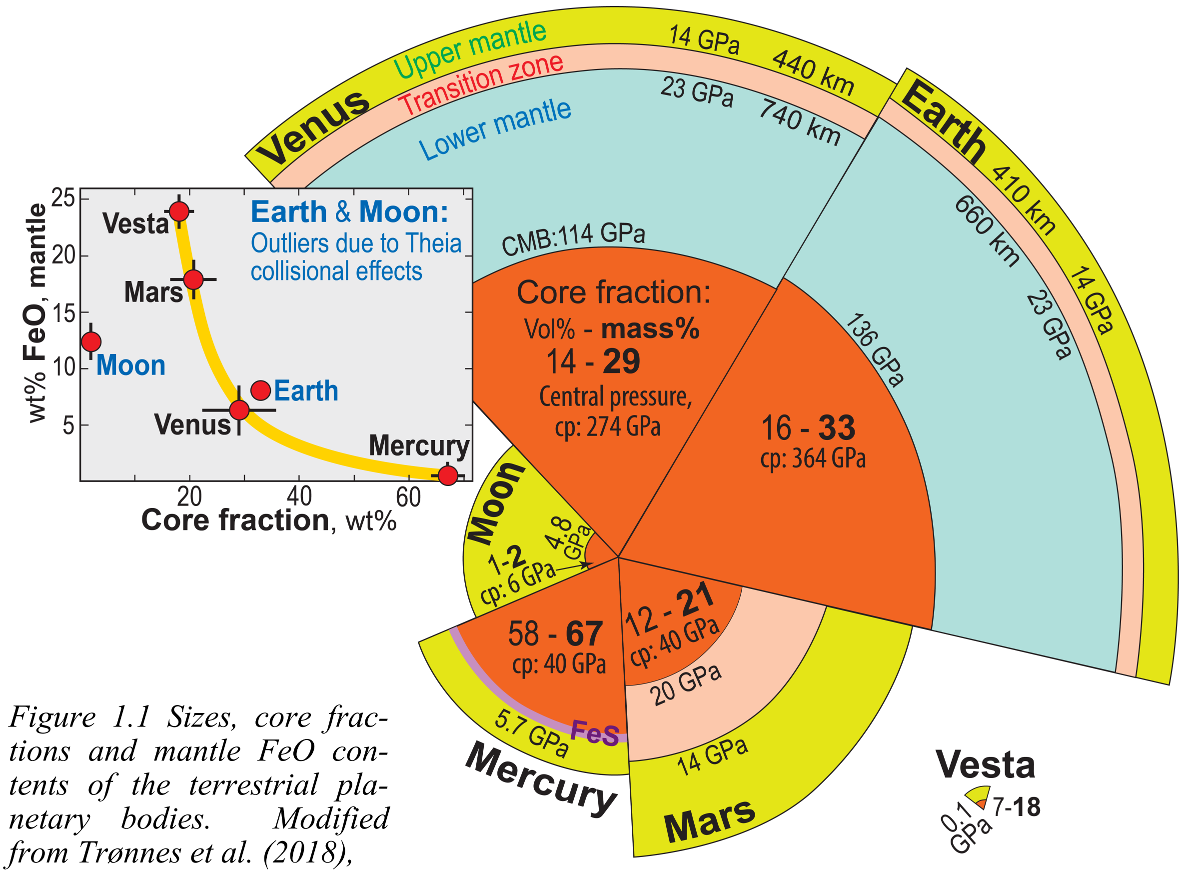


Figure 1.1 Sizes, core fractions and mantle FeO contents of the terrestrial planetary bodies. Modified from Trønnes et al. (2018),

Mercury accreted from extremely reduced materials, resulting in a very large core (67 wt%) with about 15 wt% Si and 1 wt% S, combined with a separate FeS-layer at the core-mantle boundary (CMB) and a S-rich mantle and crust. Although much of the Venus and Earth accretion was from similarly reduced material in the inner Solar system, they also received more oxidised materials. The accretion and metal separation from silicate magma oceans (MO) within these two large planets occurred at very high pressures and temperatures up to about 130 GPa and 5600 K (*Laneuville et al., 2018*). The high temperature would have driven the equilibrium $2Fe^{core} + SiO_2^{MO} = Si^{core} + 2FeO^{MO}$ towards the product (right) side, resulting in a high fO2 combined with high Si in the core.

Core-BMO chemical exchange in Earth and Venus

Planetary cooling and slow solidification of a thermally insulated basal magma ocean (BMO) would reverse the equilibrium $2Fe^{core} + SiO_2^{MO} = Si^{core} + 2FeO^{MO}$ towards the reactant (left) side, favouring core-BMO chemical exchange. The FeO (and Fe_2O_3) components from the BMO would dissolve into the core alloy, in parallel with SiO_2-crystallisation in the outer core and buoyant rise of the silica crystals into the BMO, followed by dissolution there. Figure 1.2. (next page) shows the silica liquidus surface at 136 GPa. Evidence for a non-convecting outermost core E'-layer with reduced density and seismic velocity, reviewed by e.g *Brodholt and Badro (2017)* and *Trønnes et al. (2018)*, may represent a chemical trace of the core-BMO exchange. Modelling of a 445 km thick and chemically gradational E'-layer based on observed seismic velocity gradients (*Kaneshima, 2018*), using mineral physics properties of *Brodholt and Badro (2017)*, yields an outermost E'-layer with 0.4 wt% Si, 6.7 wt% O and a density deficit of 0.98% compared to the convecting core with 3.6 wt% Si and 3.0 wt% O (*Trønnes et al. 2018*). We performed mass balance modelling of the complementary chemical impact on a basal magma ocean of primitive peridotite composition, comprising 34 wt% (28 vol%) of the mantle. The results show that the bulk SiO_2 content increases from 44.9 to 48.7 wt% and the FeO content decreases from 8.04 to 1.8 wt% in the lower third of the mantle. The continuous SiO2-addition to and FeO-extraction from the BMO will buffer the Si/(Mg+Fe) ratio to a fairly high value and greatly prolong the period of crystallisation of $MgSiO_3$-dominated bridgmanite cumulates, which today may be preserved as large refractory BEAMS (bridgmanite-enriched ancient mantle structures) or blobs (*Becker et al. 1999; Ballmer et al. 2017*).

The core-BMO exchange might have resulted in the 445 km thick, gradational and stagnant E'-layer of the outermost core (e.g. *Brodholt and Badro, 2017*; *Kaneshima 2018; Trønnes et al. 2018)*. The low fluid viscosity, combined with the recent discovery of very high thermal conductivity, led *Hernlund & McNamara (2015)* to conclude that convective entrainment is unlikely to destroy such a gradational and stagnant layer. The rate of core-BMO chemical exchange would have decreased strongly during the development of the E'-layer. The modelled chemical E'-layer gradient of *Trønnes et al*. indicates that the outermost portion directly below the CMB with 0.37 wt% Si and 6.74 wt% O would be below the silica saturation level at 0.51 wt% Si for an O-content of 6.74 wt% (*Hirose et al. 2017*). Although there is still a chemical drive for FeO-dissolution into the outermost E'-layer (*Frost et al. 2010*), the slow solid-state diffusion in ferropericlase, and especially in bridgmanite, is strongly rate-limiting.

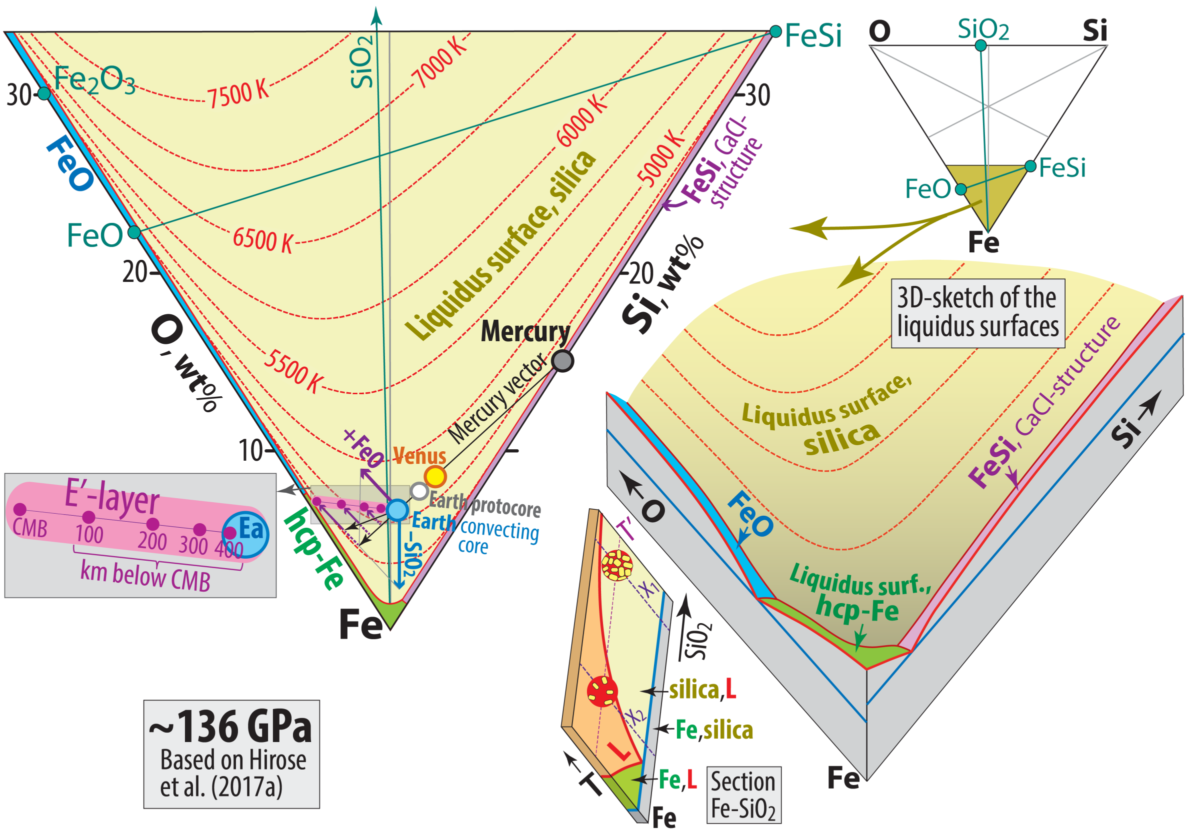


Figure 1.2. Liquidus phase relations in the Fe-rich part of the system Fe-Si-O at about 136 GPa modified from Hirose et al. (2017) and Trønnes et al. (2018). The upper panels show the liquidus phase relations and the core compositions of Mercury, Venus, Earth and Earth protocore composition. The E'-layer compositional gradient is shown by compositions at 0, 100, 200, 300 and 400 km below the CMB (see also left inset figure). The mass balance modelling involving Earth's protocore, current convecting core, E'-layer and the corresponding magma oceans is described in Trønnes et al. (2018). The lower panels include a three-dimensional perspective sketch of the liquidus surfaces (middle), a section along the Fe-rich part of the Fe-SiO_2 join (lower left). The lower left Fe-SiO_2 section illustrates the effect of aggregation of silica crystals on their stability and ability to survive during buoyant ascent through the core. At a temperature of T', silica cystals are stable in the "local" composition X_1 with high proportion of (aggregated) silica crystals. In contrast, pre-existing crystals are not stable and will tend to dissolve in the composition X_2 at the same pressure and temperature condition. hcp-Fe: hexagonally close-packed Fe.

Late-stage crystallisation and the structure of the D"-zone

The solidification of the last 5% of the BMO would increase the Fe/Mg ratio of the melt to such an extent that late-stage bridgmanite cumulates with about 16 mol% of the combined $FeAlO_3$ (FA) and $FeSiO_3$ (FS) components might have developed (*Trønnes et al. 2018*). At this a late stage, Ca-perovskite with a density similar to that of bridgmanite with 16 mol% FA+FA would crystallise and accumulate together. The partitioning coefficient $K_D = (Fe/Mg)^{bridgmanite} / (Fe/Mg)^{melt}$ decreases below 0.1 in the 80 to 136 GPa pressure range (e.g. *Tateno et al. 2014*), and the extremely Fe-rich melts would likely remain denser that the late-stage cumulates of bridgmanite with minor amounts of Ca-perovskite. We propose that the very last and dense bottom-mantle melts would have undergone simultaneous solidification and FeO-loss to the E'-layer, because the FeO-loss would also increase the solidus and liquidus. Late-stage bridgmanite-rich cumulates with 16 mol% FA+FA have a density excess corresponding to that observed for the lowermost 100-200 km of the two large low S-wave velocity provinces (LLSVPs), located antipodally under Africa and the Pacific.

Our working hypothesis is that the spherical harmonics degree-2 convection pattern, characterising the present Earth, was established well before the final BMO solidification. In that case, the dense cumulate material would immediately upon its formation have been swept into piles or layers at the root zones of the LLSVPs.

New projects

In November and December 2018 we initiated three new projects aimed at improved insights into the structure, materials and dynamics of the lower mantle and outermost core. The compositional nature and origin of the lower mantle and outermost core structure are the main focus of this research. In addition to the new projects mentioned briefly below, we are also involved in collaboration with other CEED groups to evaluate the structure and stability of the LLSVPs in the D"-zone and the other more elusive structures in the middle parts of the lower mantle.

Silica phase transitions in the lowermost mantle and the core. We extend our preliminary atomistic simulations on the β-stishovite to seifertite transition in pure SiO_2, occurring in the lowermost mantle, to the additional seifertite to pyrite-structured silica transition, occurring well inside the core. The uncertainties associated with these two transitions are large, and better constraints on their locations and Clapeyron slopes are essential to understand the densification of subducted oceanic crust in the D"-zone, as well as the silica liquidus surface in the system Fe-Si-O through the pressure range of the core.

The silica liquidus surface for selected compositions in the system Fe-Si-O through the core pressure range. In order to constrain the conditions for silica crystallisation in the core during the Hadean and Archean, we will extend the preliminary experimental results of *Hirose et al. (2017)* to the entire core pressure range. As a starting point we plan to use the convecting core compositional estimate of *Trønnes et al. (2018*; 3.6 wt% Si, 3.0 wt% O), comparing the energies of coexisting alloy and either seifertite or pyrite-type phases of pure SiO_2 at a range of p-T-conditions. Such data are essential to determine the feasibility of core-BMO chemical exchange and the development of the E' layer.

Solidification of the BMO and generation of early refractory and late-stage Fe-rich cumulates. The BMO solidification accompanied by core-BMO chemical exchange will be investigated by a combination of mass balance modelling and density calculations for a range of mineral and melt compositions, using first principles atomistic simulations, as well as the

BurnMan software. This project will contribute new constraints on the compositional nature and origin of LLSVPs, early refractory domains, and possibly also on the thin ultra-low velocity zones directly above the CMB.

Activities in seismology in 2018

Tomography of southeast China

A new tomographic technique based on beamforming of ambient noise was developed by V. Maupin (CEED) in cooperation with prof. Laiyu Lu and his PhD student Kaiming Wang from the Institute of Geophysics, Earthquake China Administation in Beijing. Kaiming Wang visited CEED from September 2017 to September 2018 and Prof. Lu visited for two months in August and September 2018. The new methodology has been applied to data from the seismological array ChinArray II with particular emphasis on the structure of the lower crust in Tibet and southeastern China (Figure 1.3). The particularly low crustal velocities we image in the Tibetan area with thickest crust is an important element to constrain the geodynamical models of the evolution of this area.. In addition to this noise-based tomography, we have pursued our collaboration with Prof. Lu on the analysis of the ellipticity of the earthquake-generated Rayleigh waves in the ChinArray dataset, in view of constraining anisotropy and heterogeneity of the area (*Wang, Lu, Maupin, Ding, Zheng and Zhong in prep*) .

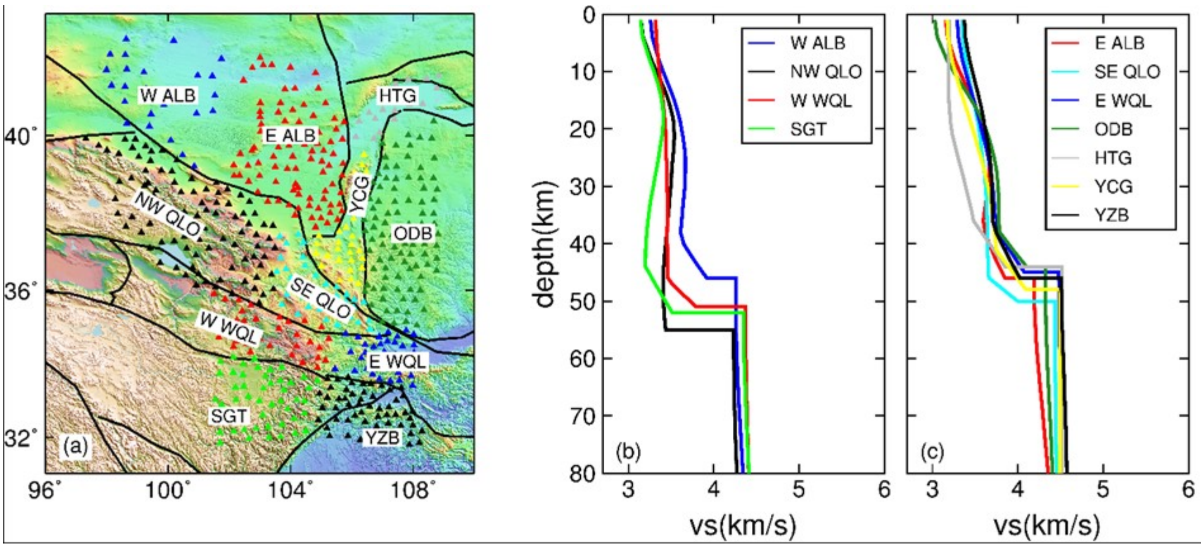


Figure 1.3. Seismic S-wave velocity in the crust in different tectonic provinces of Southeastern China. The triangles on the map show the location of the seismological stations used in this study.

Glacial seismicity at Kronebreen, Svalbard

In cooperation with Andreas Kohler and Chris Nuth from the Geography and Hydrology section from the Department of Geosciences, we have grouped in different types and studied the temporal distribution of icequakes at Holtedalfonna, located on the Kronebreen glacier in Svalbard. Glacial seismicity provides important insights into glacier dynamic processes. Using data from a single three-component seismometer installed on the glacier between April and August 2016, we investigated sources for observed icequake groups using polarization analysis and waveform modeling. Three examples of earthquake group data and modeling are shown in Figure 1.4. Processes responsible for different icequake categories are suggested, near-surface crevasse opening through brittle failure generating being the dominant icequake type. Bursts of high-frequency signals presumably caused by repeated near-surface fracturing during glacier fast-flow episodes, events related to resonance in water-filled cracks and a few deep icequakes probably caused by processes at the glacier bed are also observed.

The Kongsberg Seismological network

Eight seismological stations were granted in 2018 by the Norwegian Broadband Pool Consortium for our Kongsberg project, that aims at studying the structure of the crust, in particular Moho topography, in a radius of about 50 km around the permanent KONO station in Kongsberg. The stations were installed in April 2018 in cooperation with NORSAR and will stay in the field for two years. This will address specifically the structure of the crust at the border of the Oslo Graben but the stations are also used for other purposes, as better location of the

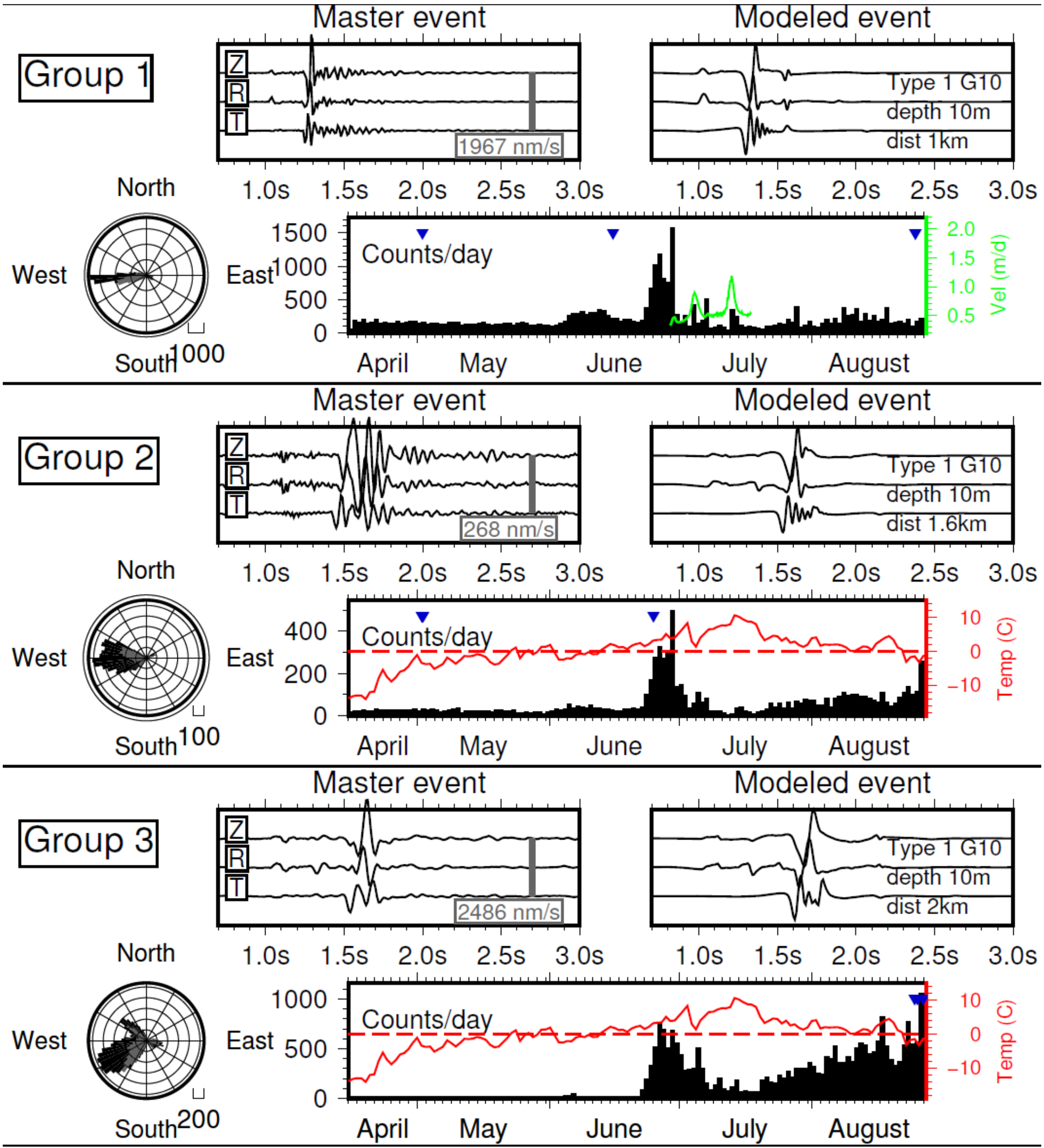


Figure 1.4. A characteristic data example, modelled waveform, azimuthal distribution from the Holtedalfonna seismometer and temporal distribution for three groups of icequakes.

seismicity in southern Norway. This Kongsberg project is part of a larger seismological temporary network installed in cooperation with the University of Aarhus and Uppsala University in southern Scandinavia. We assisted Aarhus University in testing 5 broadband Ocean Bottom Seismometers (OBS) in Norwegian waters in the Skagerrak from November 2017 to August 2018. Complementing the OBS by land stations in Denmark, Norway and Sweden, we will address some scientific questions regarding in particular the continuation of the Tornquist Zone northwards and the structure of the Oslo Graben. A more specific reason for having additional stations around Kongsberg is to try to identify the cause for an anomalous arrival in the receiver functions at KONO for events with backazimuth from about 0 to 90 degrees. This arrival, detected by Marianne Kolstrup during her PhD thesis, leads to unrealistically low mantle velocities if interpreted in a classical way with a 1D structure of the lithosphere. We suspect 3D effects. Additional data from stations in a radius of 50 km would help identify the reason for this arrival. The scientific outcome is both a better model of the structure and sharpness of boundaries at the border of the Oslo Graben, and quantifications of 3D effects that can be mistaken for low-velocities zones in the lithosphere.

We have been active in the infrastructure EPOS project that will contribute to better monitoring of the Arctic regions and to better exchange of data for multidisciplinary research by organizing workshops and meetings with several Norwegian institutions.

References

Ballmer, M.C., Houser, C., Hernlund, J.W., Wentzcovitch R.M., Hirose K. (2017). Persistence of strong silica-enriched domains in the Earth's lower mantle. Nature Geosci. 10, 236–240.

Becker, T.W., Kellogg, J.B., O'Connell, R.J., (1999). Thermal constraints on the survival of primitive blobs in the lower mantle. Earth Planet. Sci. Lett. 171, 351-365.

Brodholt, J., Badro, J. (2017). Composition of the low seismic velocity E′ layer at the top of Earth's core. Geophys. Res. Lett. 44, 8303–8310

Frost, D.J., Asahara, Y., Rubie, D.C., Miyajima, N., Dubrovinsky, L.S., Holzapfel, C., Ohtani, E., Miyahara, M., Sakai, T. (2010). The partitioning of oxygen between the Earth's mantle and core. J. Geophys. Res. 115, B02202.

Hernlund, J.W., McNamara, A.K., 2015. The core-mantle boundary region. In: Treatise on Geophys. 7.11, 461–519.

Hirose, K., Morard, G., Sinmyo, R., Umemoto, K., Hernlund, J., Helffrich, G., Labrosse, S. (2017). Crystallization of silicon dioxide and compositional evolution of the Earth's core. Nature 543, 99-102.

Kaneshima, S., (2018). Array analyses of SmKS waves and the stratification of Earth's outermost core. Phys. Earth Planet. Inter. 276, 234–246.

Laneuville, M., Hernlund, J., Labrosse, S., Guttenberg, N. (2018). Crystallization of a compositionally stratified magma ocean. Phys. Earth Planet. Inter. 276, 86–92

Tateno, S., Hirose, K., Ohishi, Y. (2014). Melting experiments on peridotite to lowermost mantle conditions. J. Geophys. Res. 123, 4684–4694.

Trønnes, R.G., Baron, M.A., Eigenmann K.R., Guren M.G., Heyn B.H., Løken A., Mohn C.E. (2018). Core formation, mantle differentiation and core-mantle interaction within Earth and the terrestrial planets. Teconophys. 10.1016.

Wang, K., L. Lu, **V. Maupin**, Z. Ding, C. Zheng and S. Zhong. Surface wave tomography of Northeastern Tibetan Plateau using beamforming of seismic noise at a dense array (in prep.)

Reidar Trønnes explaining details of the Oslo rift evolution observed at Krokkleiva. From the Oslo rift excursion in June 2018.

The Earth Modelling Team employs a variety of modeling techniques to understand the geodynamics of Earth's lithosphere and mantle, with an overall goal toward deciphering the relationship between mantle dynamics, plate tectonics, and the Earth's surface environment over Earth history. In 2018 the group was active in a wide variety of projects involving the interaction of plate tectonics with mantle flow over Earth history, the factors controlling the rise of plumes from the LLSVP edges, dragging of slabs in the mantle, the global-scale cycling of water between the oceans and the mantle, the impact of viscosity anisotropy on plate motions, and the mantle's influence on present-day true polar wander. In addition, we contributed to model development and scientific visualization for geodynamics.

In 2018 the Earth Modelling team has made significant progress both deepening and broadening the scope of our activities. We are now developing models of earth processes operating throughout the entire mantle (core-mantle boundary to the surface), and across timescales ranging from billions of years to the past century. Below is a brief synopsis of our most important 2018 activities. We are looking forward to more exciting results coming in 2019!

Ocean Plate Tectonics

Years of study of dynamic links between Earth's surface and its deep interior (e.g., *Crameri & Lithgow-Bertelloni 2018*) have demonstrated that comprehending Earth evolution and dynamics requires a fundamental understanding of whole mantle-convection. This understanding begins with the fascinating dynamic earmark of our planet, the oceanic plate. Postdoc Fabio Crameri and Professor Clint Conrad and their colleagues have published an extensive review about the dynamic life of the oceanic plate from its formation, through its cooling stage, all the way to its destruction (*Crameri et al., 2018*). In an effort to foster clear communication between the different geoscientific communities involved in the study of the oceanic plate, they presented a new concept, Ocean-Plate Tectonics (Figure 2.1), which clearly describes the dynamics of the oceanic plate as an intimate part of whole mantle convection (*Crameri 2018b*).

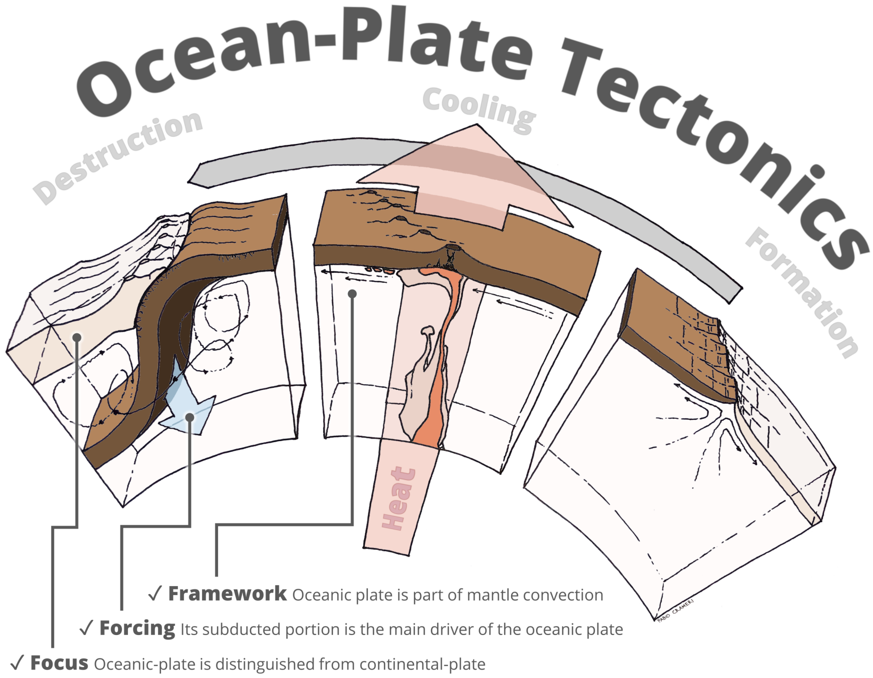


Figure 2.1. Ocean-Plate Tectonics is the concept that describes not only the horizontal surface motion of the oceanic plate (grey arrow), but also (i) highlights the pull from its subducted portion as the main driver (blue arrow), (ii) distinguishes the oceanic plate (dark brown) from its continental counterpart, (iii) acknowledges the plate–mantle coupling that induces characteristic regional mantle-flow patterns (black flow lines), and (iv) describes the dynamics of the oceanic plate as part of the larger framework of global mantle convection that transports heat out of the interior (light-red arrow).

The Breakup of Pangea Caused Mantle Water Regassing and Sea Level Drop

The last part of the breakup of Pangea (~ 150 Ma) involved opening the South Atlantic Ocean, through the birth of the mid-Atlantic ridge. This massive new ridge-system caused a doubling of the total ridge-system's length over a short period of time. According to recent plate reconstruction models, the creation of the new ridge system was not compensated by the initiation of new subduction zones, but instead by a dramatic increase in convergence velocity for already active trenches. This led to a period of rapid subduction of old oceanic lithosphere around the remnants of Earth's last supercontinent (Figure 2.2). This is important because PhD student Krister Karsen has shown that the amount of water that slabs can transport into the deep mantle depends strongly on both the velocity and age of the down-going plate. Together with Professor Clint Conrad and CEED Postdoc Valentina Magni, Karlsen has shown that this "rift pulse" of Pangea breakup was likely associated with a dramatic sea level fall of up to ~100 m, as rapid subduction transported water from the oceans into the mantle interior (*Karlsen et al., in review*).

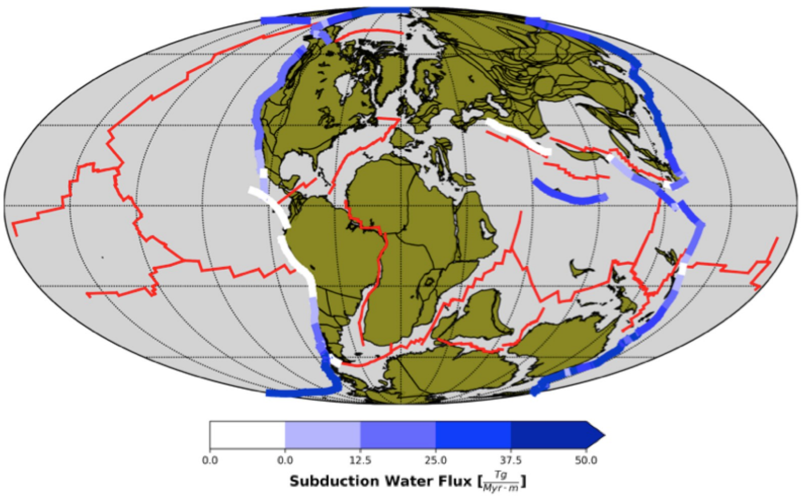


Figure 2.2. Reconstructed map of 130 Ma showing ridges (red) and the deep water flux at subduction zones (blue colors).

Mantle flow contributes large fraction of 20th century polar motion

Different processes may contribute to the geodetically observed polar motion in the last century. Environmental mass changes of glaciers and ice sheets, oceans, groundwater and reservoirs, and the resulting polar motion component (green ellipse in Figure 2.3, left), as well as the small contribution due to earthquakes (yellow circle), can be quantified relatively well but mismatch the actual rate of motion. Previously, this difference has often been attributed to glacial isostatic adjustment (GIA). A new

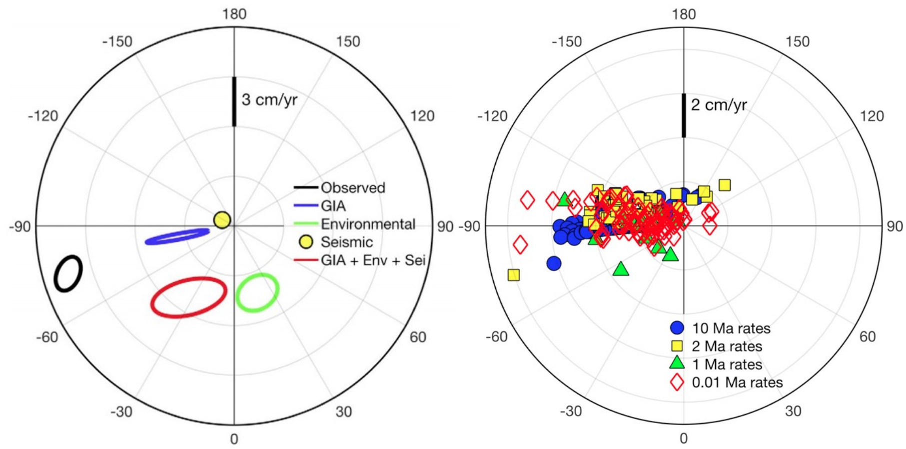


Figure 2.3. Left: Three different contributions to 20th century polar motion and their sum (red ellipse), compared to observed polar motion (black ellipse). Here we address whether the difference can be due to mantle convection. Right: Mantle contribution inferred from subduction history (10 Ma and 2 Ma rates; Steinberger et al., 2017), or from density anomalies derived from seismic tomography and associated flow (1 Ma and 0.01 Ma rates).

Bayesian analysis, which takes the background long-term triaxiality of Earth's inertia tensor into account, yields this GIA contribution (blue ellipse). While in the right direction, the GIA contribution likely explains less than half of the difference, with large uncertainty. Professor Bernhard Steinberger and colleagues examined whether polar wander predictions from mantle flow models can explain the remaining discrepancy. They found that polar motion from present-day mantle flow averages about 3 cm/yr in a direction towards ~90°W (*Adhikari et al., 2018*), which agrees within (rather large) uncertainties with true polar wander over the past 2-10 Myr derived from paleomagnetic data (Figure 2.3, right). The direction agrees almost exactly with the remaining discrepancy between the black and red ellipses. The amplitude explains about half of the difference on average, and all of it for some models.

Long-Wavelength Dynamic Topography is Smaller than Expected

Stresses from mantle convection deflect Earth's surface vertically, producing dynamic topography that is important for continental dynamics and sea-level change but difficult to observe due to overprinting by isostatic topography. Mantle flow models predict that for the longest wavelengths (~10^4 km) this topography may be up to about 1 km in amplitude, with topographic highs supported by mantle upwelling beneath Africa and the Pacific (Figure 2.4, bottom). This pattern of dynamic topography should cause both the Mid-Atlantic ridge and the East Pacific Rise to be asymmetric (Figure 2.4, top), with steeper slopes on the South American flank of these ridges. Professor Clint Conrad contributed to a study (*Watkins & Conrad, 2018*) that analysed bathymetry surrounding these ridges, and found that both ridges are indeed tilted toward South America, but with asymmetries that are consistent with only 500 m of long-wavelength dynamic topography, or about half what is predicted by most

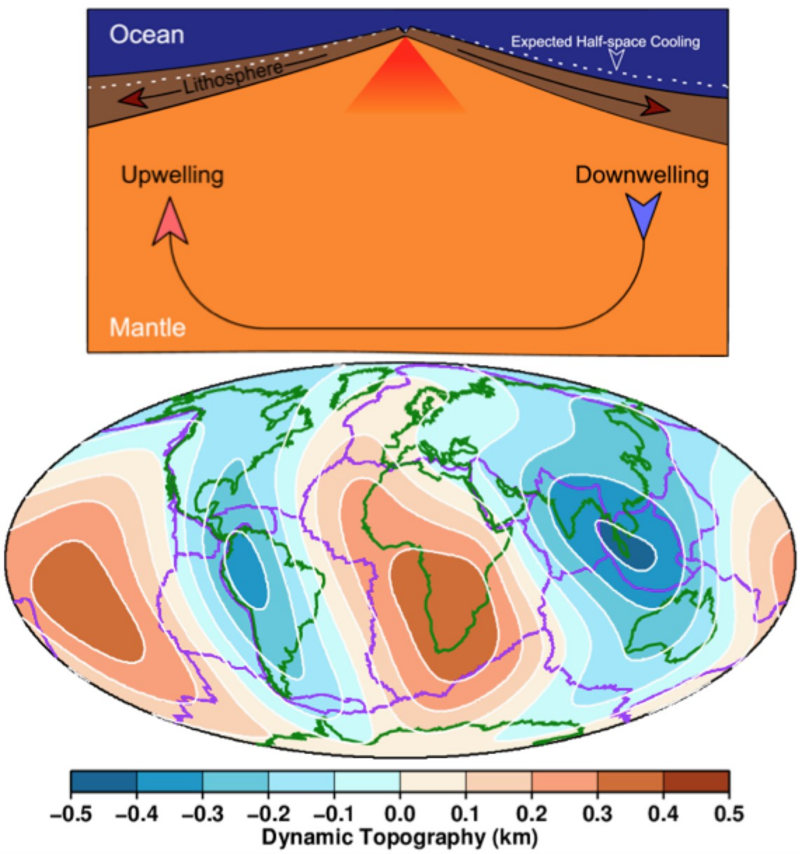


Figure 2.4. A ridge system becomes topographically asymmetric if mantle flow causes dynamic subsidence on one side of the ridge and dynamic uplift on the other (top). Numerical mantle flow models predict that this dynamic topography should cause both the East Pacific Rise and the Mid-Atlantic Ridge to be asymmetric (bottom). Bathymetric constraints for these two ridges suggest long-wavelength dynamic topography with amplitudes of ~0.5 km, which is about half the amplitude predicted by mantle flow models.

mantle flow models. This conclusion is supported by a second study (*Steinberger et al., 2018*) by Professor Bernhard Steinberger, which shows that spectral analysis of residual topography indeed shows smaller amplitudes for the longest wavelengths (mostly spherical harmonic degree 2) compared to mantle flow models. It is possible that thermochemical mantle convection models may help to explain this discrepancy.

Viscosity anisotropy in the asthenospheric mantle

The movement of the tectonic plates is the most observable expression of mantle dynamics. For plates in the Pacific basin, plate movement is mainly driven by slab pull toward subduction zones and resisted by deformation of the underlying asthenosphere. This means that viscous shear of the asthenosphere determines the velocity of a plate. This shear also tends to orient olivine grains into a lattice preferred orientation (LPO). Laboratory experiments show that it is difficult to shear olivine across the LPO, which suggests that anisotropic viscosity in the asthenosphere may impede changes in plate motions. Postdoc Ági Kiraly has been examining the implications of this anisotropic viscosity by combining a micromechanical deformation model with a texture development model for a simple plate system that assumes shear deformation within an asthenospheric layer made of equal-sized olivine grains. By first imposing shear deformation driven by motion of a rigid lithosphere with a driving force acting on one side, and then changing the direction of the driving force (Figure 2.5), we examine the impact of anisotropic viscosity on plate motions. We find that although the amplitude of the driving force is not changed, the plate velocity decreases after the change in direction because the mantle is now forced to shear at an angle relative to the olivine LPO. The amplitude this plate velocity change, and the time it needs to recover its original velocity, depends on the duration and angle over which the driving force is changed. These results may be extremely important for understanding the time-dependent history of plate motions (*Kiraly et al., 2018*)

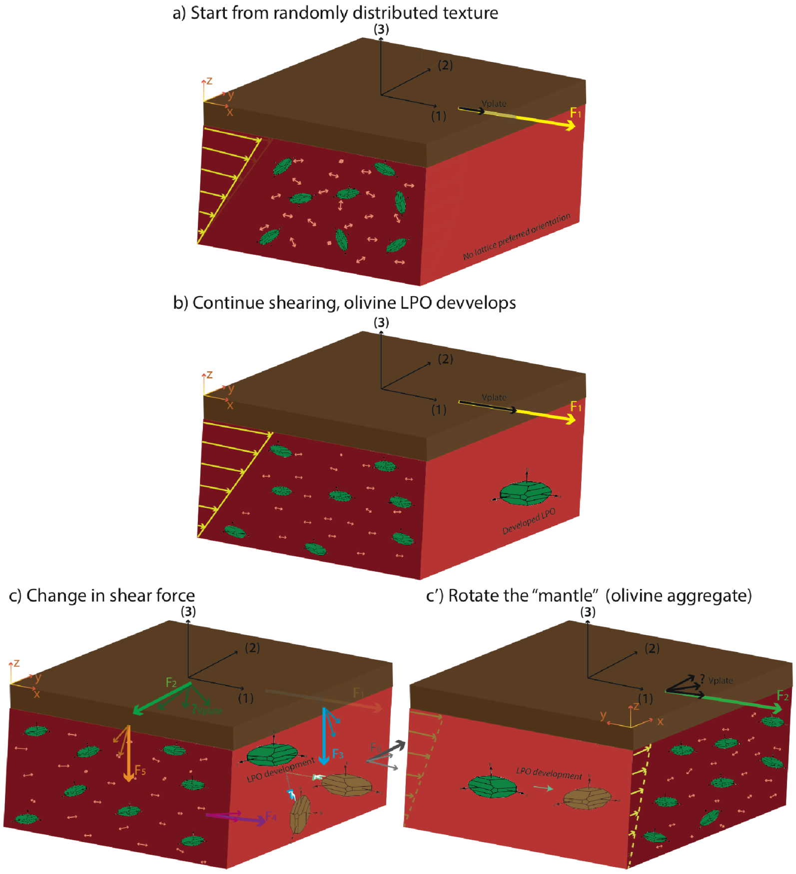


Figure 2.5. Our model starts with an initially random texture (a) that is then sheared to create an LPO texture in the asthenosphere (b). The direction of the shear force is then changed (c) and the viscous response of the model is then measured in terms of a new plate velocity and a newly developing texture. In practice, we rotate the fabric and keep the force direction the same (c').

Slab dragging and slab morphology evolution

In the current subduction paradigm, the *surface motion* of the subducting plate contributes to the sinking slab by plate motion *perpendicular* to the subduction trench. Professor Wim Spakman and colleagues recently discovered a new, potentially globally-governing, role of subducting plate motion as a driver of lateral transport of entire subduction systems (*Spakman et al., 2018)*. This transport is called “slab dragging” and denotes slab transport in the direction of the local absolute motion of the subducting plate in the mantle reference frame. By integrating 3-D numerical modelling of subduction evolution with observations from geology, mantle tomography and geodesy, Spakman and co-workers inferred slab dragging to the NNE of the east-dipping Gibraltar slab at a rate of 7-8 mm/yr by NNE African plate motion. Slab dragging is resisted by the viscous mantle, which may impact tectonic evolution at the surface as well as slab morphology and subduction zone evolution. Spakman’s group demonstrated large slab deformation resulting from viscous coupling between slab and mantle (*Chertova et al., 2018)* by numerically modelling the impact of a trench-parallel mantle wind of 30 mm/yr (Figure 2.6). This is comparable to slab dragging by 30 mm/yr in the opposite direction for a mantle that is not moving. Such a large rate of trench-parallel slab dragging was discovered by Spakman’s group for the Tonga-Kermadec slab, well-known for its strong slab-strike parallel deformation (*van de Lagemaat et al., 2018*). Lateral transport of slabs has been largely overlooked since the advent of plate tectonics and may be a globally occurring process with potentially large impact on subduction evolution.

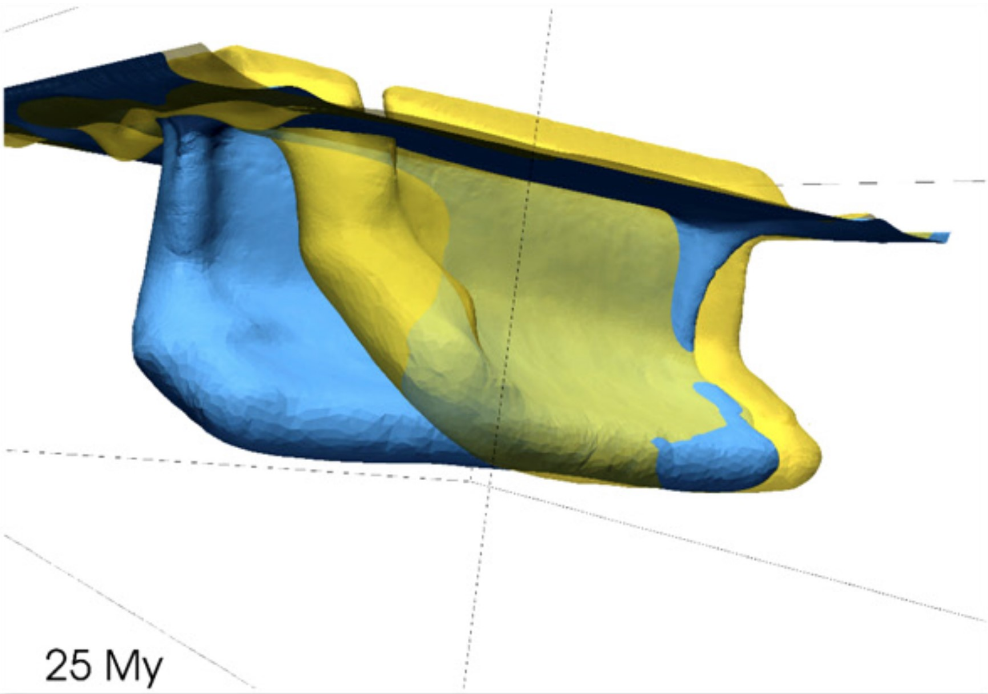


Figure 2.6. The effect on slab morphology of a uniform trench-parallel ‘mantle wind’ (30 mm/yr, entering through left). Blue slab: morphology of a 1400 km wide slab after 25 My of roll-back without mantle wind; Yellow slab: morphology after 25 My of trench-parallel mantle wind. (from: Chertova et al., 2018)

LLSVP survival and dynamics.

The large low shear velocity provinces (LLSVPs) are a dominant feature within tomographic images of the lowermost mantle, but their origin and evolution are not well understood. The most likely explanation of these regions is a dense and compositionally different material that forms hot thermochemical piles. Based on numerical models, PhD student Björn Heyn investigated the requirements for such a material to survive 4.5 Ga of mantle convection (*Heyn et al., 2018)*. This study shows that a viscosity increase related to composition can stabilize the piles and increase the mass retained in the structures. The potential increase in viscosity most likely results from interaction between the core and the Earth's mantle during the magma ocean stage, which enriched the dense material in bridgmanite (*Trønnes et al., 2018*).

Building on these observations, Heyn investigated the interaction between the pile edge and the ambient mantle in more detail. The pile edge plays an important role not only for entrainment of dense material, but also for plume generation. As shown in Figure 2.7, the pile edge moves a few tens of kilometres laterally along the core-mantle boundary (CMB) with time. This periodic movement is caused by compaction and thickening of the pile due to push of the subducted slab along the CMB, followed by a gravitational collapse of the pile as the upper part of the pile looses some of its heat. The lateral extension of the pile causes a new plume to rise at the pile edge.

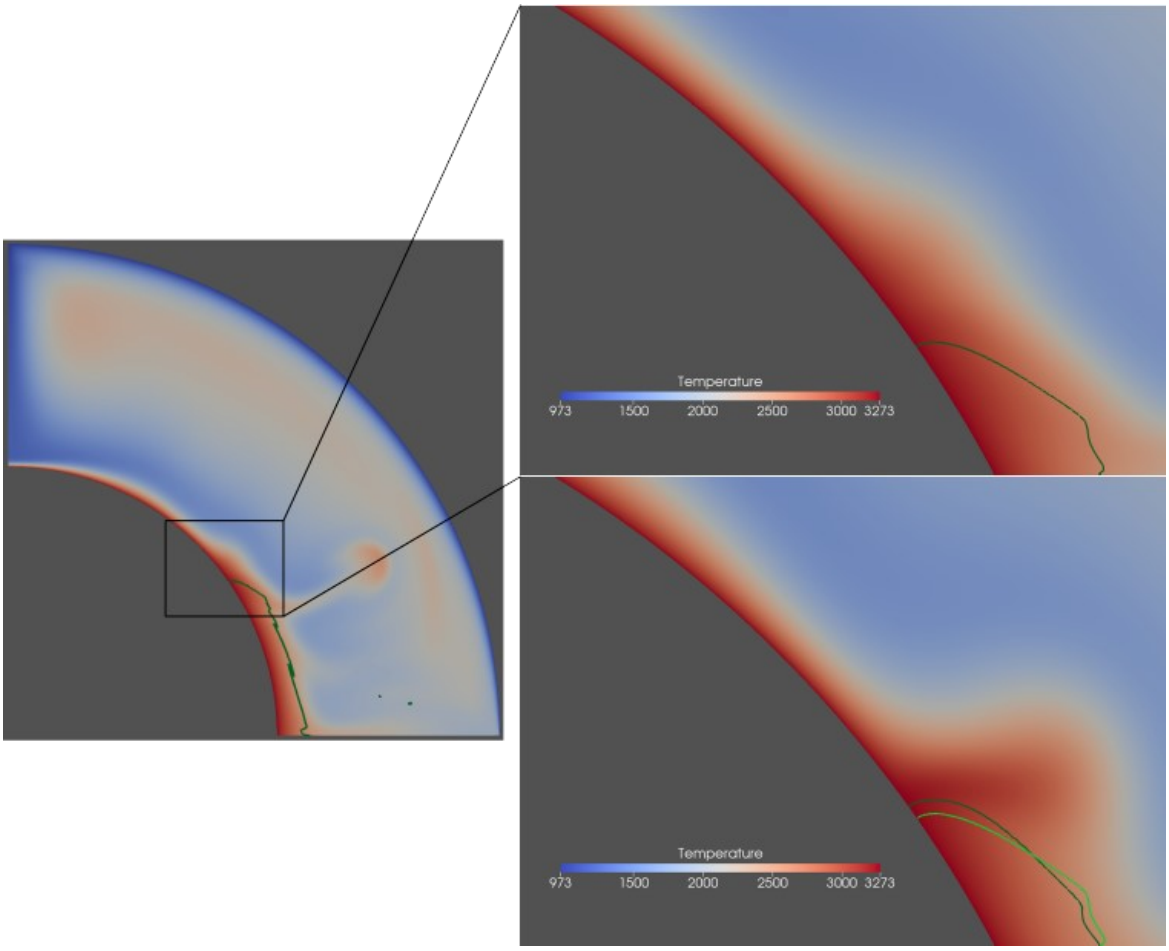


Figure 2.7. Snapshots of the temperature field at two different time steps with the pile outline marked by the dark green line. Left: the temperature field for the whole domain. Zoom-ins are shown for the pile before the collapse (top right) and during the collapse and associated triggering of the plume (bottom right). For comparison, the pile outline of the top right panel is shown in light green.

Geodynamic Modelling, Reproducibility, and Visualization

The Earth Modelling group has contributed significantly to development and visualization of geodynamic models, and the philosophy behind their use within the scientific community. For example, postdoc Fabio Crameri provides the scientific community with state-of-the-art open-access post-processing software. This includes a novel and unique set of scientific colour maps (Figure 2.8) that prevent perceptual data distortion and are inclusive for readers with colour-vision deficiencies. This suite of colour maps has been made publicly available and is widely adopted (*Crameri, 2018c*). It also forms, together with an extensive set of fully automated geodynamic diagnostics, the core functionality of the post-processing software StagLab 3.0 (*Crameri, 2018d*). Both the Scientific Colour Maps 4.0 and StagLab 3.0 are now published (Crameri, 2018a). Finally, PhD student Krister Karlsen has publicized the importance of research reproducibility for the geodynamic modelling community, and has provided tips for making computational model results reproducible by others (*Karlsen, 2018*).

Figure 2.8. Scientific Colour-Maps are (i) perceptually uniform, (ii) perceptually ordered, (iii) colour-vision-deficiency friendly, (iv) readable in black-and-white, and (v) provided in all major file formats

References

Adhikari, S., L. Caron, **B. Steinberger,** J. Reager, K.K. Kjeldsen, B. Marzeion, E, Larour, and E.R. Ivins, (2018), What drives 20th century polar motion? *Earth and Planetary Science Letters, 502*, 126-132, doi:10.1016/j.epsl.2018.08.059.

Chertova M.V., **W. Spakman**, and B. Steinberger (2018), Mantle flow influence on subduction evolution, *Earth and Planetary ScienceLetters,* 489, p. 258-266.

Crameri, F. (2018a), Geodynamic diagnostics, scientific visualisation and StagLab 3.0, *Geoscientific Model Development*, *11*, 2541-2562, doi:10.5194/gmd-11-2541-2018.

Crameri, F. (2018b), To serve Geoscientists, edited by G.E. Shephard, *EGU-Geodynamics Blog* (https://blogs.egu.eu/divisions/gd).

Crameri, F. (2018c), Scientific Colour-Maps: Perceptually uniform and colour-blind friendly, doi:10.5281/zenodo.1243862.

Crameri, F. (2018d), StagLab 3.0. http://doi.org/10.5281/zenodo.1199037

Crameri, F., C.P. Conrad, L. Montési, and C.R. Lithgow-Bertelloni (2018), The Life of an Oceanic Plate, *Tectonophysics*, *in press*, doi:10.1016/j.tecto.2018.03.016.

Crameri, F., and C.R. Lithgow-Bertelloni (2018), Abrupt upper-plate tilting during slab–transition-zone collision, *Tectonophysics*, *746*, 199–211, doi:10.1016/j.tecto.2017.09.013.

Heyn, B.H., **C.P. Conrad, C.P.**, and **R.G. Trønnes** (2018), Stabilizing effect of compositional viscosity contrasts on thermochemical piles, *Geophysical Research Letters, 45,* 7523-7532, doi:10.1029/2018GL078799.

Karlsen, K., (2018), Reproducible computational science, edited by G.E. Shephard, *EGU-Geodynamics Blog* (https://blogs.egu.eu/divisions/gd).

Karlsen, K., C.P. Conrad, V. Magni. Deep Water Cycling and Sea Level Change Since the Breakup of Pangea. G cubed, in review.

Kiraly, A., Conrad, C., Hansen, L.N. (2018). Geodynamic consequences of anisotropic mantle viscosity German-Swiss Geodynamics Workshop 2018

Spakman W., M.V. Chertova, A.P. van den Berg, and D.J.J. van Hinsbergen (2018), Puzzling features of western Mediterranean tectonics explained by slab dragging, *Nature Geoscience, 11*, 211-216, doi:10.1038/s41561-018-0066-z.

Steinberger, B., C.P. Conrad, A. Osei Tutu, and M.J. Hoggard (2018), On the amplitude of dynamic topography at spherical harmonic degree two, *Tectonophysics, in press*, doi: 10.1016/j.tecto.2017.11.032.

Steinberger B, Seidel; M-L, and **T.H. Torsvik** (2017). Limited true polar wander as evidence that Earth's nonhydrostatic shape is persistently triaxial. GRL 44, 827-834.

Trønnes, R.G, M.A. Baron, K.R. Eigenmann, M.G. Guren, B.H. Heyn, and A. Løken (2018), Core formation, mantle differentiation and core-mantle interaction within Earth and terrestrial planets, *Tectonophysics, in press*, doi:10.1016/j.tecto.2018.10.021.

Watkins, C.E., and **C.P. Conrad** (2018), Constraints on dynamic topography from asymmetric subsidence of the mid-ocean ridges, *Earth and Planetary Science Letters, 484*, 264-275, doi:10.1016/j.epsl.2017.12.028.

van de Lagemaat, S.H.A., D.J.J. van Hinsbergen, L.M. Boschman, P.J.J. Kamp, and **W. Spakman** (2018), Southwest Pacific absolute plate kinematic reconstruction reveals major mid- to Late Cenozoic Tonga-Kermadec slab dragging, *Tectonics*, *37*, 2647–2674, doi:10.1029/2017TC004901.

The Dynamic Earth Team explores plate motions and Earth history in the framework of Plate Tectonics and the Wilson Cycle. The Team is divided into three working groups (WGs), one focussing on passive margins and basin evolution (WG1: Integrated Basin and Lithospheric Studies), a second addressing continents adrift, oceanic basin formation and climate (WG2: Oceanic Basins and Climate Changes) whilst the third working group focus on subduction and collision but also old margins now variable preserved in the mountain belts (WG3: Margins and orogeny). Collectively these WGs cover the entire Wilson Cycle from Wilson kick-off through continents adrift to subduction and terminal collision. The Dynamic Earth Team strongly collaborates with the other CEED Teams and international collaborators in exploring links between plate tectonics, intra-plate volcanism and deep Earth dynamics. In 2018, Dynamic Earth members and their collaborators published 38 articles.

Working Group 1: Integrated Basin and Lithospheric Studies

In 2018, this working group and their collaborators published 13 papers mainly focused on the North Atlantic, Barents Sea and High Arctic regions. In these studies, structures and processes at lithospheric, crustal and basin scales are linked to constrain basin/margin evolution. Our published results in 2018 are divided in the following three main areas/topics.

The North Atlantic

The *Abdelmalak et al. (2018)* paper (Figure 3.1) presents a summary of the NW Atlantic tectonomagmatic evolution covering the Labrador Sea, Davis Strait and Baffin Bay areas. The work is based on integrated analysis of extensive new seismic, gravity, and magnetic datasets, complemented by seabed samples and field work. Breakup-related igneous rocks were emplaced during several Paleogene events associated with lithospheric stretching, continental breakup, and the formation of new oceanic basins. Plate reconstructions and basalt geochronology suggest that the majority of the volcanism in the NW Atlantic occurred between ~62 and ~58 Ma, associated with an increased spreading

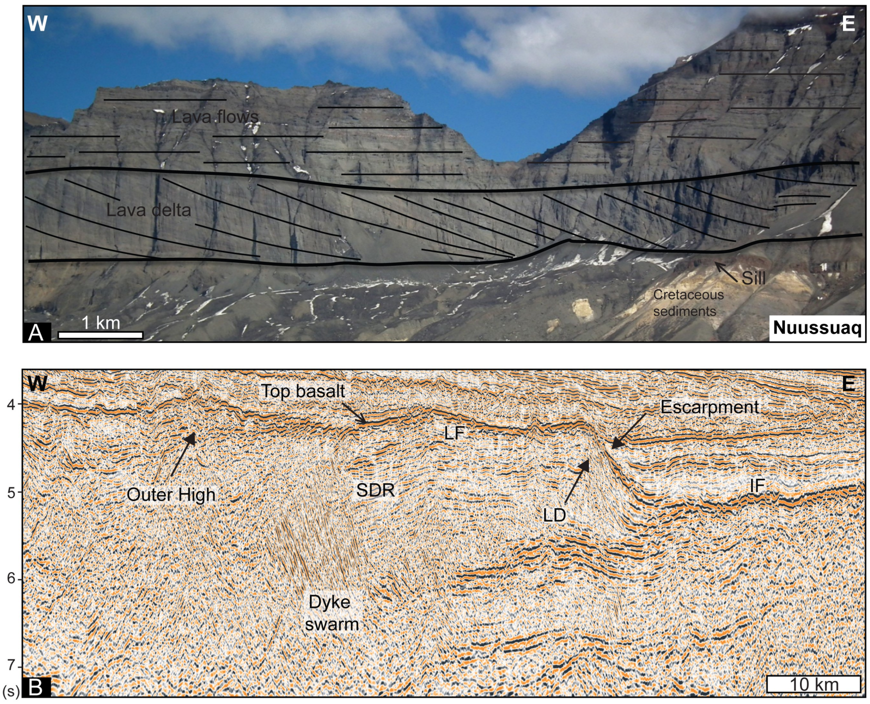


Figure 3.1 A: Volcanic rocks seen in outcrops in the Nuussuaq area in West Greenland. A lava delta unit of foreset-bedded hyaloclastites is overlain by thick horizontal lava flows. B: Seismic line from the northern Labrador Sea off SW Greenland showing a wedge of seaward-dipping reflectors (SDR). A dyke swarm feeder system cross-cut the SDR wedge. A lava delta (LD) forming an escarpment separates the landward flows (LF) from the inner flows (IF). Seismic data courtesy of TGS. From Abdelmalak et al. (2018).

rate in the Labrador Sea, starting from the onset of the Selandian (~61.6 Ma). A change in the spreading direction during the Eocene (~56 Ma), synchronously with a shift of volcanic activity from the NW to the NE Atlantic, corresponds to a northward drift of Greenland and the initiation of the Eurekan Orogeny. Our interpretations reveal a complex rift configuration along the NW Atlantic conjugate margins both prior to and during breakup.

A paper by *Tan et al. (2018)* focuses on the NE Atlantic oceanic lithosphere north of Iceland, in an area that is key for understanding the effects of the Iceland plume on the greater Jan Mayen-East Greenland Region. The 3D density structure of the crust and upper mantle is derived from regional seismic data combined with a shear wave velocity (Vs) tomography model and forward/inverse gravity modelling. A deep and broad negative mantle density anomaly under the Middle Kolbeinsey Ridge (MKR) is overlain by a narrower uppermost mantle NE-SW elongated negative density anomaly, which reflect a significantly shallower basement on the eastern side of the ridge. This is interpreted as the result of thermal erosion of the lithosphere by hot asthenospheric flow out from the Iceland plume, possibly the main driver for several eastward jumps of the MKR during the last 5.5 Ma.

The *Zastrozhnov et al. (2018)* paper (Figure 3.2) presents results of a multidisciplinary study of the northern segment of the Vøring volcanic rifted margin, offshore mid-Norway. An extensive geological and geophysical data set, including regional 2D seismic reflection and refraction profiles, potential field data and new borehole data, have been integrated and analyzed to better understand the margin architecture and geological evolution of the area. The outer and distal northern Vøring Margin represents a series of deep Cretaceous and Paleocene sag subbasins underlain by a significantly thinned continental crust. The sub-basins developed in between structural highs, which are underlain by a thicker crust and interpreted as a series of rigid continental blocks ("buffers"). During a series of Cretaceous-Paleocene extensional events the Vøring Basin axis migrated sequentially northwestward to the present-day continent-ocean boundary. The study also shows fundamental differences between the volcanic rifted mid-Norwegian Margin and non-volcanic (Iberian-type) margins and how pre-existing structures can shape the architecture and evolution of the margin.

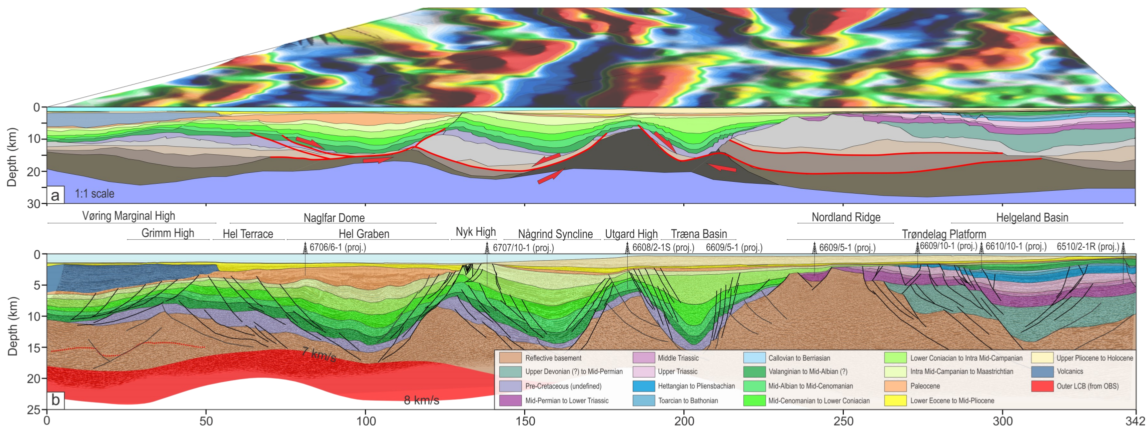


Figure 3.2 Regional profile across the northern Vøring Margin offshore mid-Norway. A: Crustal transect at 1:1 scale combined with gravity anomalies in map view. B: Depth-converted seismic line with main sedimentary sequences. Seismic data courtesy of TGS. Modified from Zastrozhnov et al. (2018).

Barents Sea - Svalbard

In the Barents Sea we have followed up the tradition of crustal-scale studies based on wide-angle seismic data. *Shulgin et al. (2018)* presents a 600 km long profile close to and along the Norwegian-Russian border in the central Barents Sea. Our model, based on both ocean-bottom and onshore seismometers, reveals a complex crustal structure of the Baltic Shield to Barents shelf transition zone, as well as strong structural variability on the shelf itself. High-velocity/density bodies in the lower crust may be linked to magmatism during Devonian rifting or they represent an integral part of the Timanides stretching from the Russian mainland into the southeastern and central Barents Sea. We also calculate net regional erosion based on the shallow velocity structure.

In collaboration with other groups/projects at the department we have also published several papers focusing on various areas in the SW Barents Sea. Some of these (*Gac et al., 2018; Indrevær et al., 2018*) involve numerical modelling addressing the vertical motion histories of key structural elements. The *Koehl et al. (2018)* paper focuses on Late Paleozoic collapse basins on the platform adjacent to the Norwegian mainland. The *Corseri et al. (2018)* paper presents high-resolution seismic data across a submarine channel formed in front of a prograding delta system.

High Arctic

Deep and complex geodynamic processes, including the effects of plumes, heat, plate tectonics and local tectonics control have shaped the circum-Arctic continental margins. In the Arctic these processes are often masked by extensive glaciations and associated erosion. In the *Medvedev et al. (2018)* paper (Figure 3.3) we model erosion backward in time by numerically restoring eroded material and calculating the flexural isostatic response repeatedly iteratively until eroded features are filled. This method, linking surface and deep Earth dynamics, estimates erosion recorded in the modern topography and models the influence of that erosion. The coupled erosion-isostatic response results in dramatic vertical motions leading to km-scale uplift in fjord carved areas of Scandinavia, Greenland, and Canadian Arctic Archipelago. The model results are also compared to gravity anomalies showing that our method is valid for both glacial and fluvial affected landscapes.

Through a Norwegian-Russian project we have continued our collaboration with Russian partners. In the *Ershova et al. (2018)* paper detrital zircon geochronological data for samples from the Severnaya Zemlya archipelago shed light on the paleogeography of the Kara Terrane in the Russian High Arctic. The (U-Th)/He ages coincide with significant regional exhumation during the Caledonian and Timanian orogenies, and combined U-Pb and (U-Th)/He dating suggest potential overlap of these orogens within the source region. A younger (375 Ma) event may be correlated with either the Ellesmerian Orogeny or the terminal Solundian/Svalbardian stages of the Caledonian Orogeny.

The main results of the *Faleide et al. (2018)* and *Minakov et al. (2018)* papers were reported last year ahead of their final publication.

Collaboration

The NOR-R-AM network (PI C. Gaina, CEED) is a key arena for our Arctic research. In particular, we have further developed our collaboration with Russian partners from St Petersburg and Moscow Universities. We also have close collaboration with other complementary projects in the Barents Sea, in particular with ARCEx (Research Centre for Arctic Petroleum Exploration). Among the international partners, we collaborate closely with GFZ Potsdam both in the Barents Sea and the NE Atlantic.

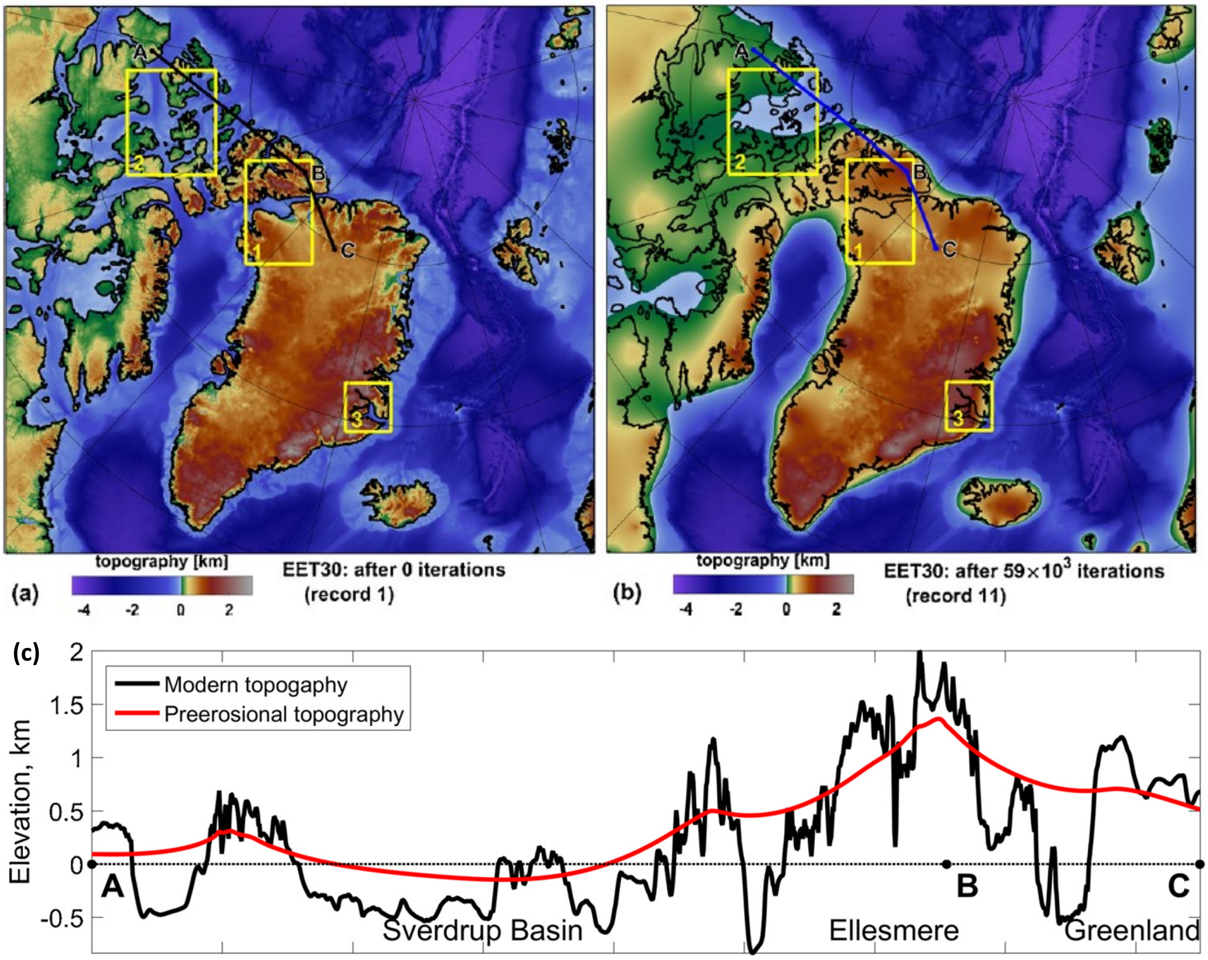


Figure 3.3. Modern topography (a) and reconstructed (pre-erosional) topography (b). The modern and pre-erosional topographies are compared along the profile A-B-C across the Canadian Arctic to North Greenland in (c). From Medvedev et al. (2018).

Working Group 2: Oceanic Basins and Climate Changes

Researchers of this group are interested in uncovering the links between the evolution of oceanic basins and adjacent continental margins and the upper and lower boundaries-the mantle and the oceans/atmosphere. We collect and interpret geophysical, geological and geochemical data, make numerical models, and collaborate with specialists in mantle dynamics and petrology, and in ocean and climate sciences. In 2018, this working group and their collaborators published 23 papers divided in two main topics:

The structure and evolution of the NE Atlantic and Arctic regions

The ice-covered Eurasia Basin in the Arctic region attracted numerous scientific expeditions since the 19th century, but its unique architecture and clues for its tectonic evolution were revealed only in the last decade due to intense international mapping and exploration. Scientists from CEED were involved in data collection and interpretation from Russian and Canadian-Swedish campaigns and were instrumental in developing new ideas about the evolution of the High Arctic realm.

Nikishin et al. (2018) used new geophysical data to demonstrate that the least explored East Eurasia Basin has an oceanic lithosphere asymmetry similar with its western part, and the eastern sector of the Gakkel Ridge displays volcanic and sparsely-volcanic segments. They were the first to describe in detail the deepest part of the ultraslow Gakkel Ridge, which they named the "**Gakkel Ridge Deep**", and its peculiar recent volcanic activity (Figure 3.4).

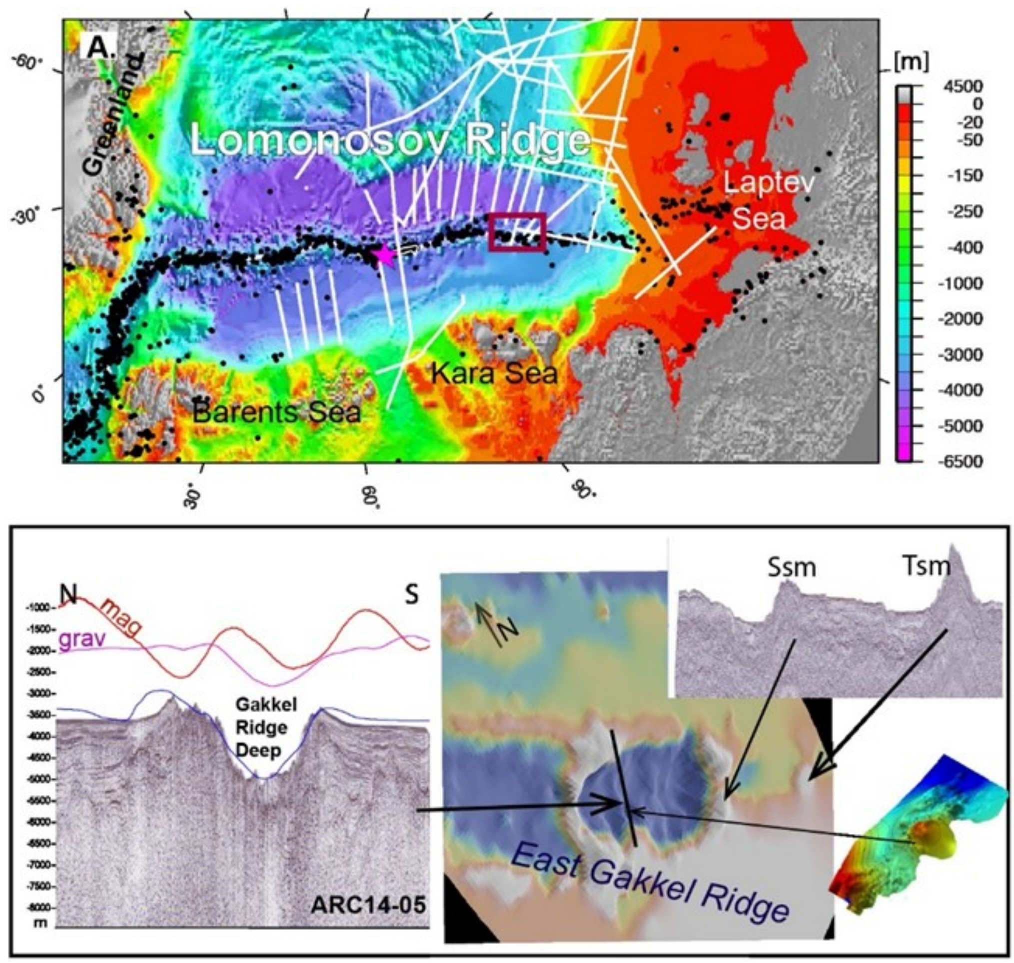


Figure 3.4., for figure caption see next side

Shephard et al. (2018) also used newly collected geophysical data in addition to global mantle tomography to suggest that the geographical North Pole may sit on a mantle thermal anomaly revealed by high heat flow values. The present day thermo-mechanical structure and effective elastic thickness of the entire Arctic lithosphere was modelled exploiting the state-of-the-art knowledge of the crustal thickness and lithospheric age (*Struijk et al., 2018),* a model that can reveal, among other things, the coupling between the upper and lower crust and the upper mantle, and therefore better understand the Arctic realm seismicity and active tectonics.

Regional and global oceanic basin dynamics and links to the mantle, oceans and climate

In order to assess how numerical modelling of mantle convection can predict the dynamics of Earth´s plate boundaries through time, and how various errors may influence these results, *Coltice & Shephard (2018)* compared the tectonic predictions (kinematics and plate boundary locations) of 3-D spherical convection models with plate-like behaviour and tectonic reconstructions. Their study suggests that calculations for short-term dynamical evolution models are more suitable experiments than instantaneous flow calculations for the inversion of the temperature field and rheological parameters. Consequently, they recommend dynamic calculations instead of instantaneous models, as they demonstrate stronger discriminating power for sources of errors in kinematic predictions.

As a follow up to the vote map methodology of *Shephard et al. (2017),* which compared multiple seismic tomography models to reveal locations and trends of subducted slabs, the study of *Hosseini et al. (2018)* involved the release of a new website called SubMachine. This community resource allows for the easy plotting and analysis of over 30 seismic tomography models, the vote maps, and other complementary surface geophysical datasets. (see example on the next page from Gaina and Jakob, 2018).

Figure 3.4 (left) Upper panel: Bathymetry of the Eurasia Basin, Arctic Ocean (Jakobssen et al., 2012). White lines are new seismic reflection profiles (Russian Federation) used to interpret the basement and sedimentary structure. Black dots show the location of seismic events. Lower panel: The Gakkel Ridge Deep (GRD, location in the upper panel-red box) – the deepest part of the ultraslow Gakkel Ridge has been characterised for the first time by Nikishin et al. (2018) study. Seismic reflection profiles shown in the left and upper right shows the wide and deep mid-ocean ridge valley, and seamounts along the ridge, respectively. The middle figure shows the GRD bathymetry and details from multi-beam bathymetry that image a cone-shaped feature within one flank of GRD, here interpreted as a young volcano. Figure modified from Nikishin et al (2018).

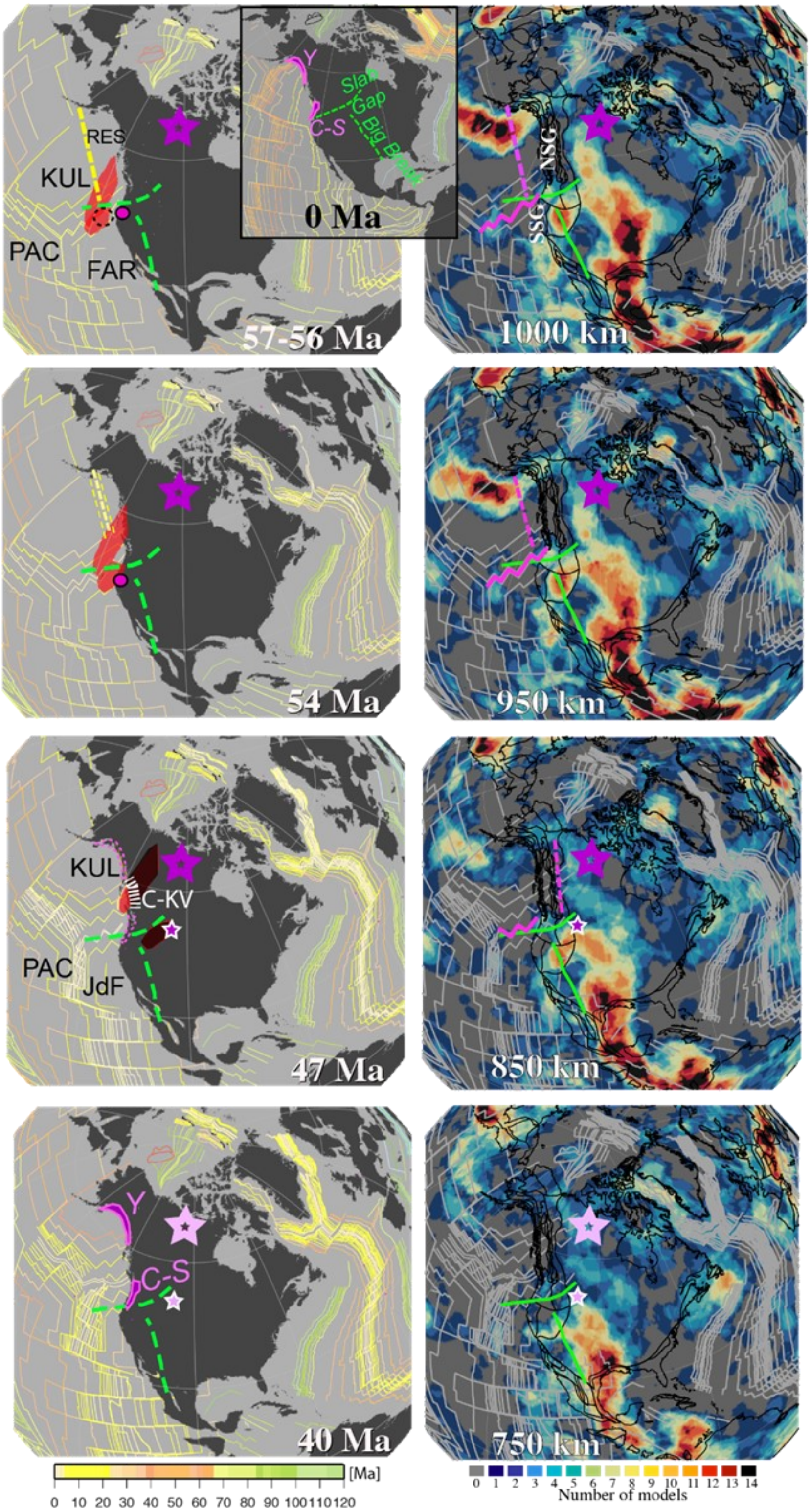
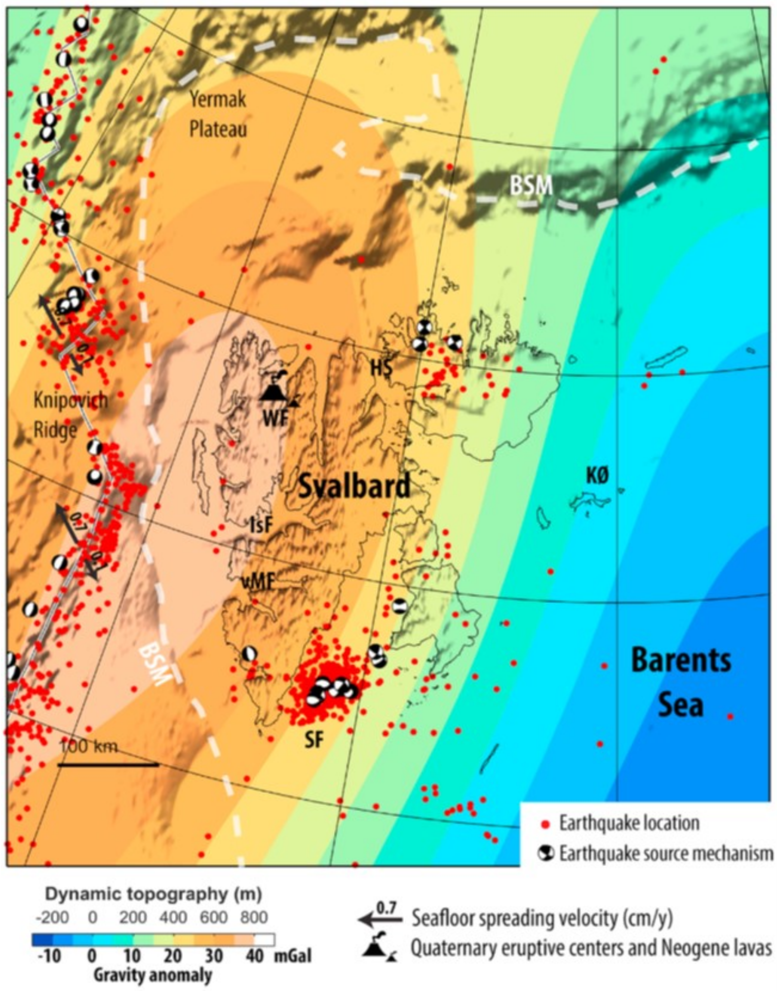


Figure 3.5. Tectonic plate reconstructions in an absolute reference frame (left panels), and subducted slab distribution ("vote maps", Shephard et al., 2017) in the lower mantle (right panels). The continents (dark grey) are outlined by present-day coastlines (black, thin lines). "S" stands for Siletzia, and "C" for Crescent accreted terrane (pink outlines). The red polygons show the estimated of the Siletzia-Crescent-Yakutat Large Igneous Province (LIP). This LIP was partly accreted (pink dashed lines) and probably also subducted (dark brown polygons) on and under the North American plate. Light green lines show the Sigloch et al., (2008) and Sigloch (2011) interpretation of slab gap boundaries (as in the inset upper panel). The magenta circle shows the approximate location of the Yellowstone hotspot, the black dotted circle in the upper left panel indicates its possible position due to mantle advection. The magenta star symbols indicate the reconstructed locations of Eocene kimberlite eruption sites (large star-Canadian location, smaller star-US location). The pale stars in the lower panels indicate inactive kimberlite sites. The reconstructed positions of mid-ocean ridges in the NE Pacific are shown as magenta segments on right panels. Abbreviations are: FAR-Farallon, JdF-Juan de Fuca, KUL-Kula, PAC-Pacific, Res-Resurrection plates, C-KV- Challis –Kamloops volcanic belt, and Y-Yakutat (modified from Gaina & Jakob, 2018)

To better understand how our planet's turning points were caused and whether sudden changes in plate tectonic configuration could have been related to continent collision, mountain building, major changes in the subduction geometry or catastrophic outbursts of volcanism often caused by mantle plume impingement at the base of the Earth's lithosphere, *Gaina & Jakob (2018)* revised the Eocene tectonic unrest which is imprinted in the world's oceanic lithosphere. They suggest that tectonic events of Eocene age recorded on the western and eastern margins of the North American plate may be linked and explained by lithosphere-mantle interactions triggered by subduction. The North American Late Paleocene-Early Eocene kimberlite magma that erupted more than 1000 km from its western plate boundary constitutes additional evidence that tectonic stresses may have affected the entire plate, and therefore also its eastern boundaries (Figure 3.5 left page).

A link between mantle convection, seafloor spreading and glaciation events is suggested by the *Minakov´s (2018)* paper (Figure 3.6). The paper focuses on the recent (10 Ma to present) evolution of the northwest Barents Sea passive margin and Svalbard archipelago, which experienced tectonic reactivation including regional uplift, volcanism and fault movements. The area is underlain by a thin lithosphere and excess mantle temperature. Seismological models of the upper mantle, gravity anomalies, rates of glacial isostatic adjustment (GIA) and the spatio-temporal characteristics of earthquakes are integrated and analyzed with the aim to (i) constrain the thermal state and rheological structure of the upper mantle beneath Svalbard, (ii) infer the magnitude of vertical motion in the late Cenozoic time related to various processes,

Figure 3.6. Dynamic topography of the Svalbard region inferred from long-wavelength gravity anomalies. The maximum of dynamic topography (~ 800 m) corresponds to the location of the Quaternary eruptive centers and Neogene lavas (WF) in Svalbard. Major fjords indicated: HS – Hinlopenstredet, IsF – Isfjorden, vMF – van Mijenfjorden, SF – Storfjorden. From Minakov (2018).



(iii) better understand the likely causes of the tectonic and volcanic activity. The relative magnitudes, and the physical relationship between surface processes, plate boundaries and mantle flow, are assessed. It is concluded that a transient temperature anomaly in the asthenosphere northeast of Jan Mayen, combined with the northwest absolute plate motion of Eurasia, is the likely primary cause of the late Cenozoic tectonic reactivation in Svalbard.

The "**Oceanic Basins and Climate Changes** " group hosts the RCN project: Coupled climate, volcanism, and ocean tectonics in deep time – **ClimVoTe**, a collaboration between CEED/the Department of Geosciences and Bjerknes Centre for Climate Research, University of Bergen. Professor K. Nisancioglu, Adj. Professor at CEED, his group at UiB, and CEED PhD student E. Straume are designing new paleooceanography models for the NE Atlantic region by using realistic paleo-bathymetry. C. Gaina and E. Straume are also participating in the Australian Research Council funded project: "How the complexity of continental breakup controls ocean circulation". Preliminary results have been presented as an invited contribution at AGU by *Straume et al., (2018)* (Figure 3.7).

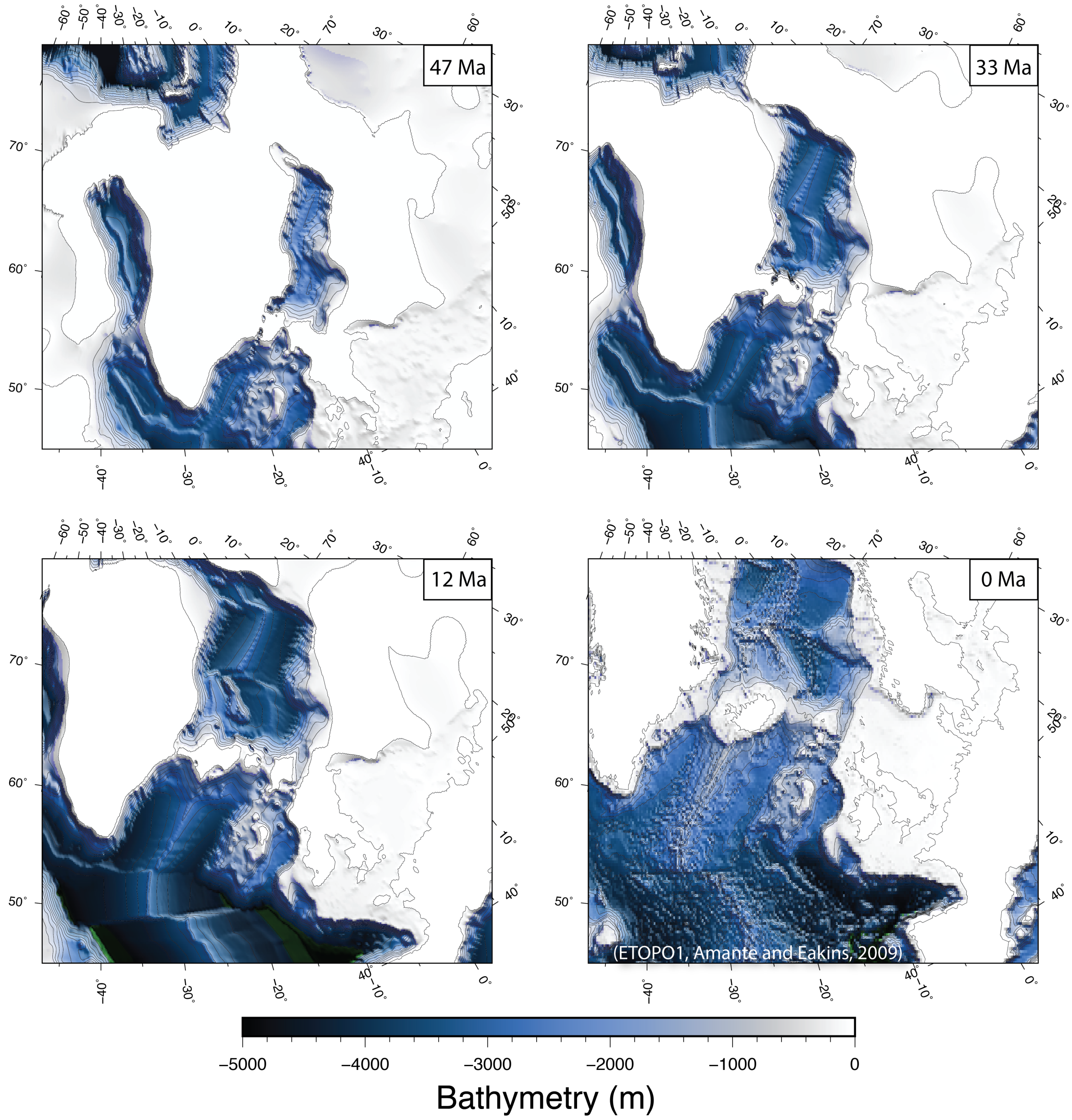


Figure 3.7. Cenozoic paleobathymetric reconstructions and present day bathymetry of the NE Atlantic (Straume et al., 2018).

Working Group 3: Margins and Orogeny

Our research in 2018 was concentrated on (1) understanding intermediate deep earthquakes and their relationships to metamorphic transformation during subduction and orogeny, and (2) to unravel the geodynamic setting and structural architecture of the pre-Caledonian margin developed along Baltica in Late Precambrian (Ediacaran) and into the Early Ordovician (Figure 3.8). We have demonstrated how the inherited passive margin architecture controlled the later structural architecture of the Scandinavian Caledonides during the Scandian collision and mountain building.

In 2018, working group 3 and collaborators published 2 papers with CEED funding (*Ferré et al., 2018* and *Jamtveit et al., 2018*), both related to deep crustal/mantle processes during collision and co-seismic faulting. However, a number of manuscripts (7 in total) were completed and submitted in 2018 for major international journals. Of these, four are already published or in press. Results of this research have also been presented in a number of contributions at various meetings, principally EGU/AGU, Nordic meeting and outreach.

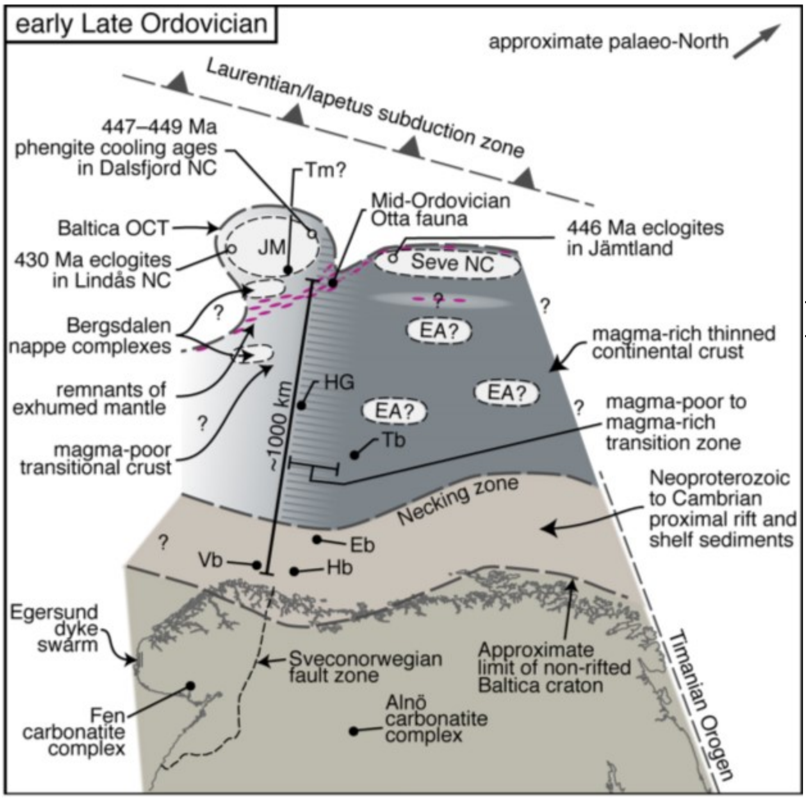


Figure 3.8. A schematic reconstruction of the pre-collision architecture of the rifted margin of Baltica in the Late Ordovician (~450±5 Ma) before onset of the Scandian collision., Purple ellipses represent mantle exposed at the sea floor. The island type Otta fauna is placed ~1000 km away from the Baltic cratonic margin. The size of the Jotun Microcontinent is approximately 200 × 300 km. Black circles indicate the palaeoposition of future thrust nappes. Open circles indicate the palaeoposition of tectonic units and geological events at some time after onset of earliest Scandian inversion of the margin. EA, extensional allochthon; Eb, Engerdalen basin; HG, Heidal Group; Hb, Hedmark basin; JM, Jotun Microcontinent; NC, nappe complex; Tb, Tossåsfjället basin; Tm, Turtagrø metasediments; Vb, Valdres basin. From: Jakob et al. (2019).

Field work and workshops

The field work in the Scandinavian Caledonides is partly of expedition-type work in remote areas, and with extensive use of helicopters, requiring permits from national park authorities in Norway and Sweden. In connection with the NRC FRINAT project *Hyper-extension in the pre-Caledonian margin of Baltica*, these studies have continued and complementary detailed work to the previous regional studies (2014-1217) of the pre- magma-rich and magma-poor ocean-continent transition zone preserved along the mountain belt in northern Scandinavia and in central Sweden and Norway was largely completed in 2018. In 2018 most of the fieldwork work has been carried out by J. Jakob and PhD student H.J. Kjøll, assisted by the international co-workers. A productive workshop in the project was arranged at CEED with participation of L. Labrousse and G. Mohn (France) and Olivier Galland from PGP (October 29 -31st). We also arranged a workshop on the deep crustal processes (Berlin, March 5-7th), with participation from CEED (Andersen), Sorbonne (Labrousse) and Freie Universität (John, Katz, Zwertani).

External funding and collaboration

A major source of external funding in 2018 has been via the NRC project *Hyperextension in the pre-Caledonian margin of Baltica*. Principal external collaborators in this project in 2018 were C. Tegner (Univ. Århus), L. Labrousse (UPMC-Sorbonne), G. Mohn (Univ Cergy -Pontoise), S. Buiter (NGU/CEED) and O. Galland (PGP). Galland has been an important contributor to our work on the magmatic plumbing system and dyke-emplacement mechanisms in the Pre-Caledonian magma-rich passive margin, which is dealt with in a manuscript (EPSL, in press) with H.J. Kjøll as the principal author (Figure 3.8). *Tegner et al. (2019*) completed a major manuscript on the geochemistry, petrology and geodynamic significance of the Large Igneous Province (LIP) expressed as the 605±10 Ma Scandinavian Dyke complex preserved in the Caledonides.

Master student involvement in 2018 includes O. Quintela (CEED, internship student) and P. Closset (Univ. Strasbourg) who completed his master thesis in the spring 2018, and L. Katz who completed her master thesis based on field studies in Norway (with T. John at Freie

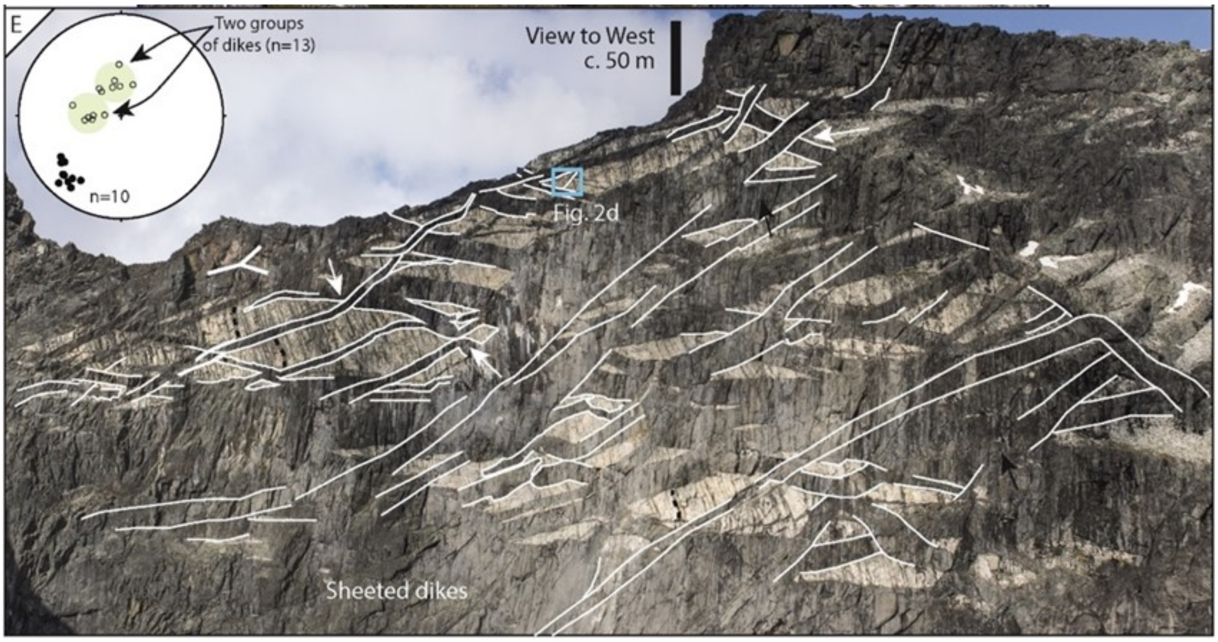


Figure 3.8. Large-scale dyke and wall rock relationships of the Scandinavian Dyke Complex in a vertical cliff section at Saräk, North Sweden. The annotated photo is of a 300-meter-high cliff showing dykes of the Scandinavian Dyke Complex (605±10 Ma) as dark rocks, highlighted locally with white lines to indicate their mutually cross-cutting relationships and their different orientations, truncating well-bedded sandstones (light coloured) with preserved near vertical bedding. Stereonet show poles of the dykes (open circles) and bedding (closed circles). Note grouping of dyke poles in two distinct orientations separated by an approximately30-degrees angle (Kjøll et al., 2019)

Universität Berlin). We also had extensive *in-house* CEED collaboration with S. Planke and M. Abdelmalak in discussions and interpretations of the magma-rich part of the Pre-Caledonian Baltican margin, and with T.H. Torsvik regarding the geodynamic setting of the 605±10 Ma pre-Caledonian LIP.

In the studies on the on deep-crustal deformation and metamorphic processes during subduction and orogeny we have worked extensively with co-workers from Freie Universität, Berlin (T. John and PhD student S. Zertani). Zertani has submitted two major publications, also based on field work in Norway, and co-supervised by T.B. Andersen.

Extensive internal UiO collaboration has been with the PGP-team, (B. Jamtveit, H. Austrheim, F. Renard and S. Incel). Results of this work has been published in Nature Scientific Reports (*Jamtveit et al., 2018*), and more recently in Geology (*Incel et al, 2019*).

References

Abdelmalak, M.M., Planke, S., Polteau, S., **Hartz, E.H., Faleide, J.I.,** Tegner, C., **Jerram, D.A.,** Millett, J.M. & Myklebust, R. (2018) Breakup volcanism and plate tectonics in the NW Atlantic. Tectonophysics, DOI: 10.1016/j.tecto.2018.08.002.

Coltice, N & G.E. **Shephard** (2018) Tectonic predictions with mantle convection models. Geophysical Journal International 213(1), 16-29

Corseri, R., Faleide, T.S., **Faleide, J.I.**, Midtkandal, I., Serck, C.S., Trulsvik, M. & **Planke, S.** (2018) A diverted submarine channel of Early Cretaceous age revealed by high-resolution seismic data, SW Barents Sea. Marine and Petroleum Geology, 98, 462-476.

Ershova, V., Anfinson, O., Prokopiev, A., Khudoley, A., Stockli, D., **Faleide, J.I.**, **Gaina, C.** & Malyshev, N. (2018) Detrital zircon (U-Th)/He ages from Paleozoic strata of the Severnaya Zemlya Archipelago: Deciphering multiple episodes of Paleozoic tectonic evolution within the Russian High Arctic. Journal of Geodynamics, 119, 210-220.

Faleide, J.I., Pease, V., Curtis, M., Klitzke, P., **Minakov, A.**, Scheck-Wenderoth, M., Kostyuchenko, S., Zayonchek, A. (2018) Tectonic implications of the lithospheric structure across the Barents and Kara shelves. Geological Society Special Publication, Volume 460, Issue 1, 2018, 285-314.

Ferre, E.C, Meado, A.L., Greissman, J.W., Di Toro, G., Spagnulo, E., Ueda, T., Ashwal, L.D., Deseta, N., **Andersen, T.B.**, Filiberto, J. & Conder, J.A. (2017). Earthquakes in the mantle? Insight from rock magnetism of pseudotachylytes. Journal of Geophysical Research Solid Earth 122, 8769-8785. DOI: 10.1002/2017JB014618

Gac, S., Hansford, P.A. & **Faleide, J.I.** (2018) Basin modelling of the SW Barents Sea. Marine and Petroleum Geology, 95, 167-187.

Gaina, C. & **J. Jakob** (2018). Global Eocene tectonic unrest: Possible causes and effects around the North American plate. Tectonophysics, 1-16.

Hosseini, K., Matthews, K. J., Sigloch, K., **Shephard, G., M. Domeier** & M. Tsekhmistrenko, (2018) SubMachine: Web-Based Tools for Exploring Seismic Tomography and Other Models of Earth's Deep Interior. Geochemistry Geophysics Geosystems 19(5), 1464-1483

Indrevær, K., Gac, S., **Gabrielsen, R.H.** & **Faleide, J.I.** (2018) Crustal-scale subsidence and uplift caused by metamorphic phase changes in the lower crust: A model for the evolution of the Loppa High area, SW Barents Sea from late Paleozoic to Present. Journal of the Geological Society, 175, 497-508.

Incel, L.Labrousse, N.Hilairet, T.John, J.Gasc, F.S, Y.Wang, **T. B. Andersen**, F. Renard1, B. Jamtveit, and A. Schubnel (2019). Reaction-induced faulting in granulite causes earthqakes in the lower continental crust.: Geology February; .https://doi.org/10.1130/G45527.1s

Jakob, J; Andersen, T.B and Kjøll, H.J. (2019). A review and reinterpretation of the architecture of the South and South-Central candinavian Caledonides—A magma-poor to magma-rich transition and the significance of the reactivation of rift inherited structures. Earth-Science Reviews. In press.

Jakobsson, M; Larry Mayer, Bernard Coakley, Julian A. Dowdeswell, Steve Forbes, Boris Fridman, Hanne Hodnesdal, Riko Noormets, Richard Pedersen, Michele Rebesco, Hans Werner Schenke, Yulia Zarayskaya, Daniela Accettella, Andrew Armstrong, Robert M. Anderson, Paul Bienhoff, Angelo Camerlenghi, Ian Church, Margo Edwards, James V. Gardner, John K. Hall, Benjamin Hell, Ole Hestvik, Yngve Kristoffersen, Christian Marcussen, Rezwan Mohammad, David Mosher, Son V. Nghiem, Maria Teresa Pedrosa, Paola G. Travaglini, and Pauline Weatherall (2012). The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0. Geophysical Research Letters, 39, L12609, doi:10.1029/2012GL052219, 2012

Jamtveit, B; Moulas, Evangelos; **Andersen, T.B;**; Austrheim, H.O.; **Corfu, F**; Petley-Ragan, A.J; Schmalholz, S.M. (2018) High Pressure Metamorphism Caused by Fluid Induced Weakening of Deep Continental Crust. Scientific Reports 2018 ; 8. s. –

Kjøll, H-J., Galland, O., Labrousse, L. and **Andersen, T.B.** (2019) Emplacement mechanisms of a dyke swarm across the Brittle Ductile Transition and the geodynamic implications for magma-rich margins (in press, EPSL,)

Koehl, J.-B., Bergh, S.G., Henningsen, T. & **Faleide, J.I.** (2018) Middle to Late Devonian–Carboniferous collapse basins on the Finnmark Platform and in the southwesternmost Nordkapp basin, SW Barents Sea. Solid Earth, 9 (2), 341-372.

Medvedev, S., **Hartz, E.H.** & **Faleide, J.I.** (2018) Erosion-driven vertical motions of the circum Arctic: Comparative analysis of modern topography. Journal of Geodynamics, 119, 62-81.

Minakov, A. (2018) Late Cenozoic lithosphere dynamics in Svalbard: Interplay of glaciation, seafloor spreading and mantle convection. Journal of Geodynamics, 122, 1-16.

Minakov, A., Yarushina, V., **Faleide, J.I.**, Krupnova, N., Sakoulina, T., Dergunov, N., Glebovsky, V. (2018) Dyke emplacement and crustal structure within a continental large igneous province, northern Barents Sea. Geological Society Special Publication, Volume 460, Issue 1, 2018, 371-395.

Nikishin, A. M., **Gaina, C.**, Petrov, E.I., Malyshev, N.A., Freiman, S.I. (2018) Eurasia Basin and Gakkel Ridge, Arctic Ocean: Crustal asymmetry, ultra-slow spreading and continental rifting revealed by new seismic data. Tectonophysics, 746, 64-82

Shephard, G.E., Matthews, K.J., Hosseini, K., **Domeier, M.** (2017). On the consistency of seismically imaged lower mantle slabs. Sci. Rep. 7.

Shephard, G., Wiers, S., Bazhenova, E., Perez, L. F., Mejia, L. M., Johansson, C., Jakobsson, M., and M. O'Regan (2018) A North Pole thermal anomaly? Evidence from new and existing heat flow measurements from the central Arctic Ocean. Journal of Geodynamics, 118, 166-181.

Shulgin, A.A., Mjelde, R., **Faleide, J.I.**, Høy, T., Flueh, E. & **Thybo, H.** (2018) The crustal structure in the transition zone between the western and eastern Barents Sea. Geophysical Journal International, 214 (1), 315-330.

Sigloch, K., 2011. Mantle provinces under North America from multifrequency P wave tomography. Geochem. Geophys. Geosyst. 12.

Sigloch, K., Mcquarrie, N., Nolet, G. (2008). Two-stage subduction history under North America inferred from multiple-frequency tomography. Nat. Geosci. 1 (7), 458–462.

Straume, E. O., Gaina, C., Medvedev, S., Lacasce, J. H., Gjermundsen, A., Klocker, A., and M. Nikurashin. (2018) NE Atlantic Cenozoic paleobathymetry: oceanic gateway formation and paleo-ocean circulation. PP13E-1363, AGU 2018, Washington, USA 9-14.12.18.

Struijk, Erzsébet L.M.; Tesauro, Magdala; **Lebedeva-Ivanova, Nina N.; Gaina, Carmen;** Beekman (2018), Fred; Cloetingh, Sierd A.P.L. The Arctic lithosphere: Thermo-mechanical structure and effective elastic thickness. Global and Planetary Change.

Tan, P., Sippel, J., **Breivik, A.J.**, Meessen, C. & Scheck-Wenderoth, M. (2018) Lithospheric Control on Asthenospheric Flow From the Iceland Plume: 3-D Density Modeling of the Jan Mayen-East Greenland Region, NE Atlantic. Journal of Geophysical Research - Solid Earth 2018, 123 (10), 9223-9248.

4. Earth`s Crises: LIPs, mass extinctions and environmental changes

In the Earth Crises Team we study volcanically driven effects on the climate system and the biosphere, focussing on Large Igneous Provinces (LIPs). The Earth Crises mission is to investigate the role of volcanism in general, and sediment-derived gases in particular, on the history of life on Earth. Here we present a selection of the results, updates, and activities from 2018, focussing on four topics: 1) sill-sediment interactions in the CAMP LIP, 2) a published paper from our Master student, 3) mercury anomalies across the Paleocene-Eocene Thermal Maximum, and 4) the new VIKINGS project. In addition, we have published on related themes including CAMP and Parańa-Etendeka volcanism (De Min et al., 2018; Marzoli et al., 2018; Jerram et al., 2018), the sub-volcanic stages of the Siberian Traps (Svensen et al., 2018), and the history of LIP-related research and terminology (Svensen et al., 2019).

Sill-evaporate interactions within the CAMP

Up to 20% of the stratigraphy of the Amazonas and Solimões basins in Brazil is composed of sills emplaced as part of the Central Atlantic Magmatic Province (CAMP). Thea H. Heimdal defended her PhD thesis in December 2018 on the topic of CAMP volcanism and its role in the end-Triassic mass extinction. In a previous paper (*Heimdal et al., 2018*), she tested the hypothesis that widespread sills of the CAMP intruded in volatile-rich Brazilian sedimentary basins and released massive amounts of isotopically light carbon. In a second paper from the thesis, published in *Earth and Planetary Science Letters* in January 2019, she presented a geochemical study of 26 dolerite samples from 6 deep boreholes in the Brazilian basins, including whole-rock major and trace elements, whole-rock Sr–Nd isotopes and detailed biotite mineral chemistry.

Heimdal et al. (2019) show that there is a strong correlation between host-rock lithology and Cl concentrations in biotite from the dolerites, and interpret this to reflect large-scale crustal contamination of the low-Ti magmas by halite-rich evaporites. The findings support the hypothesis that sill-evaporite interactions increased volatile release during the emplacement of CAMP. This strengthens the case for active involvement of this LIP in the end-Triassic crisis, and suggests that the sub-volcanic part of a LIP can be of major importance in driving climate change and mass extinctions (Figure 4.1).

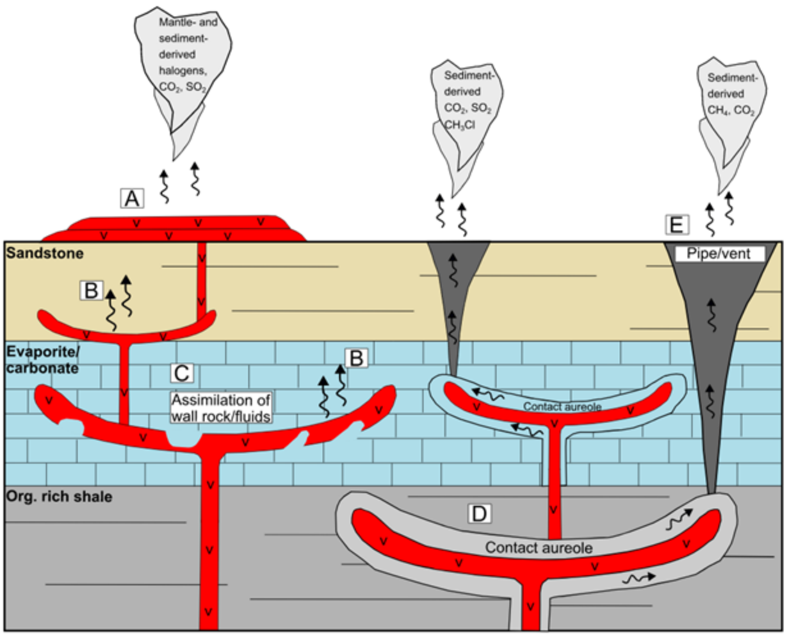


Figure 4.1 Schematic presentation of the degassing from the Solimões and Amazonas sedimentary basins (Brazil) following emplacement of the CAMP. Magma-evaporite interactions led to evaporite assimilation, resulting in elevated halogen contents in the last melt fraction crystallizing in the sills. Figure from Heimdal et al. (2019).

Published Master project about Ordovician tephras and age models Eirik G. Ballo finished his Master thesis in June 2017 and spent the next year, in between other activities, working on a paper about his results. Ballo performed zircon geochronology and cyclostratigraphy on a very well preserved section of Ordovician tephras in sedimentary rocks in Oslo. The manuscript was submitted in August 2018, accepted, and published in April 2019 in *Palaeogeography, Palaeoclimatology, Palaeoecology* (Figure 4.2).

Five of the 33 K-bentonites in the section in Oslo have been dated by high-precision chemical abrasion-thermal ionization mass spectrometry (CA-TIMS) U-Pb zircon geochronology, where the well-known Kinnekulle K-bentonite gave an age of 454.06 ± 0.43 Ma. By combining the age dating with cyclostratigraphy, Ballo made an age model showing the sedimentation rates through the section and thereby the ages of each of the 33 K-bentonites. Using the age model, *Ballo et al. (2019)* further present a new age for the Sandbian-Katian stage boundary. The section in Oslo provides the highest resolution window into the Upper Ordo-

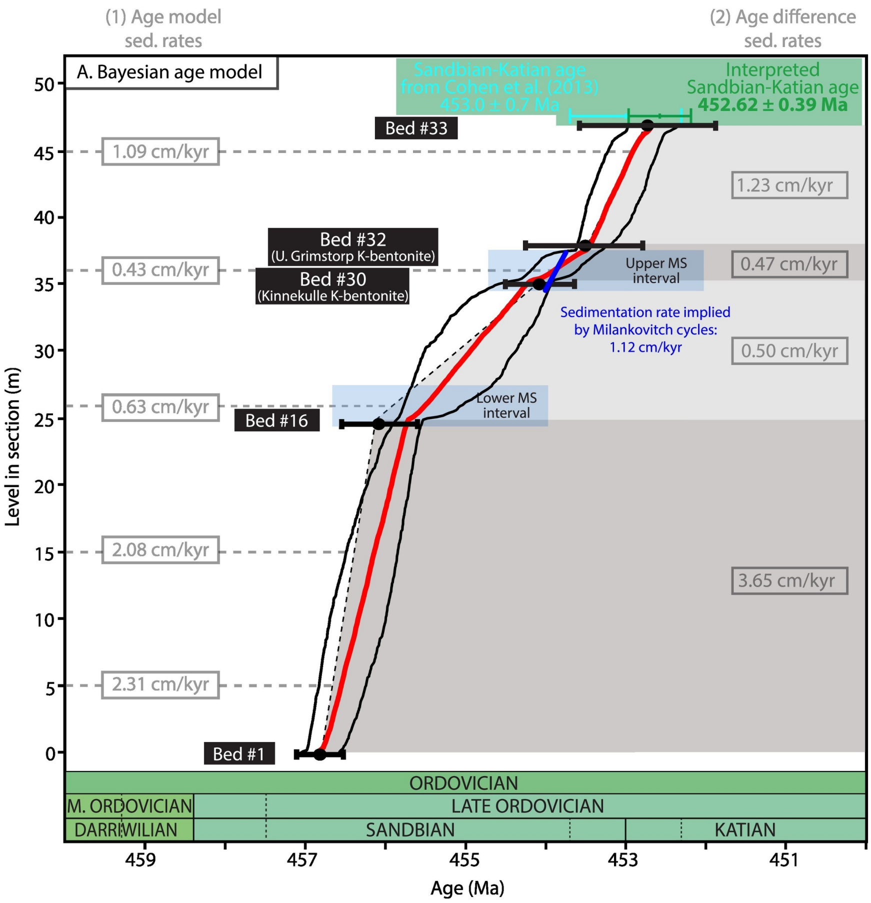


Figure 4.2. The Bayesian radiocarbon chronology package (Bchron) age model for the Sandbian aged Arnestad Formation at Sinsen (red curve). Black curves represent the upper and lower limits of 95% confidence interval. The five radiometric dated beds are shown as black dots, with 2σ error bars (horizontal black lines). Interpreted sedimentation rates from this study are included in grey boxes for two approaches: 1) Bchron age model, 2) age difference between dated levels (dashed black lines between the age anchors show linear interpolations). Ordovician stage boundaries are from the latest revision of the ICS International Chronostratigraphic Chart, Cohen et al. (2013), where the Sandbian-Katian boundary is set at 453.0 ± 0.7 Ma. Dashed lines next to the stage boundaries illustrate the uncertainties for the boundary ages. Cyclicity-derived sedimentation rate of 1.12 cm/kyr is shown in blue. From Ballo et al. (2019).

vician K-bentonite succession so far and helps shed more light on the chronology of one of the most intense volcanic periods of the Paleozoic and the relationship with the global carbon cycle changes that followed.

Mercury anomalies across the Paleocene-Eocene Thermal Maximum

The NFR-funded **ASHLANTIC** project is targeted at understanding the link between North Atlantic volcanism and the rapid climatic change during the Paleocene-Eocene Thermal Maximum. The project includes core and outcrop studies on Fur Island in Denmark, with emphasis on both stratigraphy/carbon isotopes and mercury geochemistry. In a new study *Jones et al. (2019)* have analysed five continental shelf sections located around the North Atlantic Igneous Province (NAIP) in the Palaeogene. They measured Hg concentrations, total organic carbon (TOC) contents, and $\delta^{13}C$ values to assess how Hg deposition fluctuated across the PETM carbon isotope excursion (CIE). There are huge variations in Hg anomalies between sites. The Grane field in the North Sea, the most proximal locality to the NAIP analysed, shows huge Hg concentrations in the early Eocene. Significant Hg/TOC anomalies are also present in Danish and Svalbard sections prior to the onset of the PETM and during the recovery period..

The Hg/TOC anomalies in strata deposited prior to the CIE may suggest that magmatism linked to the emplacement of the NAIP contributed to the initiation of the PETM. However, evidence for considerable volcanism in the form of numerous tephra layers and Hg/TOC anomalies post-PETM indicates a complicated relationship between LIP volcanism and climate. Processes such as diagenesis and organic matter sourcing can have a marked impact on Hg/TOC ratios and need to be better constrained before the relationship between Hg anomalies and volcanic activity can be considered irrefutable (Figure 4.3).

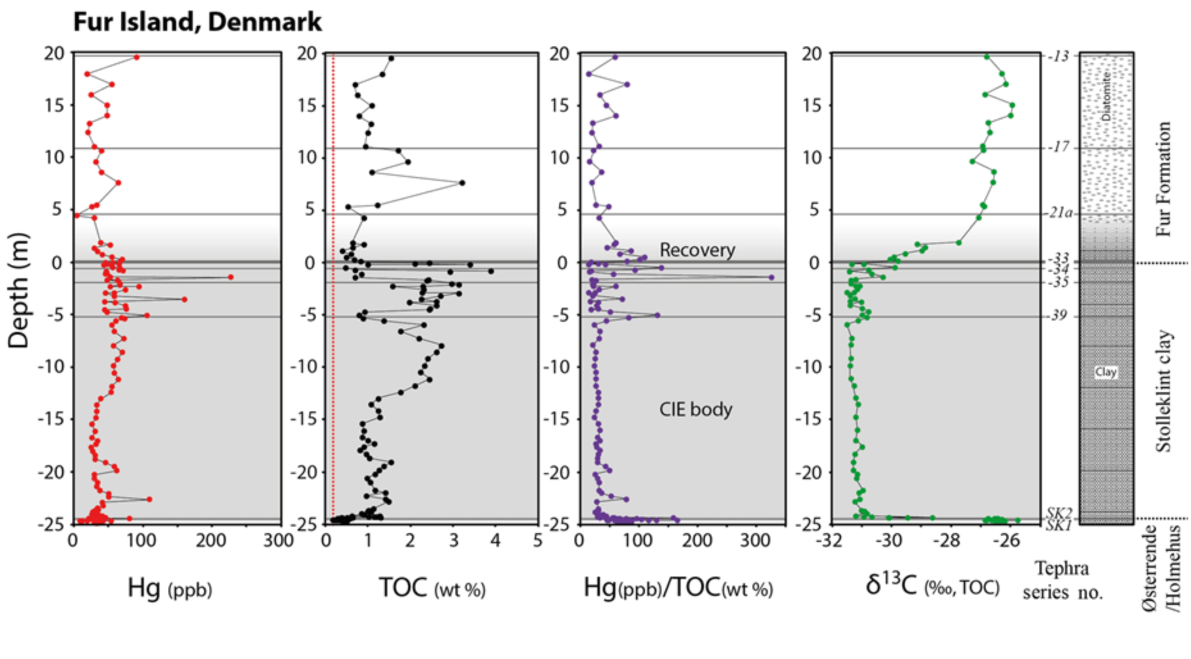


Figure 4.3. Mercury, TOC, Hg/TOC, and δ^{13}CTOC data from an expanded section of the Stolleklint beach section on Fur Island in Denmark, showing the onset of the PETM CIE. The grey shaded area shows the approximate onset and body phases of the CIE. Tephra layers SK1, SK2, and SK3 are marked at their respective depths, along with a stratigraphic log based on the beach section at Stolleklint. From Jones et al. (2019).

The VIKINGS project

The Earth Crises group is involved in the NFR/UiO funded TOPPFORSK project called **VIKINGS** (Volcanic Eruptions and their Impacts on Climate, Environment, and Viking Society in 500-1250 CE). The project is led by Prof. K Krüger (affiliated with CEED) and includes a work package led by Svensen and Jahren, involving the CEED-funded PhD student Josh Bostic, and VIKINGS-funded PhD and postdoc (Eirk G. Ballo and Manon Bajard). Bostic works on tree ring analyses, and Ballo and Bajard on lake sediment records (Figure 4.4). The VIKINGS project started 01.07.2018 and is funded for five years. The project is multi-disciplinary, including climate studies and archaeological studies, and aims to understand the role of volcanic eruptions and climate change in shaping the early history of Europe.

The period 500-1250 Common Era (CE) is characterized by natural disasters, societal unrest, Viking expansion, emerging kingship - and large volcanic eruptions evidenced by geochemical markers in natural archives. At present, we know little about the detailed climate variations in Europe and especially in Scandinavia during this period. The VIKINGS project seeks to reveal the climate of the early historic period, and resolve how volcanic eruptions and their environmental impacts facilitated societal changes during the Viking era. Lake coring started in October 2018 and was followed by high resolution stratigraphic and geochemical analyses, including core scanning XRF and CT scanning.

References

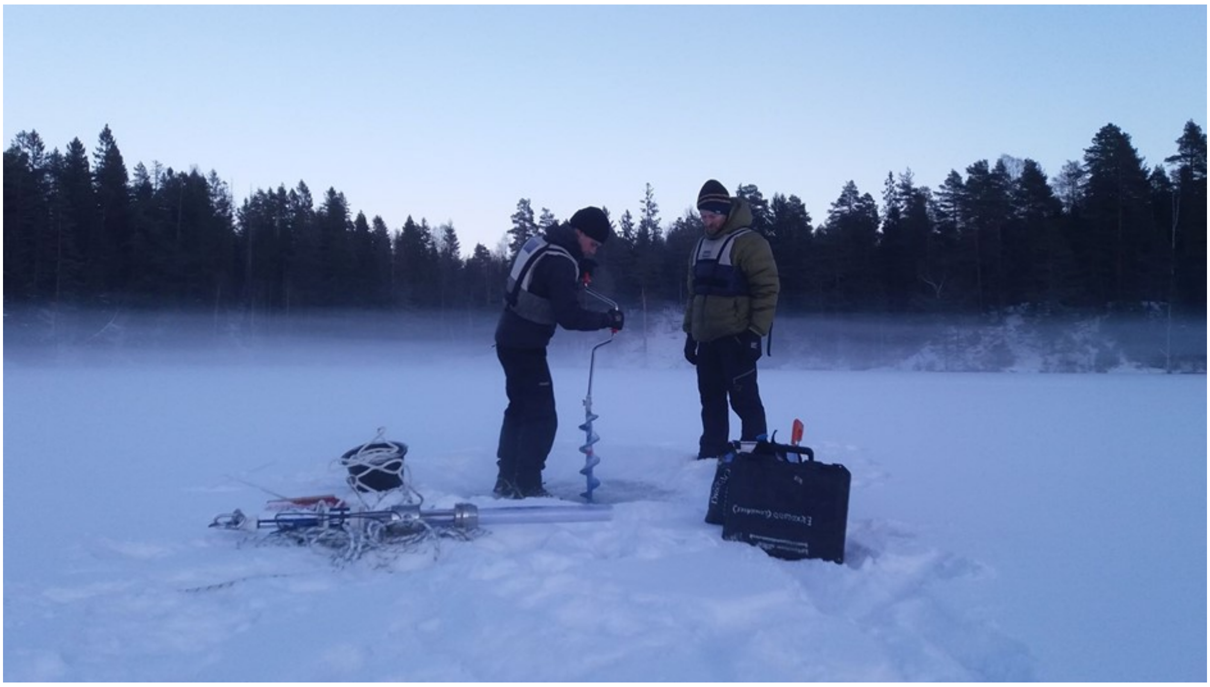


Figure 4.4. Lake coring near Asker, south of Oslo in January 2019. The project is targeting varved sedimentary archives, but finding varved lakes is difficult and involves test coring. Sediment cores, up to four meter long, are further studied and analyzed at the University of Bergen and the Earth Lab, in collaboration with Jostein Bakke and others. Other cored lakes includes Semsvann (Asker), Nordbytjern (Jessheim), Ljogottjern (Jessheim), Sagtjernet (Elverum), and Borrevannet (Horten). Varved sediments were found in several of theese lakes.

The CLIPT Stable Isotope Biogeochemistry Lab officially opened April 24, 2018 with an open house to welcome all members of CEED and the university at large, to tour the laboratory facilities. The remainder of the year was spent building a user base, in addition to setting up the highly versatile Isoprime Stable Isotope Mass Spectrometer system that was transported from the United States using CEED funds. With four peripheral instruments (an Elemental Analyzer, a dual inlet, a gas chromatograph, and an Aquaprep system), analytical capabilities were expanded to include: compound specific analysis of geologic substrates that are important for many earth history studies, including applications in the petroleum industry (such as *n*-alkanes); stable isotope analysis of natural waters; carbonates; and atmospheric gases (CO_2 and N_2). Additionally, the dual inlet provided the flexibility to prepare samples offline using non-conventional methods to address specific analytical needs that cannot be met using standardized automated analytical systems.

To date, members of the Earth Crises group within CEED have used the facility to gain stable isotope determinations upon geological substrates, specifically rock and sediment studies conducted by **Wulfsberg and Jones**. Further analyses are planned on diverse substrates ranging from fish muscle tissue (Mazzini), to micro-meteorites (Werner) to various sediment and soil (Svensen, Jakob and Planke). The CLIPT lab sees a bright future of expanding utility for multiple projects underway within CEED.

As part of the Earth Crisis group, the CLIPT lab participates in the NFR-funded project **Volcanic Eruptions and their Impacts on Climate, Environment, and Viking Society in 500-1250 CE (VIKINGS),** which began in August of 2018. The CLIPT lab's contributions to the project involve developing high-resolution climate proxies, in both tree rings and lake sediments, to detect perturbations in seasonal climate patterns following large-scale volcanic eruptions. Throughout 2018, Ph.D. student Joshua Bostic, working in concert with Henrik Svensen and Frode Iversen of the UiO Museum of Cultural History, procured samples of Norwegian Spruce from Raknehaugen, a pre-Viking age burial mound near Oslo dated to the mid-6th century. Cross-sections cut from the logs underwent dendrochrological analysis to identify rings corresponding to volcanic eruption years, with stable isotope analysis set to begin in 2019. In November 2018, CLIPT lab members also assisted CEED students Manon Bajard and Eirik Ballo with the collection of cores from two lakes near the Raknehaugen mound. Varve identification and analysis was conducted in Bergen, with geochemical and isotopic analysis set to begin in 2019.

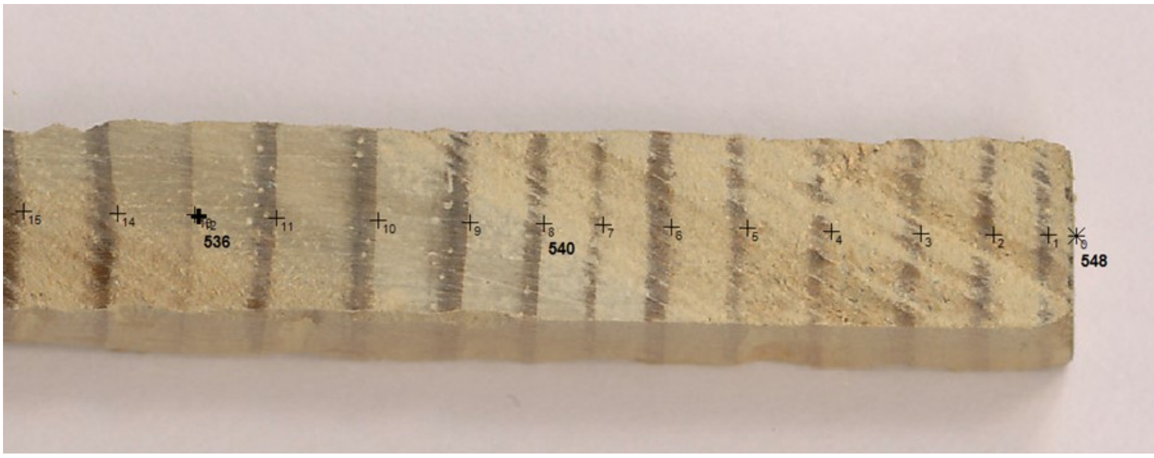


Figure 4.5. Photomicrograph of Raknehaugen wood core used to determine the tree ring corresponding to the volcanic eruption year of 536 CE.

References

Ballo, E.G., Augland, L.E., Hammer, Ø., **Svensen, H.H.** (2019) A new age model for the Ordovician (Sandbian) K-bentonites in Oslo, Norway. *Palaeogeography, Palaeoclimatology, Palaeoecology*, https://doi.org/10.1016/j.palaeo.2019.01.016.

Heimdal, T.H., Svensen, H.H., Ramezani, J., Iyer, K., Pereira, E., Rodrigues, R., **Jones, M.T., Callegaro, S.** (2018) Large-scale sill emplacement in Brazil as a trigger for the end-Triassic crisis. *Scientific Reports* 8, Article number: 141.

De Min, A., **Callegaro, S.,** Marzoli, A., Nardy, A., Chiaradia, M., Marques, L.S., Gabbarini, I. (2018) Insights into the petrogenesis of low- and high-Ti basalts: Stratigraphy and geochemistry of four lava sequences from the central Paraná basin. Journal of Volcanology and Geothermal Research 2018, Volume 355. s. 232-252.

Heimdal, T.H., Callegaro, S., Svensen, H.H., Jones, M.T., Pereira, E., **Planke, S.** (2019) Evidence for magma–evaporite interactions during the emplacement of the Central Atlantic Magmatic Province (CAMP) in Brazil. *Earth and Planetary Science Letters* v. 506, 476-492.

Iyer, K., **Svensen, H.H.**, Schmid, D. W. (2018) SILLi 1.0: A 1D Numerical Tool Quantifying the Thermal Effects of Sill Intrusions. *Geoscientific Model Development*, https://doi.org/10.5194/gmd-2017-132.

Jones, M.T., Percival, L.M.E., **Stokke, E.W.,** Frieling, J., Mather, T.A., Riber, L., Schubert, B.A., Schultz, B., Tegner, C., **Planke, S., Svensen, H.H.** (2019) Mercury anomalies across the Palaeocene-Eocene Thermal Maximum. *Climate of the Past*, 15 (1), 217-236.

Marzoli, A., **Callegaro, S**., Dal Corso, J., Davies, J.,H.F.L., Chiaradia, M., Youbi, N., Bertrand, H., Reisberg, L., Merle, R., Jourdan, F. (2018) The Central Atlantic Magmatic Province (CAMP): A Review. I: The Late Triassic World - Topics in Geobiology. Springer 2018 ISBN 978-3-319-68009-5.

Svensen, H.H., Frolov, S., Akhmanov, G.G., Polozov, A.G., **Jerram, D.A**., Shiganova, O.V., Melnikov, N.V., Iyer, K., **Planke, S.** (2018) Sills and gas generation in the Siberian Traps. Phil. Trans. R. Soc. A 376 20170080; DOI: 10.1098/rsta.2017.0080.

Svensen, H.H., Jerram, D.A., Polozov, A.G**., Planke, S.,** Neal, C.R., **Augland, L.E.,** Emeleus, H.C. (2019) Thinking about LIPs: A brief history of ideas in Large igneous province research. *Tectonophysics*, https://doi.org/10.1016/j.tecto.2018.12.008.

5. Earth and Beyond: Comparative Planetology

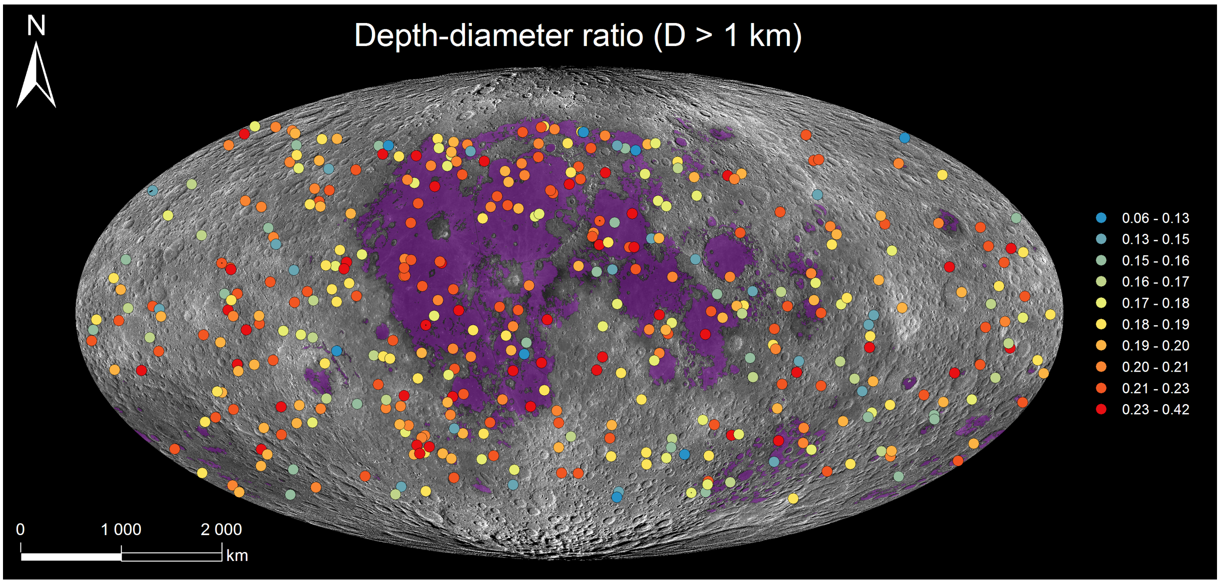
Earth and Beyond Team focuses on similarities and differences between Earth and other terrestrial planets, and why Earth may have always been the only planet with plate tectonics. In 2018 the group described why the surface of Venus recently (~600 Ma ago) got rejuvenated, used crater formation to model the properties of rocks that may be found under the Moon´s dusty surface, and discovered the last clue for Mars´s climate change by using numerical methods and experimental and remote sensing data.

Terrestrial planet evolution from far and very close, now and in deep time

To decipher the planetary surface evolution, geologic events are dated relatively, based on crater counts. This method has been calibrated on the Moon and adapted to other planetary bodies. A good calibration on the Moon is thus a valuable key to understand the chronology of all solid surface planetary bodies. Crater counts are linked to isotopically-dated Apollo and Luna samples, which provides calibrated absolute model ages (AMA). The observed crater size frequency distributions (CSFD) on defined surface units are fit with crater production functions. These are used to derive crater density measurements, which currently have resulted in several lunar chronology models. Several problems have risen regarding this method such as the uncertainty in linking returned samples and their source terrains for crater counting and used as templates. We study near infra-red images to define homogeneous units and re-determined the crater size frequencies of each Apollo and Luna landing sites to re-vise traditional lunar cratering chronology models, which should lead to re-evaluate the ages of planetary surfaces of the entire inner Solar System (Bultel et al, 2018).

Modelling of crater formation with different target properties

An important challenge in impact crater formation numerical modelling is that the geometry of a specific impact crater is ambiguous in setups and parameters. Because the crustal and material properties of planetary bodies are poorly constrained the question to whether or not the chosen numerical setup and parameters are the most adequate is difficult to answer without additional information. In order to develop a robust numerical model setup, a large number of fresh impact craters (craters that experienced very little erosion) in the database compiled by Werner & Medvedev (2010) are used. Morphological parameters (such as the depth-diameter ratio, see Figure 5.1) have been computed for those observations and are currently



being compared to the most common numerical model setups used in the cratering community. This step will help us in selecting a model setup that reflects the morphology of observed lunar and Martian craters for crater with diameters spanning a large interval (from few meters up to kilometer-size impacts) and provide the fundaments in order to test the influence of target properties on the cratering statistic method. (*Prieur et al., 2019, Werner et al., 2018*).

Mars close up and at a distance

The Planetary Terrestrial Analogues Library (PTAL) has the ultimate goal is to build a multi-instrument spectral database that will enable thorough interpretation of remote-sensing data collected, among others, to constrain the history of water on Mars and potential martian habitability. Many terrestrial environments may be considered analogues for martian ones, but in many aspects fluid-atmosphere-rock interactions on the surface of Mars differ from the Earth and no corresponding terrestrial analogues can be found. Therefore, our goal is to enhance the definition of these environmental differences by studies of meteorites, that host fluid alteration minerals (Figure 5.2) and to determine the key parameters responsible for reconstructed alteration pathways by laboratory experiments under controlled conditions. Hydrothermal laboratory experiments help understand the formation of martian clay minerals, sources of fluids for alteration and ultimately address potential habitability of such environments. (*Prieur et al., 2018; Werner et al., 2018*).

Early Mars water-rock interactions and planetary surfaces evolution

Noachian surfaces on Mars exhibit vertical assemblages of weathering horizons termed as weathering profiles; this indicates that surface water caused alteration of the rocks which required a different, warmer climate than today. Evidence of this early martian climate with CO2 vapor as the main component causing greenhouse warming has been challenged by the lack of carbonate in these profiles. We report the analysis of near-infrared data leading to the detections of carbonates using a spectral signature exclusively attributed to them. The car-

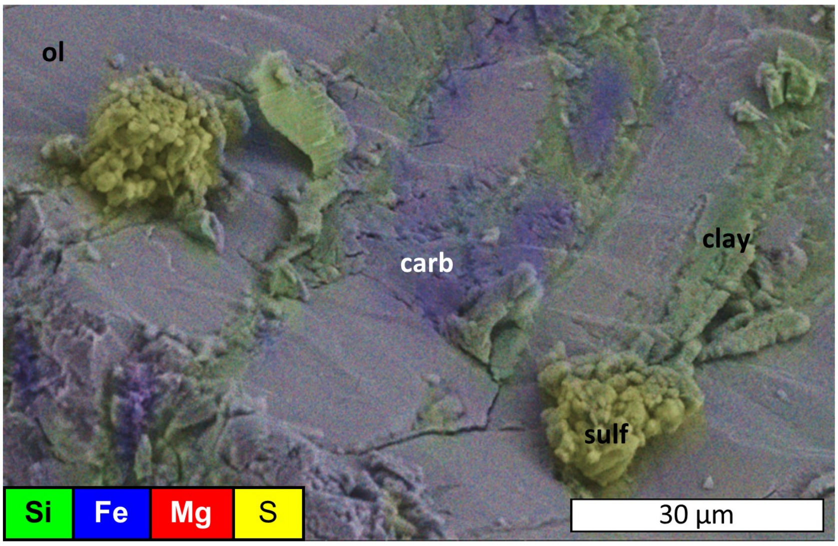


Figure 5.2 (above). Example of a meteorite that hosts fluid alteration minerals.

Figure 5.1(left). Crater morphologies on the lunar surface such as the depth-diameter ratios provide more constraints to test our impact numerical models. Locations and depth-diameter ratios of fresh simple craters from this study. The surface of the Moon is Mollweide projected. The background image is a global WAC image (NASA/GSFC/Arizona University).

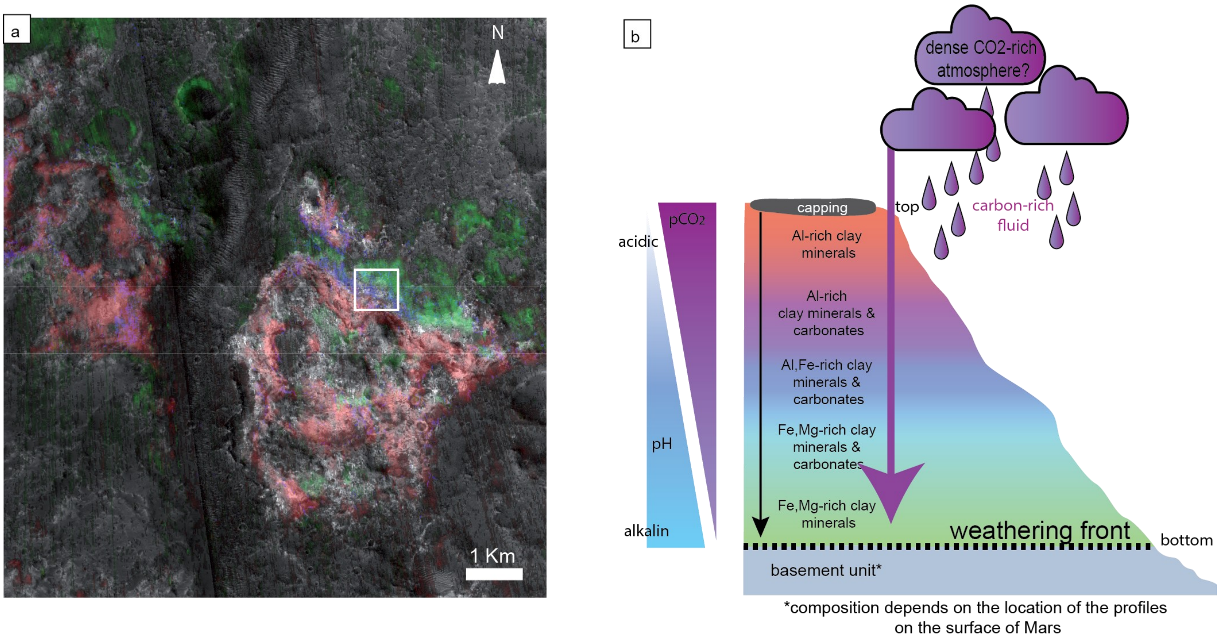


Figure 5.3. Left: CTX mosaic on Mawrth Vallis with overlapping CRISM image FRT00003BFB to visualize the mineralogy. Right: Sketch (not at the scale) of the weathering profile. The evolution trend from top to bottom of pH and pCO2 is shown. The dotted line indicates the weathering front between the Fe,Mg-rich clay minerals horizon and the basement. The black arrow symbolizes the progression of the weathering front. The droplets symbolize the percolation of the fluid through the weathering profile. The clouds symbolize a denser than today CO_2-rich atmosphere.

bonates are collocated with hydrated minerals in weathering profiles over the martian surface. The origin of CO_2 for the formation of carbonates could be the atmosphere. The widespread distribution of weathering profiles containing carbonates over the surface of the planet testifies of large scales interactions between fluids containing carbonic acid (pCO_2 >0.1) with the surface of Mars in the presence of atmospheric water until around 3.7 billion years ago (Figure 5.3; *Krezinska et al., 2018*).

Venus' surface tells about her convecting interior

Despite its similarities in size and bulk density to Earth, Venus' geodynamic evolution has been under long debate. There is a clear sparsity in the knowledge about Venus' interior and its complex surface geology. Several past studies suggested that the surface has recycled at least ~ 0.3 to 1 Ga ago. This last recycling event has been suggested to possibly have occurred through continuous magmatic resurfacing or by a whole mantle overturn events, which occur episodically. In either case, Venus presently attained a stagnant mode with a very young surface, whose global mean surface age is estimated as ± 500 Myr. This age estimate comes from the impact crater studies which also led to the assumption of near uniform global surface age. We computed global mantle convection models of Venus with an objective of reproducing young surface age distributions matching the observations. The surface age is generated self-consistently from 3D numerical models featuring both volcanic and resurfacing by overturn events. Result from these models, show that stagnant lid models have often kept the mean surface age globally as young as 250 ± 150 Myr with in a range of 100-500 Myr. In case of episodic lid models where the resurfacing is by overturn events produced age

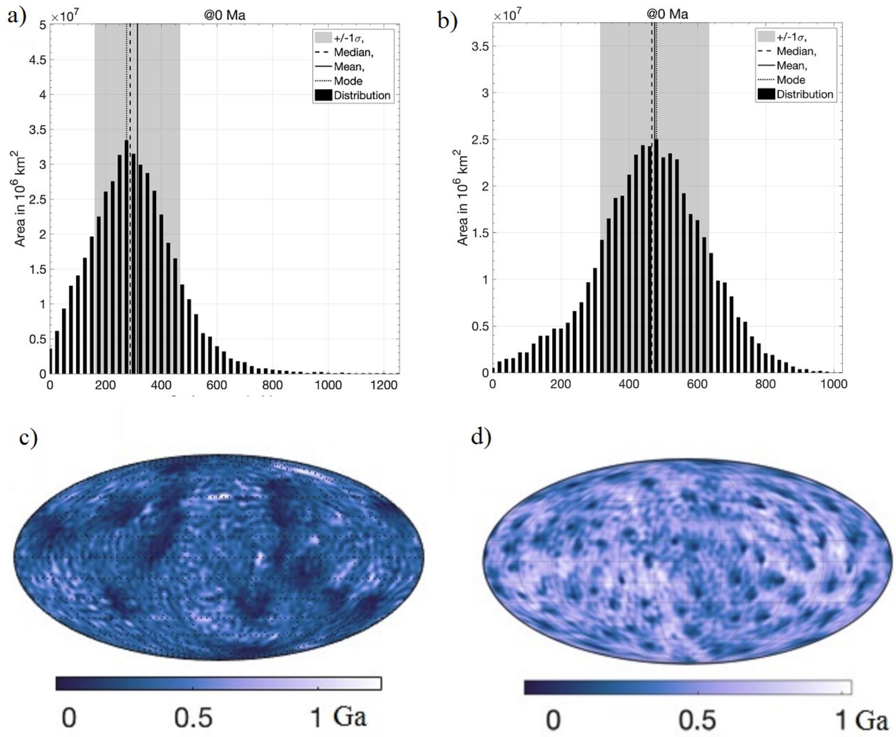


Figure 5.4. (shows a) & (c) the stagnant lid and (b) & (d) the episodic lid cases where (a) & (b) shows the histograms of surface age and (c) & (d) their spread globally at the final snapshot of model evolution in Mollweide projection.

ranges from 300-650 Myr with mean surface age at ±500 Myr (Figure 5.4). We also computed models to investigate the roles of mantle viscosity, melt eruption and internal heating rates. In episodic cases, increasing yield stress is revealed to have a greater influence in causing overturn events and has direct effect over global mean surface age distributions.

Using available surface observation data, geologic mapping is carried out to estimate the area covered by volcano-tectonic structures, plains, and tesserae. Tessera units are long debated to have survived the last overturn or recycling event. We also computed numerical models by implementing cratons to represent tesserae to understand their role on interior dynamics. By using the amount of tesserae obtained from the geologic mapping, model results can help in understanding their role in surface and mantle dynamics, especially in linking the chronological classification of various geologic landforms and the timing of resurfacing events. Furthermore, this study can be extended to understand the role of tesserae structures and their role in the Venusian dynamic evolution (*Rolf et al., 2018. Bultel et al., 2019*).

Venus' mantle dynamics modelling constrained by observed gravity and topography

One of our new projects, **PLATONICS** an NFR-funded Young-Talents grant, further bridges the gap between interior planetary dynamics and its surface expressions across different bodies of our solar system, focussing on the Earth, Venus, and one of Jupiter's icy moons with active surface tectonics, Europa (Figure 5.5; *Uppalapati et al., 2019*).

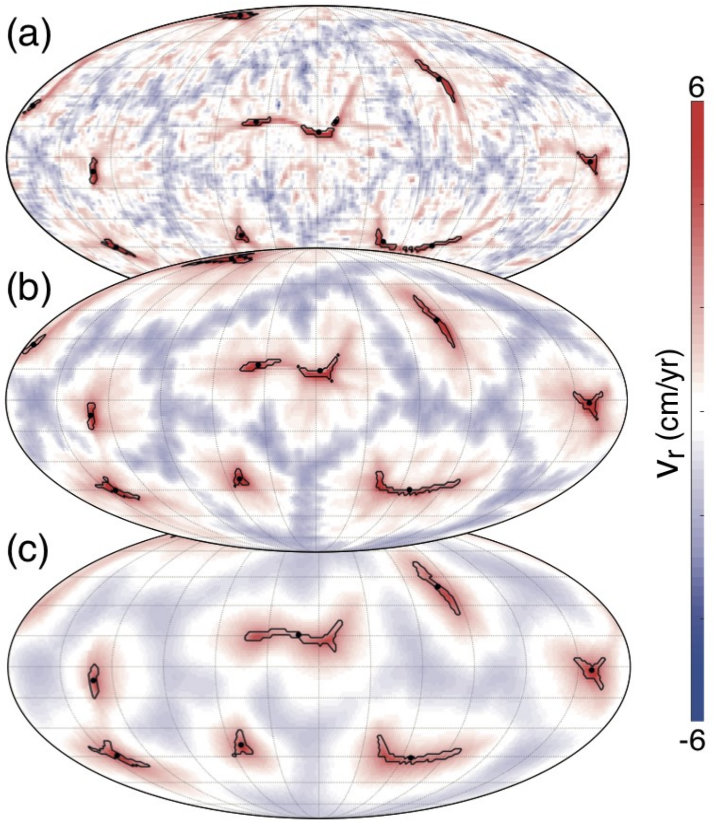


Figure 5.5. Mantle cross section of radial velocity in one of the published models of Venus' mantle dynamics. Red colour indicates upward, blue colour downward flow. Black contours surround the major upwelling regions, the black dots denotes the centroids of those. Their number in the model is in line with constraints from thermal emissivity observations on Venus' surface. The panel (a)-(c) correspond to three different depths, 590, 950, 1840 km below the surface.

References

Bultel, B., J.-C. Viennet, F. Poulet, J. Carter, **S. C. Werner** (2019) Detection of carbonates in martian weathering profiles. Journal of Geophysical Research - Planets , accepted.

Bultel, B.; Werner, S.; Fernandes, V. A. ; **Rolf, T**. (2018) Spectral mapping and crater statistics reevaluated for all Apollo landing sites. 20th EGU General Assembly, EGU2018, Vienna, Austria, p.17492

Krzesinska, A.M. et al, 2018: Constraining the Nature of Fluid Alteration Events in the Martian Subsurface Using Trace Element Signatures in Nakhlites. Meteoritics & Planetary Sciences 53, 6260-6260 (abstract)

Prieur, N. C.; Rolf, T.; Werner, S. (2018) Testing impact numerical model setups for simple craters. European Planetary Science Congress 2018, Berlin, Germany, id.EPSC2018-889 Werner, S.C., S. Medvedev (2010) The Lunar rayed-crater population – Characteristics of the spatial distribution and ray retention, Earth and Planetary Science Letters, 295 (1-2), 147-158.

Prieur, N. C.; Werner, S. C. (2019) Constraining impacts numerical model parameters with the help of fresh simple craters on the Moon. 50th Lunar and Planetary Science Conference 2019 (LPI Contrib. No. 2132)

Rolf, T., B. Steinberger, U. Sruthi, S.C. Werner (2018) Inferences on the mantle viscosity structure and the post-overturn evolutionary state of Venus. Icarus 313, 107–123

Sruthi, U., T. Rolf, F. Crameri , S.C. Werner (2019) The Role of mantle dynamics in the Rejuvenation of Venus' surface: Insights from Numerical modelling. 50th Lunar and Planetary Science Conference 2019 (LPI Contrib. No. 2132)

Werner, S. C.; Bultel, B.; Fernandes, V. A.; **Rolf, T.** (2018) Lunar Cratering Chronology - Review and Revision. American Geophysical Union, Fall Meeting 2018, Washington, USA,abstract #P23E-3488

Werner, S.C., S. Medvedev (2010) The Lunar rayed-crater population – Characteristics of the spatial distribution and ray retention, Earth and Planetary Science Letters, 295 (1-2), 147-158.

Werner, S.C.; and the **PTAL Team (**2018) The Planetary Terrestrial Analogues Library (PTAL) Second International Mars Sample Return, Proceedings of the conference held 25-27 April, in Berlin, Germany. LPI Contribution No. 2071, id.6060

6. Earth Laboratory

The Earth Laboratory Team uses paleomagnetism as an investigative tool for constraining the Earth's paleogeography, studying the history of the geomagnetic field, and developing absolute full-plate kinematic models for the motion of lithospheric plates in the geologic past.

In 2018, the Earth Laboratory team conducted several research projects aimed to generate new, high-quality paleomagnetic datasets and integrate paleomagnetic data with other geological and geophysical observations to develop full-plate paleogeographic reconstructions for the last 600 million years of the geologic history. Our researchers (Doubrovine, Kulakov) led two large collaborative studies, which were carried out in cooperation with colleagues from the UK, Finland, Ecuador, Estonia and the USA, with the aim to investigate the stability and intensity of the geomagnetic field in Mesozoic time and relate these observations to the fundamental properties of the Earth's magnetic dynamo, such as the frequency of geomagnetic reversals. Three fieldwork trips were organized for collecting new paleomagnetic materials in northern Norway (Finnmark), Russia (central Siberia) and northern China (Shnaxi province). The team members published 9 research articles in peer-reviewed scientific journals (one of them in Nature Scientific Reports, *Domeier et al., 2018*) and authored 12 conference papers that were presented at the annual meetings of the European Geosciences Union (EGU) and the American Geophysical Union (AGU). Dr. Mathew Domeier was awarded by the Reusch Medal 2018 from the Norwegian Geological Society in recognition of his contributions to the development of Paleozoic full-plate paleogeographic reconstructions.

Table 6.1. Summary of research projects for 2018

*Paleomagnetism of Mesozoic and Precambrian diabase dikes from southwestern Greenland: implications for paleogeographic fits and true polar wander (*Evgeniy Kulakov, CEED; Justin Tonti-Fillipini, Erasmus+ PhD student, Univ. Iceland)
*Baltica and Laurentia during the assembly of Rodinia: Paleomagnetic constraints from southern Norway (*Evgeniy Kulakov, CEED*)*
Precambrian paleomagnetism of northern Norway (Evgeniy Kulakov, CEED; Justin Tonti-Fillipini, Erasmus+ PhD student, Univ. Iceland)
*Latitude dependence of geomagnetic secular variation in the Cretaceous and Jurassic and its relationship with the frequency of magnetic reversals (*Pavel V. Doubrovine and Evgeniy Kulakov, CEED)
*Intensity of the geomagnetic field in the Cretaceous and Jurassic: Implications for the long-term history of Mesozoic geodynamo (*Evgeniy Kulakov and Pavel V. Doubrovine, CEED)
Paleomagnetism of 510 Ma Kalkarindji large igneous province from northwestern Australia (Mathew Domeier, CEED)
The Triassic Nicola Group and Cretaceous Spences Bridge Group from western Canada: Paleomagnetic records and implications for the tectonics of the North American Cordillera (Mathew Domeier, CEED)
Refining the Permian position of Africa with paleomagnetic data from the volcanics of Morocco (Mathew Domeier, CEED)
Paleomagnetism and dating of Neoproterozoic sediments in Northeast Svalbard (Hans Jørgen Kjøll, PhD student at CEED)
*Age and environmental evolution of early syn-rift stratigraphy, Corinth Rift, Greece (*Gauti T. Eliassen, UiB, visiting)
Paleomagnetism and magnetic fabric of shallow igneous intrusions from the Early Cretaceous Diabassoden suite, Svalbard (Erik Halvorsen, UiB, visiting)

The national geomagnetic facility is hosted by CEED in partnership with the UiB, NTNU, and the Geological Survey of Norway (NGU), and has been run and maintained by the Earth Laboratory team since 2016, with support from the Research Council of Norway (NFR). In accordance with the plans for operating the Norwegian national research infrastructure for geomagnetism, paleomagnetism and rock magnetism (the Ivar Giæver Geomagnetic Laboratory, IGGL), two research visits by scientists from the University of Bergen (UiB) were organized and conducted at the IGGL. Below is a brief synopsis of the most important outcomes of our 2018 activities. The full list of research projects conducted by or with assistance of the Earth Laboratory team is given in Table 6.1.

Paleomagnetism

Paleomagnetic study of Mesozoic coast-parallel dykes of southwestern Greenland

It is a well-known and still unresolved problem that the Jurassic to Early Cretaceous segments of paleomagnetically-derived paths of apparent polar wander (APWP) for North America (Laurentia) and Eurasia show a clear discrepancy when they are corrected for the relative motion between the two continents. Paleomagnetic poles from coeval Early Cretaceous-Jurassic rocks of North America and Eurasia differ significantly, with North American poles characterized by shallower pole latitudes. The APWP mismatch cannot be resolved by correction for inclination shallowing or using different plate circuits. One of the possible explanations for the observed discrepancy is that paleomagnetic data from North America have been possibly affected by younger remagnetizations and/or tectonic rotation. In an attempt to resolve this problem, paleomagnetic study of samples from Late Jurassic to Early Cretaceous coast-parallel mafic dykes exposed in SW Greenland (part of Laurentia) was carried out. Paleomagnetic samples have been subjected to a step-wise thermal and alternating field demagnetization which yielded well-defined directions of characteristic remanent magnetization. A primary nature of the characteristic remanence is supported by positive baked-contact tests and the presence of paleomagnetic directions of both polarities that pass a reversal test. Our results indicate that the paleomagnetic pole for Greenland has higher latitude than the coeval North American poles and plots closer to the APW path for Eurasia (Figure 6.1). This observation does not support a hypothesis of a rapid true polar wander episode with magnitude of over 20 degrees at ~150-145 Ma. The preliminary results of this study have been reported at the General Assembly of the European Geosciences Union 2018 in Vienna, Austria

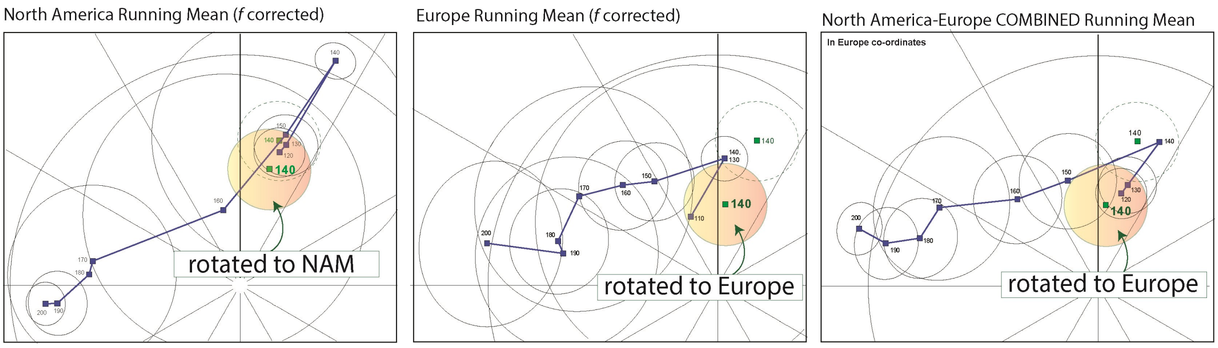


Figure 6.1. Jurassic trough Early Cretaceous segments of apparent polar wander paths for North America (left) and Eurasia (center) of Torsvik et al. (2012) compared to the ~140 Ma pole from dykes of SW Greenland (green square with orange-shaded 95% uncertainty region) rotated to North America and Eurasia, respectively. The right panel shows the comparison with a synthetic APWP combining the poles from North America and Eurasia in European coordinates (Kulakov et al., 2018a).

(*Kulakov et al., 2018b*) and the work on the analysis of paleomagnetic and rock-magnetic data from dykes of SW Greenland will continue in 2019 and will be finalized by the end of the year.

Paleosecular variation in the Cretaceous and Jurassic and its relationship with the frequency of geomagnetic reversals

Changes in the Earth's magnetic field have led to numerous polarity reversals in the geologic past, causing the field directions over the entire Earth to be opposite to those observed today. More subtle changes during periods of stable field polarity are referred to as "secular variation." In paleomagnetic studies, the level of field variability is commonly estimated by the directional dispersion of remanent magnetization vectors in rapidly-cooled igneous rocks (lavas and shallow intrusions), or by the dispersion of virtual geomagnetic poles (VGPs) corresponding to these directions. Estimates of paleosecular variation (PSV) derived from geologically recent lavas (0-5 Ma) showed that the dispersion of VGPs has systematically varied with latitude during this period, being approximately twice lower at the equator compared to high latitudes. Further analyses of PSV extending back to the Early Jurassic suggested that there existed a link between the latitude variation of VGP dispersion and the frequency of geomagnetic reversals, and hence that the latitude behavior of PSV can be used as a proxy for assessing the stability of geomagnetic dynamo process with regard to its propensity to produce reversals.

In this study, we have compiled a new paleomagnetic database from rapidly-cooled igneous rocks that were specifically selected to obtain reliable PSV estimates in Late Cretaceous through Jurassic time, allowing us to compare the latitude dependence of PSV during time intervals characterized by drastically different frequencies of geomagnetic reversals. Specifically, we compared the latitude patterns of PSV for a long interval of stable polarity in the

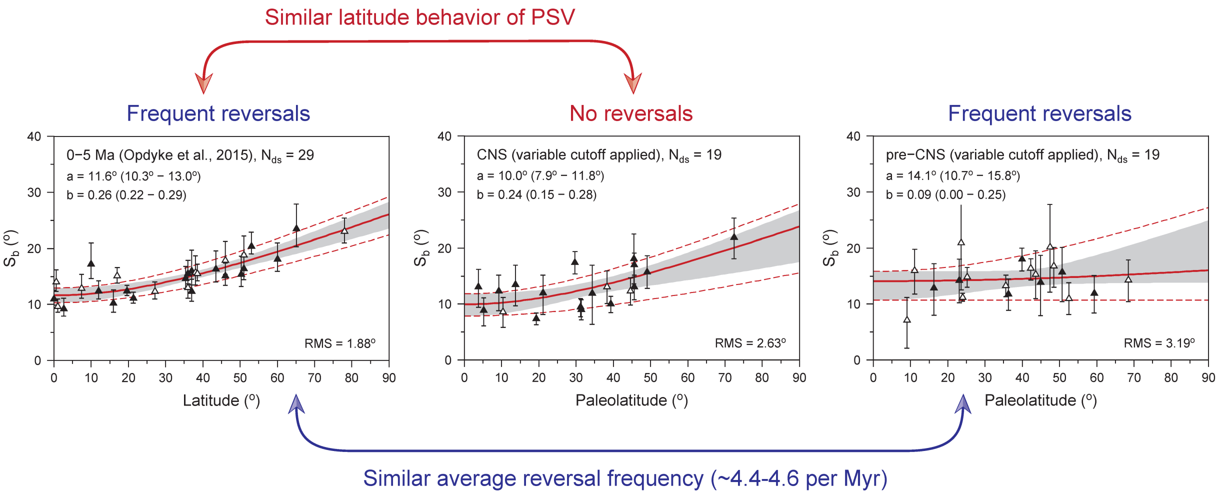


Figure 6.2. Latitude dependence of PSV estimated by the angular dispersion of VGPs (Sb) for 0-5 Ma (left, data from the compilation of Opdyke et al. (2015)), the Cretaceous Normal Superchron (84-126 Ma, center) and the preceding Early Cretaceous-Jurassic interval (126-198 Ma, right) (Doubrovine et al., 2019). Black and white triangles show the individual PSV estimates from rock formations paleogeographically located in the northern and southern hemispheres, respectively. Red solid curves show the fits of Model G of McFadden et al. (1991) that describe the overall patterns of latitude variation. Red dashed lines correspond to the 95% uncertainties of Model G parameters; gray-shaded fields show the true 95% confidence regions, which take into account the covariance of model parameters.

Cretaceous (the Cretaceous Normal Superchron, CNS, 84-126 Ma) and the preceding Early Cretaceous-Jurassic interval (pre-CNS, 126-198 Ma), during which geomagnetic reversals were frequent (average reversal frequency of ~4.6 Myr-1). We found that the CNS was characterized by a strong increase in the VGP angular dispersion with latitude, whereas the VGP dispersion for the pre-CNS period was nearly invariant as a function of latitude (Figure 6.2). However, a comparison with the PSV behavior for the last 5 or 10 million years (average reversal frequency of ~4.4-4.8 Myr-1) showed that the latitude invariance of VGP scatter cannot be considered as a characteristic feature of a frequently-reversing field, and that a strong increase in VGP dispersion with latitude was not restricted to the long periods of stable polarity (Figure 6.2). We also showed that the existing models describing the latitude dependence of PSV do not provide reliable proxies for the reversal frequency and should not be used to make inferences about the geomagnetic field stability. **The latitude-invariant PSV behavior during the pre-CNS interval suggests that the geodynamo may have operated in a regime characterized by a high degree of equatorial symmetry. In contrast, more asymmetric geodynamos suggested for 0-10 Ma and the CNS were evidently capable of producing a very wide range of reversal frequencies.** A paper describing the results of this study has been accepted for publication in Geochemistry, Geophysics, Geosystems (*Doubrovine et al., 2019*).

Variations in the intensity of geomagnetic field in the Mesozoic

A new global paleointensity database for 65-200 Ma was compiled and analyzed using a modified suite of paleointensity quality criteria (QPI) such that the likely reliability of measurements was assessed objectively and as consistently as possible across the diverse dataset. This interval was chosen because it includes dramatic extremes of geomagnetic polarity reversal frequency ranging from greater than 10 reversals per million years in the Jurassic hyperactivity period (JHAP, 155-171 Ma) to effectively frequency zero during the Cretaceous Normal Superchron (CNS, 84-126 Ma). Our analyses indicate that independent of the selection criteria applied, data consistently exhibit the strongest median virtual dipole moment (VDM) values during the CNS (Figure 6.3 next page). In addition, the CNS and JHAP are characterized by the highest and lowest percentage of VDMs exceeding the overall median for the 65-200 Ma interval, respectively. **These observations suggest that the superchron dynamo was able to generate stronger fields than the dynamo operating in the frequently reversing regime. While the precise mechanism remains unclear, our results are compatible with the hypothesis that field strength and reversal rate variation are controlled by changes in core-mantle boundary thermochemical conditions.** The results of this study have been presented at the Fall Meeting of the American Geophysical Union Fall Meeting 2018 in San-Francisco, CA, USA (Kulakov et al., 2018), and have been submitted for publication to the Journal of Geophysical Research (*Kulakov et al., submitted*).

Paleogeography and Plate Tectonics

Reconsidering the Grenville-Sveconorwegian-Sunsas link in Rodinia reconstructions

The Grenville, Sveconorwegian, and Sunsas orogens are typically inferred to reflect collision between Laurentia, Baltica, and Amazonia at ca. 1.0 Ga, forming a central portion of the Rodinia supercontinent. This triple-junction configuration is often nearly identical in otherwise diverse Rodinia reconstructions. However, available geological data suggest that although the Grenville and Sveconorwegian provinces shared a similar tectonic evolution from

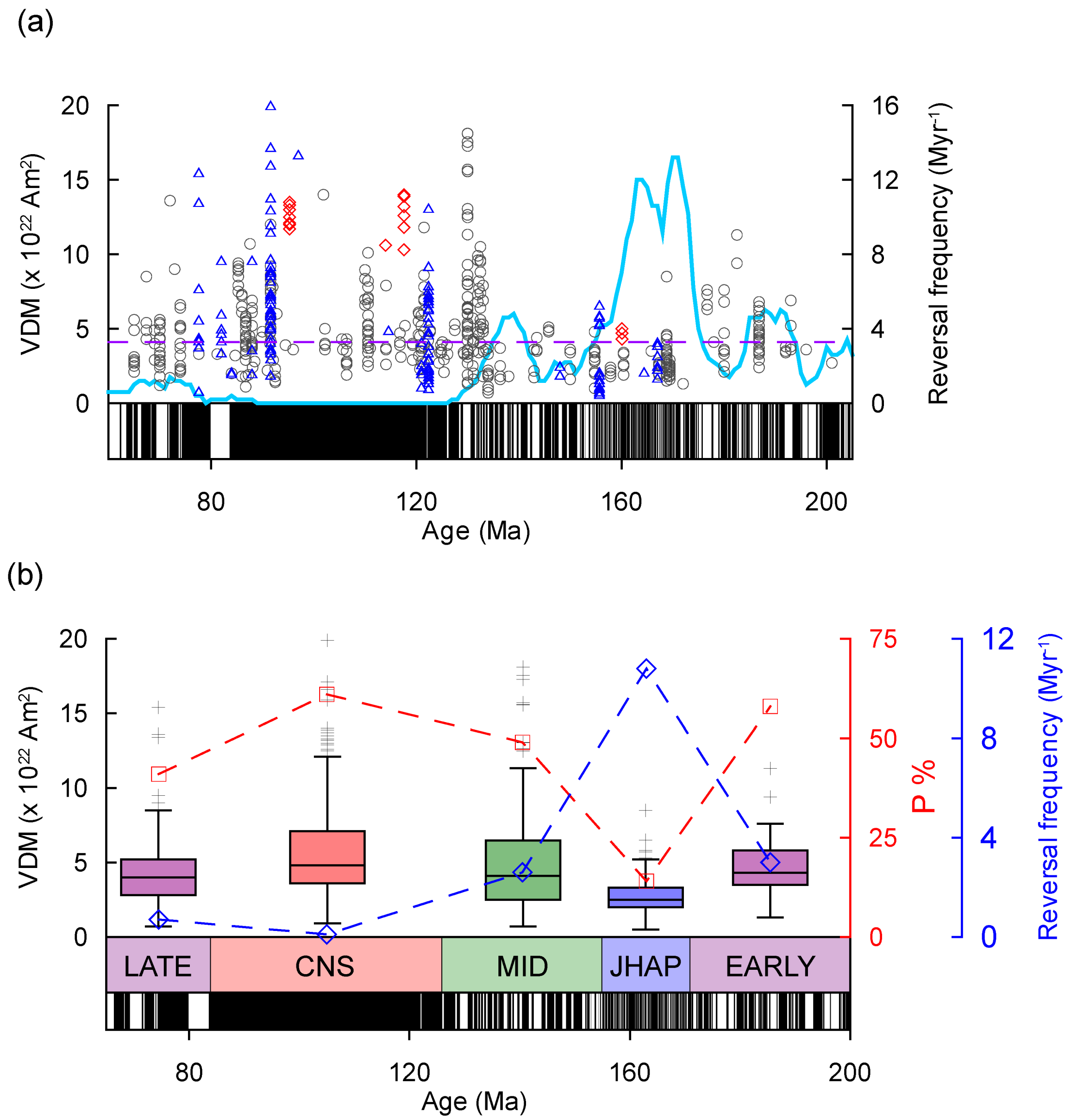


Figure 6.3. Paleointensity data for 65-200 Ma expressed as values of Virtual Dipole Moment (VDM). (a) Site-mean VDMs based on analyses of bulk rocks (grey circles), submarine basaltic glass (SBG; blue triangles), and single silicate crystals (red diamonds). The light blue curve shows the average reversal frequency calculated with a 5 Ma sliding window. The geomagnetic polarity timescale (Ogg, 2012) shows the normal/reverse polarity as black/white bars. (b) Box plot for data within the selected time bins (EARLY: 200-171 Ma; the Jurassic hyperactivity period, JHAP: 171-155 Ma; MID: 155-126 Ma; the Cretaceous Normal Superchron, CNS: 126-84 Ma; and LATE: 84-65 Ma). Horizontal lines are median VDM values, color boxes show the interquartile range (IQR), error bars show the full range excluding outliers (black crosses). Outliers are defined as being more than ±1.5 IQR outside of the box. Blue open diamonds indicate the average reversal rate for the selected time bins. Red open squares show the percentage (P%) of VDM values exceeding the overall 65-200 Ma median for individual time bins.

pre-1.8 to ca. 1.3 Ga, they record distinctly different tectonic histories leading up to, during, and following Grenville–Sveconorwegian orogenesis. Whereas Grenvillian tectonic evolution likely ended in collision with Amazonia at 1.1–1.0 Ga, Sveconorwegian orogenesis is interpreted to have ended when the active continental margin retreated to a more outboard position at ca. 0.9 Ga. From then on, active-margin processes continued as the Valhalla orogeny and this long-lived evolution can be traced until the Iapetus ocean opening at ca. 0.6–0.55 Ga (Figure 6.4 next page). Our interpretations suggest that most published Rodinia reconstructions and evolutionary models need to be revised and illustrate the power of considering both pre- and post-orogenic evolution when correlating orogenic systems in supercontinent reconstructions, requiring an understanding of different systems both prior to and following the onset of an orogenic event. A manuscript describing these findings has been submitted for publication in Geology (*Slagstag et al., submitted*).

Full-plate paleogeographic reconstructions for the Paleozoic and the latest Neoproterozoic

Full-plate paleogeographic models (e.g., *Domeier and Torsvik, 2019*) can provide key input for linking the evolution of paleogeography with the underlying processes of global plate tectonics, and developing full-plate reconstructions has been one of the main research activities of the Earth Laboratory team. As a continuation of an on-going, overarching project to construct a spatially and temporally seamless plate tectonic model of the Earth for the last 600 Myr (*Domeier and Torsvik, 2014; Domeier, 2016; 2018*), much work in 2018 has been spent on compiling and distilling geological information from the major continents for the time period between 600 and 500 Ma. This window of time represents the final period for which fundamental reconstructions with plate boundaries are lacking, and so the last major obstacle to completing a continuous 600-Myr plate model. Our present aim is to be finished with this work by late 2019.

In addition to that main research theme, we have conducted two additional projects that have spawned from the full-plate models. Both of these projects focused on the calculation of the global subduction-flux and linking its temporal evolution to other geodynamical processes. The first project investigated the possible temporal connection between changes in the global rate of subduction and subsequent changes in the rate of geomagnetic reversals, which should be sensitive to changes in the core-mantle boundary heat flow (the latter being presumably modulated by changes in the rate or volume of lithosphere subducted as a function of time). The results of this study have been published in Tectonophysics (*Hounslow et al., 2018).* The second project considered the possible link between regional changes in the subduction flux along specific continental margins, and resulting changes in arc magmatism along those margins, insofar as the latter can be estimated from zircon age frequencies. This study has been published in Nature Scientific Reports (*Domeier et al., 2018*). **Both studies argued for significant linkages between the time-dependent subduction flux and the geodynamic processes considered, and present examples of the utility of full-plate models** (Figure 6.5, page 61).

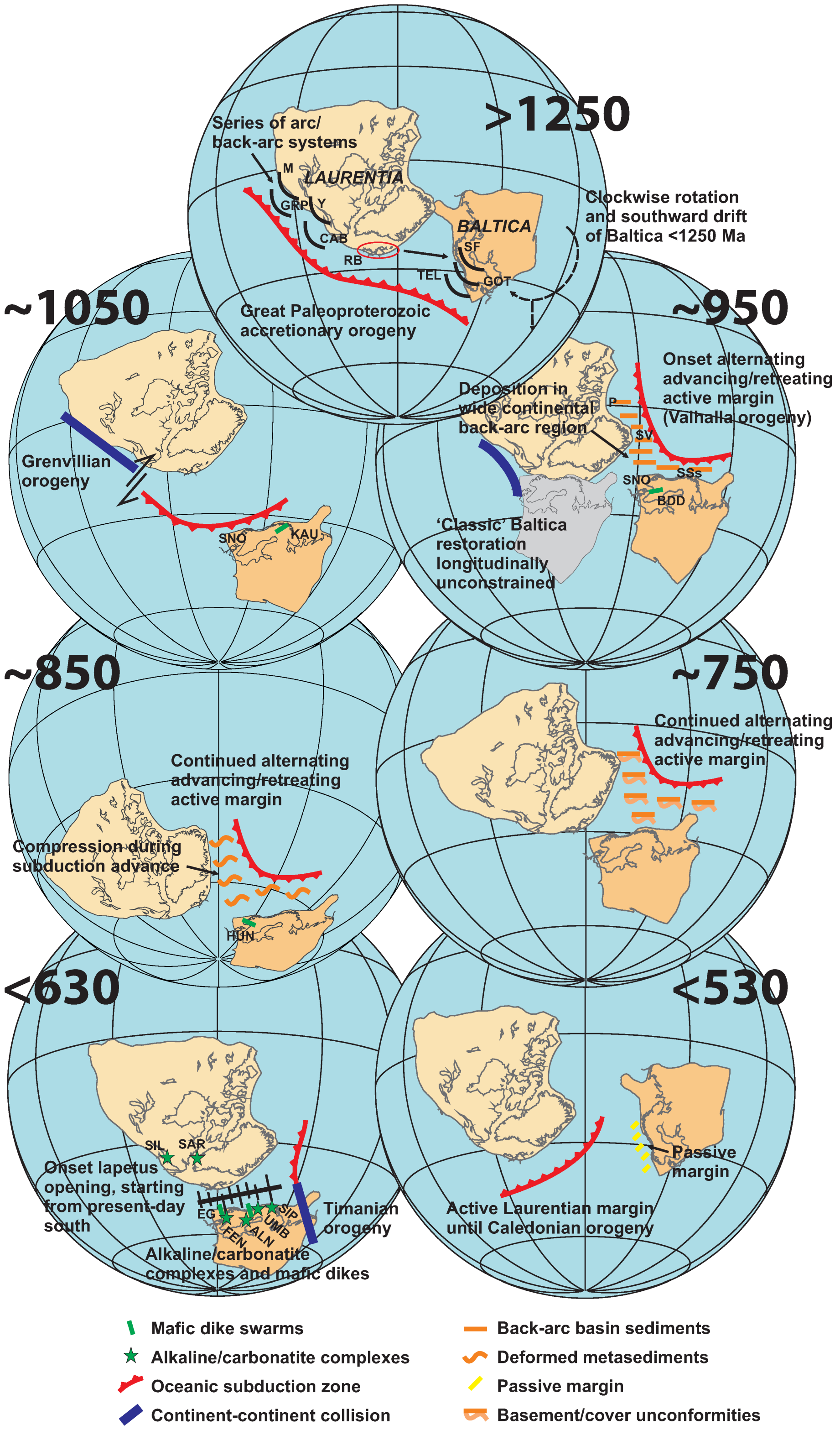


Figure 6.4. Mesoproterozoic and Neoproterozoic paleogeographic reconstructions of Laurentia and Baltica and interpretations of the tectonic events leading to, during, and following the development of the Sveconorwegian orogeny (Slagstad et al., submitted).

References

Domeier, M. (2016). A plate tectonic scenario for the Iapetus and Rheic oceans, Gondwana Research 36, 275-295,

Domeier, M. (2018). Early Paleozoic tectonics of Asia: towards a full-plate model, Geoscience Frontiers, doi: 10.1016/j.gsf.2017.11.012.

Domeier, M., Torsvik, T. H. (2014). Plate tectonics in the late Paleozoic, Geoscience Frontiers 5 (3), 303-350.

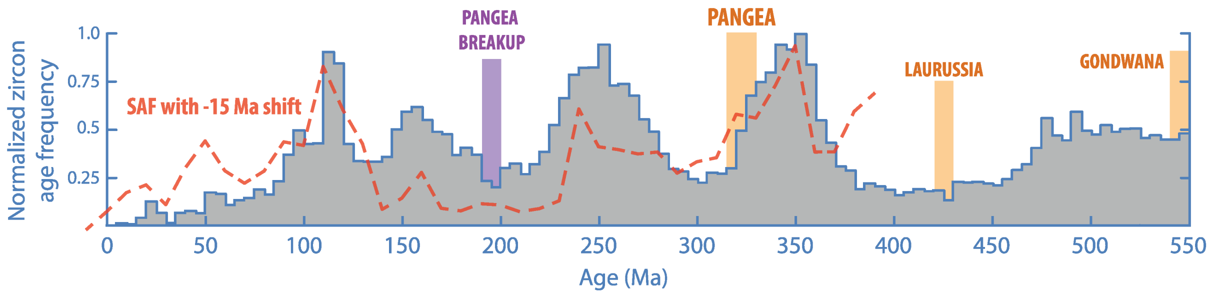


Figure 6.5. Episodic age distribution of zircons in the Phanerozoic (Domeier et al., 2018). Gray bars show the age frequency distribution of Phanerozoic detrital zircons from arc environments. Vertical yellow bars mark major continental assembly and dispersal events. The red -dashed line shows the subduction area flux of the last 410 Ma, shifted by 15 Ma according to the best-fit correlation lag-time determined by Hounslow et al. (2018).

Domeier, M., Torsvik, T.H. (2019). Full-plate modelling in pre-Jurassic time, Geological Magazine, 156, 261-280.

Domeier, M., Magni, V., Hounslow, M.W., & **Torsvik, T.H**. (2018). Episodic zircon age spectra mimic fluctuations in subduction, Scientific Reports 8, 17471.

Doubrovine, P. V., Veikkolainen, T., Pesonen, L. J., Piispa, E., Ots, S., Smirnov, A. V., **Kulakov, E. V.,** & Biggin, A. J. (2019). Latitude dependence of geomagnetic paleosecular variation and its relation to the frequency of magnetic reversals. GGG, 20, doi: 10.1029/2018GC007863.

Hounslow, M. W., **Domeier, M.,** & Biggin, A. J. (2018). Subduction flux modulates the geomagnetic polarity reversal rate, Tectonophysics 742-743, 34-49.

Kulakov, E. V., et al. (2018). The long-term history of the Mesozoic geodynamo: A paleointensity perspective, Geophysical Research Abstracts 20, EGU Vienna, Austria, April 8-13, 2018.

Kulakov, E. V. Doubrovine, P. V., Torsvik, T. H., Werner, S. C., & Silkoset, P. (2018). Paleomagnetism of Late Jurassic-Early Cretaceous coast-parallel dykes in SW Greenland, Abstract GP13A-33, AGU Fall meeting 2018, Washington, D.C., December 10-14, 2018.

Kulakov, E. V., Sprain, C., Smirnov, A. V., Biggin A. J., Hawkins, L., Paterson, G. A., Fairchild, L., **Doubrovine, P. V.,** & Piispa, E. J. Analysis of an updated paleointensity database (QPI-PINT) for 65-200 Ma: A consensus on long-term history in average dipole moment through the Mesozoic, Jounal of Geophysical Research & Geochemistry (submitted).

McFadden, P. L., Merrill, R. T., McElhinny, M. W., Lee, S. (1991). Reversals of the Earth's magnetic field and temporal variations of the dynamo families. Journal of Geophysical Research, 96(B3), 3923-3933

Ogg, J. G. (2012). Geomagnetic Polarity Time Scale. In F. M. Gradstein, J. G. Ogg, M. G. Schmitz, G. M. Ogg (Eds.), The Geologic Time Scale (pp. 85-113). Boston, MA: Elsevier

Opdyke, N. D., Kent, D. V., Foster, D. A., & Huang, K. (2015). Paleomagnetism of Miocene volcanics on Sao Tome: Paleosecular variation at the Equator and a comparison to its latitudinal dependence over the last 5 Myr. Geochemistry Geophysics Geosystems, 16(11), 3870-3882

Slagstad, T., **Kulakov E. V.,** Kirkland, C. L., Romerts, N. M. W., & Ganerød, M. Breaking the Grenville-Sveconorwegian-Sunsas Link in Rodinia Reconstructions. Geology. Submitted).

Torsvik, T. H., R. Van der Voo, U. Preeden, C. MacNiocaill, **B. Steinberger, P. V. Doubrovine**, D. J. J. van Hinsbergen, **M. Domeier, C. Gaina,** E. Tohver, J. G. Meert, P. J. A. McCausland and L. R. M. Cocks (2012). Phanerozoic polar wander, paleogeography and dynamics, Earth Science Reviews 114, 325-368 .

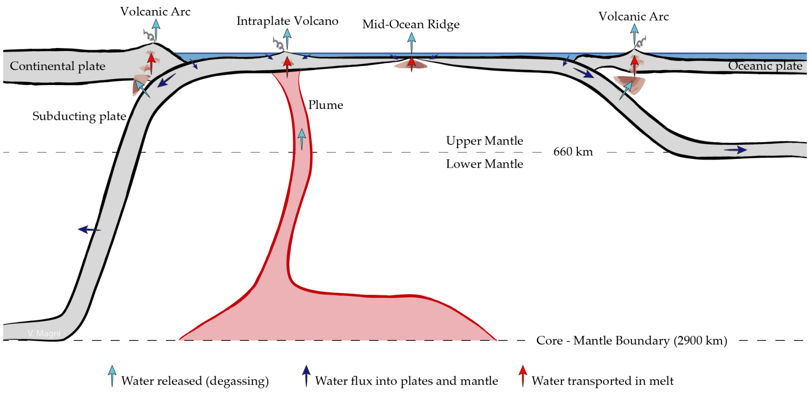
The Water Planet

The Water Planet is an umbrella project that explores and develops water-related linkages among the CEED teams. This project recognizes the ubiquity of water within the Earth system, extending from the hydrous minerals within Earth's deep interior to the active role of water within Earth's surface environment. Using the commonality of water within the research of all the CEED teams, the Water Planet project helps to build a collaborative and interdisciplinary environment within CEED.

Water is tightly linked to planetary dynamics on a variety of timescales, and therefore represents a theme running through the research activities of all the CEED teams. In particular, water plays an important role in topics as diverse as planetary formation, mantle dynamics, sedimentology, glaciology, biology, and hydrology. Many water-related topics, such as sea level change, link geoscience research with problems of significant public interest.

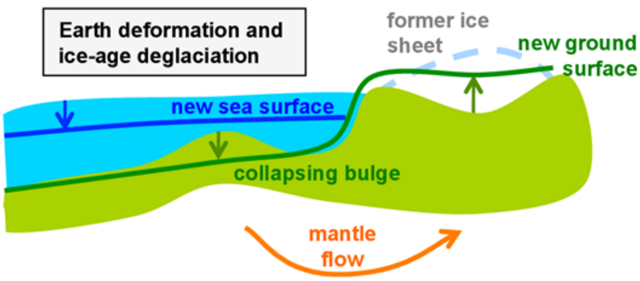
In 2018, CEED initiated the "**Water Planet**" umbrella project. This project aims to explore and develop water-related linkages among the CEED teams, with outreach to the Geosciences Department, other UiO entities, and international collaborators. We will organize interactions through seminars, discussions, and contributions from all CEED teams, and document our activities using the new water planet website: www.waterplanet.no. Already, we have begun to develop research themes that help to focus the efforts of the Water Planet project. Here we describe the four research themes that we have developed so far.

Mantle Dynamics



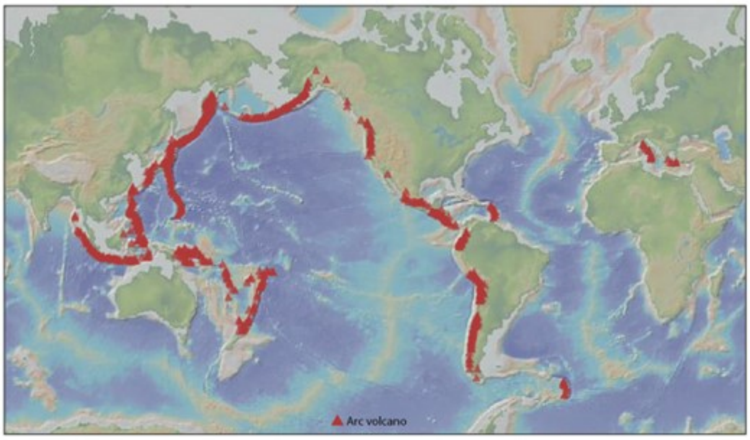
Water is present not only on the surface of the Earth, but also within its interior. It is stored in small percentages or parts per million in hydrous and nominally anhydrous minerals that are stable at different pressures and temperatures. How much water is present in the Earth's mantle is unknown; estimates range from about half to seven times the present-day ocean mass. The links between shallow and deep water at the mantle scale are interesting to explore as they affect many aspects of our dynamic planet.

Surface Deformation



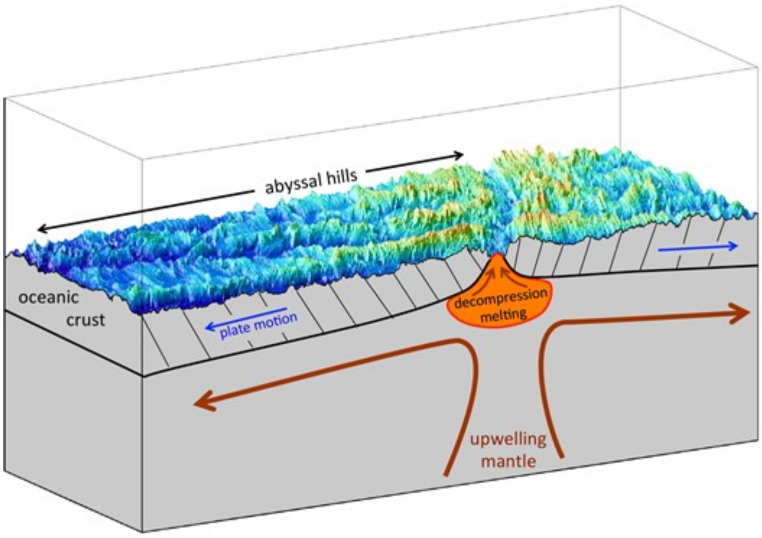
Water on Earth's surface is stored primarily as seawater in the ocean basins and as ice and groundwater on the continents. Changes to Earth's climate cause water to move between these storage reservoirs, resulting in adjustments to Earth's hydrological load. These changes can deform the Earth's solid surface, deflect Earth's gravitational field, and perturb Earth's rotation axis. On longer timescales, geologic and geophysical processes can alter the shapes of ocean basins and continents, influencing sea level and affecting climate. Study of water movements across recent history and distant geologic time can help us to understand the deformation processes occurring within the Earth.

Volcanism



Water is a key ingredient of volcanism; it plays a major role in the formation of many volcanoes, it affects both the viscosity of magmas and the explosiveness eruptions. The volcanic arc chains at convergent margins, such as the volcanoes of the "ring of fire" around the Pacific Ocean, form thanks to the water released from the subducting plate at depth. Away from subduction zones, magmas produced at the mid-ocean ridges and in intraplate settings can also release small amounts of water transported from the deep mantle. All of these volcanic systems can interact with water near the Earth's surface, producing hydrothermal or hybrid systems, or eruptions associated with glacial unloading. As a result, water is intimately linked to volcanism throughout the earth system, from the deep mantle to the surface, across timescales as short as those relevant for climate change and as long those associated with earth's geologic history.

Seafloor



While Earth's continents have been explored and studied in detail, the other ~70% of our planet's surface has been more difficult to study because it is covered by water. Indeed, massive features such as Earth's global mid-ocean ridge system were discovered as late as the 1950s, and only after extensive shipboard mapping efforts. Now, satellite mapping of gravity variations give a much more detailed picture of seafloor topography, but our knowledge of seafloor processes is still very much limited by the underwater environment. Despite these challenges, some of our most fundamental advances in the earth sciences, such as the theory of plate tectonics, have resulted from geological and geophysical observations of the ocean floor. This is because the continuous recycling of seafloor into Earth's interior links it tightly to our planet's interior processes and keeps it young enough (less than 180 million years, compared to Earth's age of 4.54 billion years) that key tectonic and volcanic processes can be observed in a relatively pristine state. For these reasons, marine geology and geophysics represents an important frontier for the Earth sciences, despite the difficulty of making observations beneath a covering of water.

The Else Ragnhild Neumann award

Centre for Earth Evolution and Dynamics (CEED) awards every year the Else-Ragnhild Neumann Award for Women in Geosciences. The award goes to a woman who through PhD or postdoctoral work has made a significant contribution to research in Geosciences.

Requirements for nomination

The nominee should reside in Norway at the time of nomination. Women are eligible for the first 7 years following their degree, except in the case of significant interruptions to a research career.

About the award

The Else-Ragnhild Neumann award honours the scientific contribution of Professor Else-Ragnhild Neumann. In 1981, she became the first female professor in Geosciences in Norway. Neumann worked with the University of Oslo and are still active and publish about volcanism and links to mantle processes. She studied the Oslo region, the Canary Islands and other volcanic islands, the Siberian Traps and other areas that experienced significant magmatism.

On the 7th of December CEED celebrated the 80th birthday of the first female professor in Geosciences in Norway: **Else-Ragnhild Neumann**. She became a Full Professor in 1981, the year the world was revolutionised by the first IBM personal computer (PC). Was it the dawn of a new era?

The information about when the first woman completed a doctoral degree in Geosciences in Norway was difficult to find, but it was 1903 when the first woman defended a doctoral thesis in Kristiania (now Oslo), and 1912 when the University of Oslo appointed the first female professor, the zoologist Kristine Bonnevie. Another 69 years passed until a female geoscientist was found qualified to become a Professor!

The statistics based on data available for the last six years show that in 2018 women represent 25% from the number of full professors in Norwegian Universities. The Department of Geosciences at University of Oslo has 7 female full professors, out of the total of 29 professors, confirming the national ratio (1/4) published earlier this year.

Although an improvement since 1981, talented young women who choose to pursue an academic career still encounter more obstacles than their male peers. A society like the one built in Norway where children care is supposed to be equally shared by both parents is a big step forward. Despite this, the society, families, colleagues expect a woman to first fulfil her tasks as a mother and as a partner, and only after that to think about a (time) demanding academic career.

Because an academic career means uncertainty, unorthodox working hours, days, weeks and even months away from home, moving your family around the world, and maybe having your mind and attention hooked on strange, abstract problems. Last year, when I have first proposed the idea of an award recognising early career female geoscientists, I have received the reply: “Do you really think that there are so many candidates for that award”?

ELSE-RAGNHILD
NEUMANN
AWARD
FOR WOMEN IN GEOSCIENCES

Else-Ragnhild Neumann Award Logo designed by CEED Researcher Fabio Crameri

Yet, the Else-Ragnhild Neumann award international committee received 6 excellent nominations and they have selected two amazing young and talented women who deserve the prize for contributing in a significant way to the field of Geosciences during their PhD and postdoctoral studies. They are both working now with the University of Oslo.

Dr. Anya Røyne is a Norwegian physicist turned into a geoscientist, has three children, received a PhD in 2011, and has published 25 papers. Her work advanced our understanding of mineral growth in porous media, fluid and hydration, and crystal growth by using original experimental approaches and new devices.

The award is shared with **Dr. Grace E. Shephard**, an Australian scientist who moved to Norway immediately after completing her doctoral studies in 2014. Dr. Shepard is commended for her growing scientific production that provides fundamental contribution on understanding the link between shallow surface process and deep mantle dynamics. A considerable amount of both awardees scientific work was developed in Norwegian centers of excellence (in Physics of Geological Processes-PGP, and the Center for Earth Evolution and Dynamics-CEED, respectively).

Being recognized early in your career can change many things. It feels good to know that what one does from passion and dedication is helpful and important. It opens doors, at least this is how the history, mainly written by our male colleagues, goes. And maybe the (academic) world can suddenly become a more accessible arena, and a career that leads to a professorship may turn more often into reality. For women too.

Snapshots from the Else Ragnhild Neumann seminar and award ceremony at the Norwegian Academy of Science and Letters, Oslo, Norway, 07.12.2018. ***Left*** *– Inaugural Else Ragnhild Neumann awardees for Women in Geosciences: Anja Røyne and Grace Shephard (UiO) and Head of Department of Geosciences, Brit Lisa Skjelkvåle; Middle –Else Ragnhild Neumann on her 80th birthday; Right – Grace Shephard and Carmen Gaina (CEED).*

Young CEED

In 2018, a new initiative was brought to life to foster new ideas on long-standing geoscientific questions and to support CEED's early career researchers with developing broad scientific and academic skills and establishing a presence in the research community. The novel YoungCEED initiative aims to bring together a diverse group of early career researchers, from CEED but also from other research institutes abroad, to work on a cross-disciplinary topic of the Earth Sciences. The main research is carried out during a week-long intensive workshop in the Oslo area, which is in its entirety organised by some of the participating YoungCEED researchers.

YoungCEED workshop 2018 – Subduction Initiation: When do oceanic plates start to sink?

The first YoungCEED workshop was held between 5.-12. November 2018. A total of 14 cross-disciplinary scientists were involved, among which were 8 international and 6 CEED-based scientists, to spend a full week (i.e., 7 days) in the UiO-owned, Biology research station in Drøbak.

The 2018 cross-disciplinary project focussed on how, when and where new subduction zones form on the recent (i.e., <200 Ma) Earth in the presence of ongoing present-day style of plate tectonics. Subduction zones are the regions where surface plates collide with other plates and subsequently sink into the mantle. The formation of new subduction zones is important to understand as it enables and maintains Earth-like, present-day plate tectonics. Subduction-zone initiation is thereby the crucial geodynamic feature that keeps distinguis-

The UiO-owned, Biology research station in Drøbak.

hing the Earth's evolution from the evolution of all other known rocky planets.

The aim of the workshop was to shed new light on this hugely important, but still elusive aspect of the Earth's evolution by collecting and interpreting all available cross-disciplinary data. By studying the literature and diagnosing plate reconstruction models and seismic tomography data sets of present-day slabs, a novel Subduction-Zone Initiation (SZI) Database was created. The SZI-Database will be made openly accessible and published alongside a publication in which this extensive data set will be analysed. This not only improves the characterisation of individual SZI events, but also shines important new light on the general dynamics involved in SZI.

This intensive workshop, that brought together 14 inter-disciplinary early-career scientists, was a novel way to tackle this long-standing, inter-disciplinary problem of the Earth Sciences. Apart from producing new scientific insights and providing each participant with an incredibly broad understanding of SZI, it fostered the development of each participant by training academic independence (from current supervisors) while forming new (and strong) connections to peers.

A summary of the first YoungCEED workshop has been posted on the CEED webpage (https://www.mn.uio.no/ceed/english/about/news-and-events/news/2018/young-ceed-subduction-initiation.html).

Organisers: Valentina Magni, Grace Shephard, Mat Domeier, Fabio Crameri

Funding: Centre for Earth Evolution and Dynamics (CEED)

The workshop in numbers:

Total expenses: 100,000 NOK, Participant statistics

Number of unique nationalities: 12

Number of unique University affiliations: 8

% of female participants: 64 %

Participants: Kiran Chotalia (UCL, UK), George Cooper (U.Durham, UK), Fabio Crameri (CEED, UiO), Mathew Domeier (CEED, UiO), Caroline Eakin (ANU, Australia), Antoniette Grima (UCL, UK), Derya Gürer (U.Queensland, Australia), Ági Király (CEED, UiO), Valentina Magni (CEED, UiO), Elvira Mulyukova (Yale, USA), Kalijn Peters (U.Utrecht, The Netherlands), Boris Robert (CEED, UiO), Grace Shephard (CEED, UiO), Marcel Thielmann (U.Bayreuth, Germany).

Outreach highlights

Over the course of the 2018 calendar year there were numerous individual and CEED-driven outreach initiatives, including both online/digital and in-person. CEED's outreach strategy includes the dissemination of discrete research output (i.e. publications) as well as more general content (i.e. education, research and societal-related content, for example, commentary on external news items and events, blogs and news articles, job advertisements, thesis defenses, public lectures, science fairs, secondary school visits, field work and excursions, awards and honours, visiting researchers, other UiO/Geo/MatNat events and initiatives, conferences and workshops, etc.). The outreach activities aim to showcase the wide range of CEED's research interests and activities, thus all employees and students of CEED are encouraged to be proactive in outreach activities.

An aim of CEED's outreach activities is to engage both the fellow geoscientific community as well as the general public, depending on the nature of the content. It is also an opportunity to update those within the CEED community about their own colleagues' activities. Outreach posts or events include those in English, Norwegian, or both (articles in other languages, including those of the researchers' native languages is also encouraged). For the online-based outreach, CEED's main avenues include the CEED website, social media (Facebook and Twitter; YouTube from 2019), the Department of Geosciences website, and the UiO news outlets Titan.uio.no, Apollon, and Uniforum. In the Norwegian media avenues have included NRK (radio, TV and online), TV2, and www.forskning.no. New to 2018, a Wikipedia editing session (led by the 'Wikimedia' foundation) was held on the 10th October.

Selected highlights of in-person outreach events from 2018 include:

- Open Day at the new Stable Isotope Laboratory (lead by Anne Hope Jahren) 24th April 2018.
- Henrik Svensen's book: Stein på stein (2018). Including book launches and interviews, Dagbladet's recommended reading. See also Svensen's extensive individual outreach efforts.
- Nils Prieur popular science talk at "Astronomy on Tap" at Brygg Pub 26h November 2018
- Forskningtorget booth (School Science Fair) 21-22 September 2018, Oslo.
- GEO-Onsdag talks – held on at the UiO Natural Sciences Library and streamed online.
- *More events listed in "In the media"*

CEED's social media presence includes accounts on Facebook (@CEEDOslo; 469 likes, 198 individual posts in 2018) and Twitter (@CEEDOslo; 905 followers, 116 tweets and 1.3 million "impressions" in 2018). Where possible, the posts include photos and/or video and a link to more in-depth information i.e. the journal article, CEED webpages etc. The re-sharing of posts is encouraged by individual CEED members from their own social media accounts – and the significant knock-on effect of such sharing is visible in the account's statistics.

Wikipedia editing course held at CEED

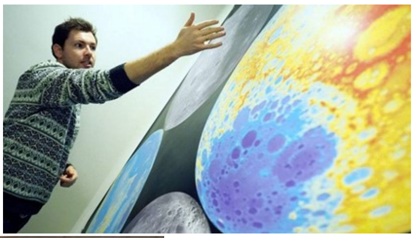
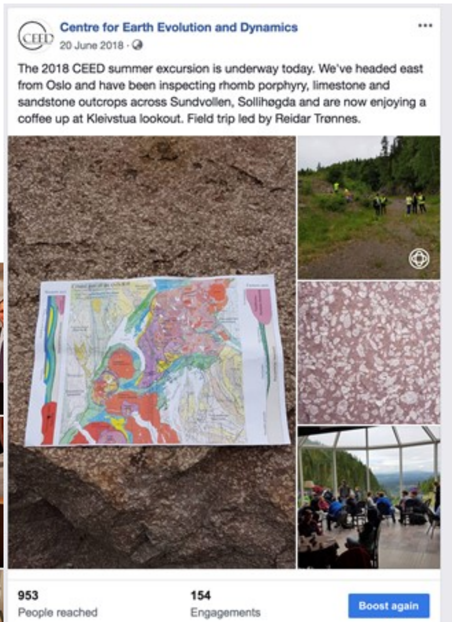
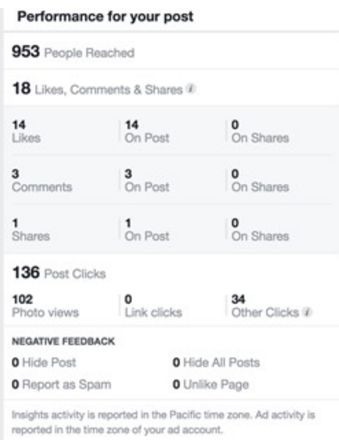


Photo: Clockwise. Nils Prieur and "Astronomy on Tap," CEED at GEO-Onsdag with talk by Trond Torsvik, and CEED at Forskningstorget in 2018.

Selected highlights of online/digital outreach events from 2018 included:

- "A Film about the Creation of Iceland" by Alisha Steinberger made in association for Steinberger et al., (2018, Nature Geoscience) publication
- DEEP and NOR-R-AM course video made by Eivind Straume
- "Postcards from CEED" over the summer week a geoscience-related photo submitted by CEED members is posted on our social media accounts
- Reidar Trønnes, various interviews with NRK (see 'In the media')
- Aswin Sekhar. Gender gaps in academia. Nature Correspondence (2018)
- Trond Torsvik and Reidar Trønnes featured in the VPRO Television (Netherlands) TV episode "The mind of the universe. A journey along the frontiers of knowledge"
- New CEED logos designed by Fabio Crameri (see page 3)





Two example posts from Facebook (Pingchuan Tan's PhD defence, and the CEED summer party 2018 with related statistics to the right).

DEEP and teaching at CEED

CEED scientists participate in several teaching activities. In addition to teaching regular courses at the Department of Geosciences (see Table on next page), in 2018 they were involved in coordinating, running and lecturing in several DEEP courses as following:

GEO-DEEP9400 Intensive course: Solid Earth – Fluid Earth Interactions (16 – 20 April 2018): This intensive PhD course addressed topics like material recycling across the geospheres and how mantle dynamics, volcanism, plate tectonics influences long-term, global environmental and climatic changes. The course organizer was **Carmen Gaina** and she taught the course with 12 others, among them **Stephanie Werner, Clint Conrad, Valerie Maupin, Grace Shephard, Valentina Magni, Morgan Jones** and **Reidar Trønnes** (CEED) plus international lecturers. 12 PhD students and 1 PostDoc participated, including 6 from CEED (Straume, Uppalapati, van den Broek, Karlsen, Heyn, Zaputlyaeva).

GEO-DEEP9500 Intensive course: Arctic tectonics, volcanism and climate at Svalbard (3 – 10 August 2018): This intensive PhD course was organized in collaboration with the University Centre in Svalbard (UNIS) and NOR-R-AM. NOR-R-AM is a Norwegian-Russian -North American collaboration in Arctic research and education across several world-leading institutes. This course addressed the diverse geological history of the Arctic region, including both onshore and offshore regions from Paleozoic to recent times. It focused on the interplay of plate tectonics and volcanism (including, arc, rifting and plume-related) and explored some of the outstanding region-by-region case studies/questions within the Arctic research community. Based in the gateway to the Arctic, Svalbard, the course was complemented by a field trip.

The course organizers were **Carmen Gaina, Grace Shephard** and Kim Senger (UNIS) and they taught the course with 8 others. The other teachers from CEED were Morgan Jones, Lars Eivind Augland and **Alexander Minakov**. Of the 15 PhD and master students participating were 5 from CEED (Straume, Zaputlyaeva, Heyn, Uppalapati, Corr).

GEO-DEEP9100 Planetary Physics and Global Tectonics (24 – 28 September 2018): The course gave an introduction to the physics and tectonic processes that govern the properties and evolution of the Earth and other planets. The course responsible was **Stephanie Werner** and she taught the course with 9 others. The other teachers from CEED were **Bernhard Steinberger, Valentina Magni, Fabio Crameri, Grace Shephard, Clint Conrad, Pavel Dubrovin, Mat Domeier** and **Evgeniy Kulakov**. 6 PhD and master students registered and 4 completed the course.

DEEP has also offered several non-scientific courses in 2018:

- Course in Science communication (24-26 January 2018), 2 participants from CEED
- Bringing out the best in your students: A seminar for PhD supervisors (19 February 2018), 6 participants from CEED
- Writing for Scholars (22-23 February + 22-23 March 2018), 5 participants from CEED
- Your academic care - Building your academic CV and writing successful project proposals (21 June 2018), 1 participant from CEED
- Nature master class – advanced writing course (6-7 September 2018).

Each year DEEP also arranges the DEEP General Assembly. In 2018 it was hosted on Hurtigruta from Bergen to Trondheim with 51 participants, including 16 participants from CEED. This is a gathering of all DEEP PhD students and their supervisors to present and discuss their science.

Teaching by CEED staff at UiO

DEEP courses are given in **bold**

Course code & name	Semester	ECTS	Course responsible / assisting
GEL2140 Geofysikk og global tekto-nikk	Spring 18	10	**A.J. Breivik**
GEL2150 Field course and methodolo-gy in geology and geophysics	Spring 18	10	A.M. Lundmark, **L.E. Augland**, F. Franeck
GEO4120 Near-Surface Geophysics	Autumn 18	10	**A.J. Breivik,** S. Bazin, T. Eiken
GEO4240 Seismic interpretation	Spring 18	10	**J.I. Faleide,** M. He-eremans
GEO4270/9270 Integrated basin analy-sis and prospect evaluation	Autumn 18	10	**J.I. Faleide,** M. Heeremans
GEL4360 Field methods in hydrogeo-logy	Spring 18	5	A. Sundal, C. Seena, **A.J. Breivik,** P. Aaagaard, H. French (NMBU).
GEO4630/9630 Geodynamics	Autumn 18	10	**C. Conrad, B. Steinber-ger, S. Buiter, V. Magni**
GEO4840/9840 Tectonics	Spring 18	10	**T.B. Andersen, C. Gaina / M. Domeier, J. Jakob, H.J. Kjøll** for
GEO4860/GEO9860 Advanced Petro-logy	Spring 18	10	**R.G. Trønnes,** B. Jam-tveit
GEO4620/9620 Seismic waves and seismology	Autumn 18	10	**V. Maupin**
GEO-DEEP 9400 Intensive course: Solid Earth – Fluid Earth In-teractions	Spring 18	5	**C. Gaina**
GEO-DEEP 9500 Intensive course on Arctic tectonics, volcanism and cli-mate at Svalbard	August 18	5	**C. Gaina/G. Shephard**
GEO-DEEP9100 Planetary Physics and Global Tectonics	Autumn 18	5	**S.C. Werner**
ISSMN4030 - A changing Arctic	Summer School	15	**C. Gaina/ G. Shephard**

CEED members and invited guests at Krokkleiva during the Oslo rift excursion the 19th of June

International cooperation

Country	Activity	Person(s) involved
Australia	Joint publications, collaboration, visits	C. Gaina, E. Straume, G. Shephard, H.J. Kjøll, A. Minakov
Brazil	Collaboration, joint publication, visiting student	H. Svensen, T.H. Heimdal
Canada	Research cooperation	C. Gaina, J. Jakob
Denmark	Field work (Fur, Greenland), joint supervision and collaboration, joint publications	M. Jones, T.B. Andersen, H.J. Kjøll, P. Doubrovine, E. Kulakov, C. Gaina, S. Callegaro, A. Shulgin
France	Visiting students, Field work, collaboration	T.B. Andersen, J. Jakob, C. Gaina, A. Minakov, S. Werner, C.E. Mohn, M, Baron
Germany	Visitors; Joint publication (s), collaboration	T.B. Andersen, B. Steinberger, S. Werner, A. Mazzini, C. Gaina, C. Conrad, A. Breivik, T. Rolf, N.C. Prieur
Iceland	Collaboration	C. Gaina
Indonesia	Joint research project	A. Mazzini
Italy	Collaboration	C. Gaina, A. Kiraly, T.B. Andersen,
Japan	Collaboration	R. Trønnes, S. Werner, V. Maupin
Kina	Collaboration	V. Maupin,
Russia	Field work; Research cooperation; Joint publication(s)	A. Polozov, R. Kulakov, C. Gaina, J.I. Faleide, A. Minakov, A. Mazzini
South Africa	Field related work; Joint publication(s)	T.H. Torsvik, H. Svensen
Sweden	Collaboration	S. Callegaro
The Netherlands	Joint publication(s), research collaboration, Exo Mars landing site.	T.H. Torsvik, W. Spakman, C. Gaina, S. Werner
Turkey	Collaboration, visiting student	M. Domeier, T.H. Torsvik, V. Maupin
UK	Lab work; Joint publication (s), collaboration	J. Dougal, R. Trønnes, T.H. Torsvik G. Shephard, V. Maupin, F. Crameri, C.E. Mohn, V. Magni
USA	Joint publication(s), Lab. Facilities, studetn visit, research cooperation	C. Conrad, A.H. Jahren, T.H. Heimdal, C. Gaina, F. Crameri

PhD student projects (**in bold**: finished in 2018)

Name	Topic	CEED supervisors	Funding
Ballo, Eirik	Reconstructing climatic, environmental and societal dynamics in Scandinavia in the Iron- and Viking-Age (RECESS)	Svensen, Bajard, Makke	UiO
Broek, Joost van den	The role of subduction in the formation and evolution of continental slivers and microcontinents	Gaina, Buiter, Gabrielsen, TB Andersen, Magni	EU
Bostic, Joshua N.	Reconstructing the magnitude and societal effects of acute climate changes during the Viking dark ages	Jahren, H. Svensen,	UiO
Heimdal, Thea H.	**The geochemistry of sill-sediment interactions and the implications for global environmental crises – case studies from the Tunguska, Amazon and Solimões Basins. PhD defence 6 Dec. 2018**	**Svensen, Callegaro, Jones, Trønnes**	**UiO & SFF**
Heyn, Bjorn H.	Convective dynamics in the lowermost mantle	Conrad, Trønnes,	UiO
Karlsen, Krister S.	The effects of water on mantle convection dynamics - Linking the Earth's hydrological, thermal and tectonic histories	Conrad, Trønnes, Magni	UiO
Kjøll, Hans Jørgen	Wilson-cycle 'kick-off': Large Igneous Provinces, the Neoproterozoic and Cambrian evolution of Baltica and adjacent continents	TB Andersen, Torsvik	RCN & SFF

Above: Thea H. Heimdal and her main supervisor Henrik Svensen at her PhD defence party.

Left: Dr. Nils C. Prieur with his doctorial hat.

PhD student projects (cont.)

Name	Topic	Internal superv.	Funding
Prieur, Nils C.	**The influence of target properties on simple crater evolution. PhD defence 13 Feb. 2018**	**Werner**	**RCN**
Stokke, Ella W.	The effects of volcanic eruptions and degassing during the North Atlantic LIP on the PETM thorugh geochemical analyses and studies of ash layers i the Fur Fm, Denmark	Jones, Svensen	RCN
Straume, Eivind O.	Paleoclimate in the Cenozoic time: Quantifying the role of North Atlantic plate tectonicsa amd mantle processes	Gaina, LaCasce, Nisancioglu, Svensen	UiO
Tan, Pingchuan	**Magmatic development of the Jan Mayen - East Greenland corridor, NE Atlantic. PhD defence 29 Oct. 2018**	**Breivik**	**UiO**
Uppalapati, Sruthi	Cooling of a planet – Mechanisms tested for Venus and Io	Werner, Rolf, Crameri, Conrad	UiO
Zastrozhnov, Dmitry	Structure and Evolution of Mid-Norway Continental Margin	Faleide, Planke, Gabrielsen	RCN
Zaputlyaeva, Alexandra	Fluid-rock interactions and geochemistry of the Lusi mud eruption, Java, Indonesia	Mazzini, Svensen	UiO

Dr Philos project

Name	Topic
Halvorsen, Erik	Paleomagnetic and magnetic fabric studies of Early Cretaceous sills from Central Svalbard: unraveling Early Cretaceous paleopole and suggested Cenozoic remagnetization in addition to divergent magnetic fabric.

Master student projects

Bold: finished in 2018

Name	Topic	CEED supervisor(s)
Bruland, Charlotte	**Ambient noise tomography at the Oseberg oil and gas field, North Sea. Master exam in June 2018**	**Maupin**
Corr, Michael E.	'Satellite Gravity Data and Lithospheric Stresses'	Minakov, Gaina
Gilje, Kristina	Interpreting the statistics of small craters on Mars by coupling cratering statistics and numerical modelling	Werner, Prieur
Hatalova, Petra	Guiding of Tectonic Plate Motions by Transform Faults	Conrad
Kolstad, Kristian G.	**Relative relocation of earthquakes along the northern North Atlantic Ridge using Rayleigh waves. Finished in June 2018**	**Maupin**
Karlsson, Rebecca	Rifting on Venus: Insights from Beta Regio system	Werner
Quintela, Orlando	Structural geology and tectonic history of the Caledonian "mèlange" near Lesja, Central-South Norway	TB Andersen, Jakob
Myhre, Ragnhild	**Identification of seismic records left by different landslide types in Norway . Master exam in June 2018**	**Maupin**

Conferences and workshops (co-)organized by CEED

Date	Title and organizers (bold: organizers from CEED)
28.2	CEED - no longer a teenager.A five-year celebration of The Centre for Earth Evolution and Dynamics. Gamle Festsal, Domus Academica. Organizers: **C. Gaina** and **T-L K. Gørbitz**
19-20.4	Scanarray workshop CEED. 18 participants from Denmark, Turkey, Germany, Sweden,, Australia and Norway. Organizer: **V. Maupin**,
11.4	EGU short course - Geodynamics 101: how to use and interpret numerical models of the solid Earth, Vienna, Austria . Organizers: Zelst, Pusok, Rozel, **F. Crameri**, Dannberg, Glerum,
21.9	New Frontiers in Palaeogeography and Biogeography, the Geological Society, Burlington House, London. Organizers: C. Mac Niocaill, **T.H. Torsvik** and D. Harper.
5-12.11	YoungCEED workshop, Drøbak. Organizers: **F. Crameri, V. Magni, G. Shephard** and **M. Domeier**
5.12	A symposium to honour Else Ragnhild Neumann, the first female Professor in Geosciences in Norway. The Academy of Sciences. Organizers: **H. Svensen, C. Gaina** and **T-L.K. Gørbitz**

Labwork, workshops attended outside UiO		
Date	**Event**	**Attendant(s)**
29-30.5	Magellan workshop GEOMAR	A. Breivik
15-19.10	Instructor at the "École De Physique des Houches", which is a PhD training school that is run out of France. The school runs all year round for different topics in physics	C. Conrad
4.10	IODP workshop Trondheim	C. Gaina
29.1	North Atlantic workshop BHP Houston	C. Gaina
20.3	Maggelan IODP workshop Tromsø	C. Gaina
25-27.9	IODP Workshop Mt. Hood, Oregon USA	J. Jakob
28.5 to 3.6	Raman spectroscopy (RSCM) in Paris, France, together with Olivier Beyssac	J. Jakob
24- 29.9	IODP workshop, Oregon, USA	J. Jakob
	Lab work in Copenhagen	M. Jones
19-22.8	German-Swiss Geodynamics Workshop 2018, in Kiel	A. Kiraly
21.9	German-Swiss Geodynamics Workshop 2018 - Arranged by Geomar. at Schloss Noer	V. Magni
2.9	European Seismological Conference, 36th General Assembly	A. Minakov, A. Mironova,
	NOR-R-AM Workshop, St.Petersburg State University	A. Minakov
16.1-24.2	National Oceanographic Center (NOC) i Southampton , organic geochemistry work	E. Stokke
23.6-1.7	Workshop in Geology and Geophysics of the solar system organized in Petnica Science Center,Serbia	S. Uppalapati
16-22.8	Workshop "Mud Volcanism and Petroleum Systems", Baku, Azerbaijan	A. Zaputlyaeva
Autumn	Stockholm, ion probe at Nordsim	S. Callegaro
Autumn	Raman spectroscopy	S. Callegaro

Field work in Norway		
19-24.9.	Svalbard, Eocene sedimentary rocks and ash deposits	LE Augland
Nov.	Coring campagn, Hedmark, Akershus, Aust-Agder, Vest Agder	E. Ballo, M. Bajard
28-30.6 16.7 8-18.8 20-24.8	The Røros area Rølldal Tromsø-Vesterålen-Lofoten Sognefjell	F. Corfu F. Corfu, L.E. Augland F. Corfu F. Corfu
2-9.5.	Student field course in Western Norway	J. Jakob, H.J. Kjøll, S. Callegaro
1.7 to 14.9	Field Work Norway and Sweden	J. Jakob
15-19.8	Corrovarre (Troms/Finnmark)	Kjøll
15-31.8	Kautokeino-Karasjok, Finmark	Kulakov, Silkoset
Summer	Deltadalen, Svalbard	S. Planke, Sleve-land
Summer	Jessheim, Akershus	H. Svensen
Field work in Europe outside Norway		
Summer	Fur, Denmark	M. Jones, E. Stok-ke
15-19.8 3-10.9.	North Sweden and Sarek, North Sweden	H.J. Kjøll
April	Fieldwork at the Salinelle di Paterno' conducting a multidisciplinary sur-vey including fluids sampling, drone photogrammetry and 3D geoelect-rics.	A. Mazzini

Coring in lake Berse by the Vikings project members, november 2018

Field work outside Europe		
Autumn	Karoo, S. Africa with the Earth Crises Team: Augland, Callegaro, Heimdal, Jones, Stokke, Svensen	Earth Crises
12.08.-03.09.	A 3 week paleomagnetic fieldwork campaign in the Verkhoyansk fold-belt, northeast Siberia, Russia	M. Domeier
16-30.5	a 2 week paleomagnetic fieldwork campaign in Shanxi Province, China	M. Domeier
Summer	Kimberlite reconnaisance trip Cortland, NY	P. Doubrovine, E. Kulakov,
June to July	TTR-BL-18 cruise in Lake Baikal focusing on seafloor sampling and acoustic investigations of gas seeps, flares, mud volcanoes, slumps and debris flows, canyons and channels in the coastal proximity.	A. Mazzini
August to 26	Baku, Azerbadjan. Summer school in Azerbaijan on "Mud volcanism and petroleum systems" including with seminars and field excursions and exercises visiting mud volcanoes and petroleum systems outcrops.	A. Mazzini, A. Zaputlyaeva,
September	Indonesia Fieldwork: Sampling of noble gasses from gas and oil fields around Lusi and the hydrothermal springs, drone sampling of Lusi crater	A. Mazzini, A. Zaputlyaeva
Summer	Siberia for the project Ørnen	S. Planke

CEED's researcher Adriano Mazzini reports from Baikal, seen on Russian television. ***Mazzini:*** *"We found a new gas bearing structure that we named MSU (Moscow State University), the institute of the expedition organizer. The main Russian TV channel came and the journalist made a short reportage collating our drone and underwater camera videos + the interview of the cruise chief scientist.". Photo from Russian TV.*

Project funding

UiO project #	Projects, project leader	Total funding (kkr)
SFF 143906	123272 Centre for Earth Evolution and Dynamics, Gaina (2013-23), In kkr:	155 000
143899	235058/F20 CraterClock, Werner (2014-18) In kr:	8 853
143997	226214/F50 National Geomagnetic lab, Torsvik (2014-18) In kkr:	8 000
144151	246929/F20 Clim-VoTe,ISP-Geofag, Niscancioglu (2015-20) In kkr:	1 395
190647	234153/E30 BarPz, Faleide (2015-18) CEED-part. In kkr:	1 091
144251	249040/F60 DEEP Research school, Werner (2016-23) In kkr:	23 400
144252	250327 Hyperextension, TB Andersen (2016-19) In kkr:	5 333
144312	250111 600 Myr Plate Model, Domeier (2016-20) In kkr:	6 997
144256	254962 Basement and Depos. Systems, Faleide (2016-19) In kkr:	4 980
144446	261729 Changes at the Top of the World, Gaina (2017-19) In kkr:	4 500
144450	263000 Ashlantic, Jones (2017-20) In kr:	7 818
190645	268094/E10 The Future is, Svensen (2017-20) CEED part In kkr:	228
144657	276032 Platonics, Rolf (2018-22) In kr:	7 678
650129	Lusi Lab ERC start up grant, Mazzini (2013-18) In Euro:	1 422 420
651025	Subitop European Training network, Gaina (2016-20), In Euro.	286 275
651021	PTAL H2020 COMPET, Werner (2016-19) In Euro:	599 914
690471	3D Earth, ESA ITT, Gaina (2017-19), In Euro	250 000
690477	Cratering Rates on Moon and Mars, ESA Prodex Werner (2017-20), In Euro:	320 000
421048	Chronos, Stein/Hannah 2014-18. To CSU: 14 5000 kkr, to UiO in kkr:	9 500
461349	Shephard, G. VISTA, (salary at Vista), running costs at UiO in kkr:	100
421269	Ørnen, Det Norske, Planke/Faleide (2018-20), in kkr	900
UiO funding	Strategy grant (2013-22) in kkr	2 000
UiO funding	3+2 PhD positions incl. Running costs in kkr	3 728
UiO funding	Salary paid by UiO (not PhD-pos). in kkr	4 744
500-103601	Desktop, Conrad/Heeremans USIT funding in kkr	1 050
UiO funding	overhead from other projects , CEED part in kkr	852
UiO funding	PES funding in kkr	160
Covered by UiO	Overhead on SFF staff, overhead on UiO staff, estimate in kkr	7 399

Invited guest lectures at CEED

1. Glacial retreats in the Barents Sea: implications for gas hydrates formation - Nov. 26, by **Renata Lucchi**, Geosciences Research Group, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Trieste, Italy.
2. The development of rifting and magmatism in Ethiopia: implications for the development of continent-ocean transition - Nov. 21, by **Ian Bastow** ,Imperial College London, UK
3. The importance of subduction history and mineral grain size evolution to mantle dynamics - Nov. 19, by **Juliane Dannberg** ,Department of Earth and Planetary Sciences, University of California, USA
4. Laurentia in the mid-Cretaceous (120 to 90 Ma): Reconciling the Cordilleran and Cratonic geological records - Nov. 15, by **Stephen Johnston** ,Dept. of Earth & Atmospheric Sciences, University of Alberta, Canada
5. Small lunar crater degradation and crater's SFD and lifetime - Nov. 2, by **Boris Ivanov** Institute for Dynamics of Geospheres, Russian Academy of Science
6. Discrepancies in SKS-SKKS shear wave splitting: An indicator for contributions ,lowermost mantle anisotropy - Nov. 1, by **Michael Grund** ,Karlsruhe Institute of Technology, Germany
7. Ophiolites: A window on past subduction initiation events - Oct. 18, by **Marco Maffione** School of Geography, Earth and Environmental Sciences, University of Birmingham, UK
8. Geophysical observations and a radical model for the the North Atlantic and Iceland - Oct. 11, by **Christian Schiffer** Durham University (UK) and Uppsala University (Sweden)
9. Generating plate tectonics ,the grain to global scale - Oct. 4, by **David Bercovici** Department of Geology and Geophysics, Yale University, USA
10. An ab initio perspective on the magma ocean stage of the Early Earth Sep. 27, by **Razvan Caracas** CNRS, Ecole Normale Supérieure de Lyon, Laboratoire de Géologie de Lyon, France
11. Subduction zones dynamics and structure ,coupled geodynamic and seismological modelling - Sep. 20, by **Manuele Faccenda** , Dipartimento di Geoscienze, Università di Padova
12. The CEED Wilson Lecture 2018: Discovering the Deep - Deep-Sea Volcanic and Hydrothermal Processes in the 21st Century. By Professor **Daniel J. Fornari,** Woods Hole Oceanographic Institution Sep. 18.

From the CEED Wilson lecture 18 September by Daniel J. Fornari.

13. Modelling the Eurasian ice sheet complex and its environmental legacy during the Last Glacial Maximum and beyond – Sep. 13, by **Henry Patton** ,CAGE, University of Tromsø Norway

14. Orphan Slabs at Mid-Mantle Depths - June 7, by **Antoniette Grima** UCL, London, UK

15. Modelling continental crust formation on Archean Earth - May 31, by **Gregor Golabek** Bayerisches Geoinstitut, University of Bayreuth, Germany

16. Key role of Upper mantle rocks in Alpine type orogens: Some speculations derived extensional settings for subduction and collisional processes - May 24, by **Othmar Müntener** University of Lausanne, Switzerland

17. Past warm climates and their implications for future climate sensitivity - May 3, by **Chris Poulsen** Earth and Environmental Sciences, University of Michigan, USA

18. Subduction dynamics in the Western Pacific: Slab dips, plate velocities, and mantle pressure - Apr. 26, by **Adam Holt** Earth, Atmospheric and Planetary Sciences, MIT, USA

19. Reconstructions of Arctic climate seasonality during the Cenozoic using fossil wood - Apr. 24, by **Brian Schubert** University of Louisiana at Lafayette, USA

20. Oceanic gateway, seafloor roughness and oceanic circulation - Apr. 19, 2018 1:15 PM - 2:00 PM, Geology Building Auditorium 1 by **Joanne Whittaker** University of Tasmania

21. Stardust - About micro-meteorites - Apr. 18, 2018 by **Jon Larsen,** Norway

22. Why does the Earth stay habitable? - Apr. 5, by **Philip Pogge von Strandmann** UCL, London, UK

23. Marine ecosystem response to Mesozoic warming events - Mar. 22, by **Richard Twitchett** Natural History Museum, UK

24. Climate crises past and future - Mar. 15, by **Dana Royer** Department of Earth and Environmental Sciences, Wesleyan University, USA

25. Why is there an ocean overturning circulation in the North Atlantic (and not in the North Pacific)? Exploring three hypotheses - Mar. 13, by **David Battisti** Department of Atmospheric Sciences, University of Washington, USA

26. Understanding the links between surface and deep Earth processes: Observations and numerical modeling - Mar. 8, by **Pietro Sternai** University of Geneva, Switzerland

27. Chondritic Xenon in the Earth's mantle: new constrains on mantle plume feeding volcanism in Europe - Mar. 2, by **Antonio Caracausi** Istituto Nazionale di Geofisica e Vucanologia (INGV), Palermo, Italy

28. Trace metal outgassing and sulfide saturation in basaltic magmas - Feb. 15, by **Emma Liu** Department of Earth Sciences, Cambridge, UK

29. Reconstructing oceans lost: the fate of the eastern Mediterranean Paleo- and Neotethys - Feb. 8, by **Derya Gürer** Mantle Dynamics & Tectonics Group, Utrecht University, The Netherlands

30. Climate change, ocean warming, land ice melt and sea level rise - Feb. 1, **Anny Cazenave** Laboratory of Geophysical and Oceanographic Studies (LEGOS), Toulouse, France & ISSI, Bern, Switzerland

31. What controls the slab dynamic in the transition zone and lower mantle - Jan. 25, by **Roberto Agrusta** University of Lyon, France

Scientific publications (red: high impact journals, 13 out of 129 *: young scientists)

1. ***Abdelmalak, Mohamed Mansour; Planke, Sverre**; Polteau, Stephane; **Hartz, Ebbe Hvidegård; Faleide, Jan Inge;** Tegner, Christian; **Jerram, Dougal Alexander**; Millett, John M; Myklebust, Reidun. Breakup volcanism and plate tectonics in the NW Atlantic. Tectonophysics 2018 s. 1-30.
2. Adhikari, Surendra; Caron, Lambert; **Steinberger, Bernhard**; Reager, John T.; Kjeldsen, Kristian K.; Marzeion, Ben; Larour, Eric; Ivins, Erik R.. What drives 20th century polar motion?. Earth and Planetary Science Letters 2018 ; 502. s. 126-132
3. Advokaat, Eldert L.; Marshall, Nathan T; Li, Shihu; **Spakman, Wim**; Krijgsman, Wout; van Hinsbergen, Douwe J J. Cenozoic Rotation History of Borneo and Sundaland, SE Asia Revealed by Paleomagnetism, Seismic Tomography, and Kinematic Reconstruction. Tectonics 2018 ; 37.(8) s. 2486-2512
4. Akhmanov,G.G; O.M. Khlystov, M.A. Solovyeva, V.N. Efremov, O.N. Vidishcheva, **A. Mazzini,** A.A. Kudaev, I.A. Bulanova, A.A. Barymova, E.K. Gordeev, M.T. Delengov, E.D. Egoshina, Ya.V. Sorokoumova, P.O. Ponimaskin (2018) Moscow University Geology Bulletin. November 2018, Volume 73, Issue 6, pp 582–587.
5. Allan, Neil L.; Thomas, Lynne; Hart, Judy; Freeman, Colin; **Mohn, Chris Erik**. Calcite–magnesite solid solutions: using genetic algorithms to understand non-ideality. Physics and chemistry of minerals 2018 s. 1-10
6. Bellwald, B. and **Planke, S.** (2018) Shear margin moraine, mass transport deposits and soft beds revealed by high-resolution P-Cable three-dimensional seismic data in the Hoop area, Barents Sea. Geological Society, London, Special Publications, 477, SP477-29.
7. Bellwald, Benjamin; **Planke, Sverre**; Piasecka, Emilia Daria; Matar, Mohammed A.; Andreassen, Karin. Ice-stream dynamics of the SW Barents Sea revealed by high-resolution 3D seismic imaging of glacial deposits in the Hoop area. Marine Geology 2018 ; 402. s. 165-183
8. Boschman, L. M., van Hinsbergen, D. J. J., Kimbrough, D. L., Langereis, C. G., & **Spakman, W.** (2018). The dynamic history of 220 Million Years of subduction below Mexico: A correlation between slab geometry and overriding plate deformation based on geology, paleomagnetism, and seismic tomography. Geochemistry, Geophysics, Geosystems, 19, 4649–4672
9. ***Bostic, Joshua Neilson; Hagopian, William Martin; Jahren, Anne Hope**. Carbon and nitrogen stable isotopes in U.S. milk: Insight into production process. Rapid Communications in Mass Spectrometry 2018 ; 32.(7) s. 561-566
10. Bredow, Eva; **Steinberger, Bernhard**. Variable Melt Production Rate of the Kerguelen HotSpot Due To Long-Term Plume-Ridge Interaction. Geophysical Research Letters 2018 ; 45.(1) s. 126 -136
11. Chertova, Mariya V.; **Spakman, Wim; Steinberger, Bernhard**. Mantle flow influence on subduction evolution. Earth and Planetary Science Letters 2018 ; 489. s. 258-266
12. ***Collignon, Marine; Mazzini, Adriano**; Schmid, Daniel Walter; Lupi, Matteo. Modelling fluid flow in active clastic piercements: challenges and approaches. Marine and Petroleum Geology 2018 ; 90. s. 157-172
13. ***Collignon, Marine**; Schmid, Daniel Walter; Galerne, Christophe Yann; Lupi, Matteo; **Mazzini, Adriano**. Modelling fluid flow in clastic eruptions: Application to the Lusi mud eruption. Marine and Petroleum Geology 2018 ; 90. s. 173-190
14. Coltice, Nicolas; **Shephard, Grace**. Tectonic predictions with mantle convection models. Geophysical Journal International 2018 ; 213.(1) s. 16-29
15. **Corseri, Romain**; Faleide, Thea Sveva; **Faleide, Jan Inge**; Midtkandal, Ivar; Serck, Christopher Sæbø; Trulsvik, Mikal; **Planke, Sverre**. A diverted submarine channel of Early Cretaceous age revealed by high-resolution seismic data, SW Barents Sea. Marine and Petroleum Geology 2018 ; 98. s. 462-476
16. ***Crameri, Fabio**. Geodynamic diagnostics, scientific visualisation and StagLab 3.0. Geoscientific Model Development 2018 ; 11.(6) s. 2541-2562
17. ***Crameri, Fabio; Conrad, Clinton Phillips; Montési, Laurent;** Lithgow-Bertelloni, Carolina. The dynamic life of an oceanic plate. Tectonophysics 2018
18. ***Crameri, Fabio**; Lithgow-Bertelloni, Carolina. Abrupt upper-plate tilting during slab-transition-zone collision. Tectonophysics 2018 ; 746. s. 199-211

19. De Min, Angelo; **Callegaro, Sara**; Marzoli, Andrea; Nardy, A.; Chiaradia, Massimo; Marques, Leila S; Gabbarini, Ilaria. Insights into the petrogenesis of low- and high-Ti basalts: Stratigraphy and geochemistry of four lava sequences from the central Paraná basin. Journal of Volcanology and Geothermal Research 2018, 355. s. 232-252

20. Di Felice, F; **Mazzini, Adriano**; Di Stefano, G; Romeo, G. Drone high resolution infrared imaging of the Lusi mud eruption. Marine and Petroleum Geology 2018 ; 90. s. 38-51

21. Di Stefano, Giuseppe; Romeo, G; **Mazzini, Adriano**; Iarocci, Alessandro; Hadi, S.; Pelphrey, S.. The Lusi drone: A multidisciplinary tool to access extreme environments. Marine and Petroleum Geology 2018 ; 90. s. 26-37

22. DiMarzio, Jenna M; **Georgiev, Svetoslav; Stein, Holly J.; Hannah, Judith L.**. Residency of rhenium and osmium in a heavy crude oil. Geochimica et Cosmochimica Acta 2018 ; 220. s. 180-200

23. ***Domeier, Mathew**. Early Paleozoic tectonics of Asia: Towards a full-plate model. Geoscience Frontiers 2018 ; 9.(3) s. 789-862

24. ***Domeier, Mathew; Magni, Valentina;** Hounslow, Mark W; **Torsvik, Trond**. H. (2018). Episodic zircon age distributions mimic fluctuations in subduction. Scientific Reports 8, Article number: 17471.

25. Ershova, Victoria; Anfinson, Owen; Prokopiev, Andrei; Khudoley, Andrei; Stockli, Daniel; **Faleide, Jan Inge; Gaina, Carmen**; Malyshev, Nikolay. Detrital zircon (U-Th)/He ages from Paleozoic strata of the Severnaya Zemlya Archipelago: Deciphering multiple episodes of Paleozoic tectonic evolution within the Russian High Arctic. Journal of Geodynamics 2018

26. Eshagh, Mehdi; **Steinberger, Bernhard**; Tenzer, Robert; Tassara, Andres. Comparison of gravimetric and mantle flow solutions for sub-lithopsheric stress modeling and their combination. Geophysical Journal International 2018 ; 213.(2) s. 1013-1028

27. **Gac, Sebastien**; Hansford, Peter Anthony; Faleide, Jan Inge. Basin modelling of the SW Barents Sea. Marine and Petroleum Geology 2018 ; 95. s. 167-187

28. **Gaina, Carmen; Jakob, Johannes**. Global Eocene tectonic unrest: Possible causes and effects around the North American plate. Tectonophysics 2018 s. 1-16

29. Georgiev, Svetoslav; Zimmerman, Aaron; Yang, Gang; Goswami, Vineet; Hurtig, Nicole C.; **Hannah, Judith L.; Stein, Holly J**.. Comparison of chemical procedures for Re-isotopic measurements by N-TIMS. Chemical Geology 2018 ; 483. s. 151-161

30. Glerum, Anne; Thieulot, Cedric; Fraters, M; Blom, Constantijn; **Spakman, Wim.** Nonlinear viscoplasticity in ASPECT: Benchmarking and applications to subduction. Solid Earth (SE) 2018 ; 9.(2) s. 267-294

31. Gordienko, I.V.; Metelkin, D.; Vetluzhskikh, L.I.; Mikhaltsov, N.E.; **Kulakov, Evgeniy**. New palaeomagnetic data from Argun terrane. Testing its association with Amuria and the Mongol-Okhotsk Ocean. Geophysical Journal International 2018 ; 213.(3) s. 1463-1477

32. Goswami, Vineet; **Hannah, Judith L.; Stein, Holly J..** Why terrestrial coals cannot be dated using the Re-Os geochronometer: Evidence from the Finnmark Platform, southern Barents Sea and the Fire Clay coal horizon, Central Appalachian Basin. International Journal of Coal Geology 2018 ; 188. s. 121-135

33. Gürer, D.; Plunder, A.; Kirst, F.; **Corfu, Fernando**; Schmid, S.M.; van Hinsbergen, D.J.J.. A long-lived Late Cretaceous-early Eocene extensional province in Anatolia? Structural evidence from the Ivriz Detachment, southern central Turkey. Earth and Planetary Science Letters 2018 ; 481. s. 111-124

34. Gyøry, Emil; Hammer, Øyvind; Jorde, Knut; Nakrem, Hans Arne; Swajda, Michael; **Domeier, Mathew.** The origin of telemarkites from the mesoproterozoic of telemark, Norway. Norsk Geologisk Tidsskrift 2018 ; 98.(1) s. 25-39

35. **Hagopian, William M**; Schubert, Brian A; Graper, Robert A; **Jahren, Anne H.** Plant growth chamber design for subambient pCO₂ and ? ¹³C studies. Rapid Communications in Mass Spectrometry 2018 ; 32.(15) s. 1296-1302

36. ***Heimdal, Thea Hatlen; Svensen, Henrik**; Ramezani, Jahandar; Iyer, Karthik Herman; Pereira, Egberto; Rodrigues, René; **Jones, Morgan Thomas; Callegaro, Sara**. 2018. Large-scale sill emplacement in Brazil as a trigger for the end-Triassic crisis. Scientific Reports 8 (1), 141.

37. ***Heyn, Björn Holger; Conrad, Clinton Phillips; Trønnes, Reidar G**. Stabilizing effect of compositional viscosity contrasts on thermochemical piles. Geophysical Research Letters 2018 ; 45.(15) s. 7523-753.

38. Hosseini, Kasra; Matthews, Kara J.; Sigloch, Karin; **Shephard, Grace; Domeier, Mathew;** Tsekhmistrenko, Maria. SubMachine: Web-Based Tools for Exploring Seismic Tomography and Other Models of Earth's Deep Interior. Geochemistry Geophysics Geosystems 2018 ; 19.(5) s. 1464-1483.

39. Hounslow, Mark W.; **Domeier, Mathew;** Biggin, Andrew J.. Subduction flux modulates the geomagnetic polarity reversal rate. Tectonophysics 2018 ; 742-743. s. 34-49

40. Indrevær, Kjetil; **Gac, Sebastien**; Gabrielsen, Roy H; **Faleide, Jan Inge** (2018). Crustal-scale subsidence and uplift caused by metamorphic phase changes in the lower crust: A model for the evolution of the Loppa High area, SW Barents Sea from late Paleozoic to Present. Journal of the Geological Society 2018 ;Volum 175.(3), s. 497-508.

41. Inguaggiato, Salvatore; **Mazzini, Adriano**; Vita, Fabio; Sciarra, Alessandra. The Arjuno-Welirang volcanic complex and the connected Lusi system: Geochemical evidences. Marine and Petroleum Geology 2018 ; 90. s. 67-76

42. Iyer, K., **Svensen, H.H.**, and Schmid, D. W. (2018) SILLi 1.0: A 1D Numerical Tool Quantifying the Thermal Effects of Sill Intrusions. Geoscientific Model Development, 11, 43-60, 2018

43. Jamtveit, Bjørn; Moulas, Evangelos; **Andersen, Torgeir Bjørge**; Austrheim, Håkon Olaf; Corfu, Fernando; Petley-Ragan, Arianne Juliette; Schmalholz, Stefan Markus. High Pressure Metamorphism Caused by Fluid Induced Weakening of Deep ontinental Crust. Scientific Reports 2018 ; 8. s. -

44. Jannin, S., Gervais, F., Moukhsil, A., & Augland, L.E. (2018) Late-Grenvillian channel flow in the central Grenville Province (Manicouagan Reservoir area): New constraints from a structural and geochronological study of the Allochthon Boundary Thrust. Journal of Structural Geology. ISSN 0191-8141. 115, s 132- 151

45. Jeanniot, Ludovic; **Buiter, Susanne**. A quantitative analysis of transtensional margin width. Earth and Planetary Science Letters 2018 ; 491. s. 95-108

46. Jensen, Mari Fjalstad; **Nisancioglu, Kerim Hestnes**; Spall, Michael A.. Large changes in sea ice triggered by small changes in Atlantic water temperature. Journal of Climate 2018 ; 31.(12) s. 4847-4863

47. Karstens, Jens; Haflidason, Haflidi; Becker, Lukas; Berndt, Christian; Rüpke, Lars Helmuth; **Planke, Sverre**; Liebetrau, Volker; Schmidt, Mark; Mienert, Jurgen. Correction: Glacigenic sedimentation pulses triggered post-glacial gas hydrate dissociation (Nature Communications DOI: 10.1038/s41467-018-03043-z). Nature Communications 2018 ; 9.(1)

48. Kastner, Felix; Giese, Rudiger; **Planke, Sverre**; Millett, John M; Flovenz, Olafur G. Seismic imaging in the Krafla high-temperature geothermal field, NE Iceland, using zero- and far-offset vertical seismic profiling (VSP) data. Journal of Volcanology and Geothermal Research 2018

49. Khudoley, Andrei K.; Verzhbitsky, Vladimir E.; **Zastrozhnov, Dmitry**; O'Sullivan, Paul; Ershova, Victoria B.; Proskurnin, Vasily F.; Tuchkova, Marianna I.; Rogov, Mikhail A.; Kyser, T. Kurtis; Malyshev, Sergey V.; Schneider, Gennady V.. Late Paleozoic ? Mesozoic tectonic evolution of the Eastern Taimyr-Severnaya Zemlya Fold and Thrust Belt and adjoining Yenisey-Khatanga Depression. Journal of Geodynamics 2018

50. ***Kiraly, Agnes**; Faccenna, Claudio; Funiciello, Francesca. Subduction zones interaction around the Adria microplate and the origin of the Apenninic arc. Tectonics 2018 s. 1-13

51. ***Kiraly, Agnes**; Holt, Adam; Funiciello, Francesca; Faccenna, Claudio; Capitanio, Fabio A.. Modeling Slab-Slab Interactions: Dynamics of Outward Dipping Double-Sided Subduction Systems. Geochemistry Geophysics Geosystems 2018 ; 19.(3) s. 693-714

52. Koehl, Jean-Baptiste; Bergh, Steffen G; Henningsen, Tormod; **Faleide, Jan Inge** (2018). Middle to Late Devonian–Carboniferous collapse basins on the Finnmark Platform and in the southwesternmost Nordkapp basin, SW Barents Sea. Solid Earth (SE) 2018; Volum 9.(2), s. 341-372
53. Konrad, Kevin; Koppers, Anthony A.P.; **Steinberger, Bernhard**; Finlayson, Valerie A.; Konter, Jasper G.; Jackson, Matthew G.. On the relative motions of long-lived Pacific mantle plumes. Nature Communications 2018 ; 9.
54. Kouhestani, Hossein; Mokhtari, Mir Ali Asghar; Chang, Zhaoshan; **Stein, Holly J.;** Johnson, Craig A.. Timing and genesis of ore formation in the Qarachilar Cu-Mo-Au deposit, Ahar-Arasbaran metallogenic zone, NW Iran: Evidence from geology, fluid inclusions, O-S isotopes and Re-Os geochronology. Ore Geology Reviews 2018 ; 102. s. 757-775
55. Lebedeva-Ivanova, N., Polteau, S., Bellwald, B., **Planke, S**., Berndt, C. and Stokke, H.H., (2018) Toward one-meter resolution in 3D seismic. The Leading Edge, 37(11), pp.818-828.
56. Lerch, Benedikt; Karlsen, Dag Arild; Thießen, Olaf; Abay, Tesfamariam Berhane; van Soelen, Elsbeth Ester; Kürschner, Wolfram Michael; **Planke, Sverre**; Backer-Owe, Kristian. Investigations on the use of triaromatic dimethylcholesteroids as age-specific biomarkers in bitumens and oils from Arctic Norway. Organic Geochemistry 2018 ; 122. s. 1-16
57. Li, Yunguo; Vocadlo, Lidunka; **Brodholt, John Peter**. The elastic properties of hcp-Fe alloys under the conditions of the Earth's inner core. Earth and Planetary Science Letters 2018 ; 493. s. 118-127
58. Liu, S.V., Moore, L.B., Halliday, T.M., **Jahren, A.H**., Salva, J., Hendrick, V.E., Marinik, E.L., and Davy, B.M. (2018) Short-term changes in added sugar consumption by adolescents reflected in the carbon isotope ratio of fingerstick blood. Nutrition and Health, 24(4):251-253.
59. Lupi, Matteo; **Mazzini, Adriano**; Sciarra, Alessandra; **Collignon, Marine**; Schmid, Daniel Walter; **Husein, Alwi**; Romeo, Giovanni; Obermann, Anne; **Karyono, Karyono**. Enhanced hydrothermal processes at the new-born Lusi eruptive system, Indonesia. Journal of Volcanology and Geothermal Research 2018 ; 366. s. 47-57
60. ***Løken, Andreas**; Ricote, Sandrine; Wachowski, Sebastian Lech. Thermal and chemical expansion in proton ceramic electrolytes and compatible electrodes. Crystals 2018 ; 8.(9) s. -
61. MacDougall, Carly R.; Hill, Catelyn E.; **Jahren, Anne Hope**; Salva, Jyoti; Riebl, Shaun K.; Hedrick, Valissa E.; Raynor, Hollie A.; Dunsmore, Julie C.; Frisard, Madlyn I.; Davy, Brenda M.. The δ13C Value of Fingerstick Blood Is a Valid, Reliable, and Sensitive Biomarker of Sugar-Sweetened Beverage Intake in Children and Adolescents. Journal of Nutrition 2018 ; 148. s. 147-152
62. Malvoisin, Benjamin; **Mazzini, Adriano**; Miller, Stephen A.. Deep hydrothermal activity driving the Lusi mud eruption. Earth and Planetary Science Letters 2018 ; 497. s. 42-49
63. Mauri, Guillaume; **Husein, Alwi; Mazzini, Adriano**; Irawan, Dwinata; Sohrabi, Reza; Hadi, Soffian; Prasetyo, Hardi; Miller, Stephen A.. Insights on the structure of Lusi mud edifice from land gravity data. Marine and Petroleum Geology 2018 ; 90. s. 104-115
64. Mauri, Guillaume; **Husein, Alwi; Mazzini, Adriano; Karyono, Karyono**; Obermann, Anne; Bertrand, Guillaume; Lupi, Matteo; Prasetyo, Hardi; Hadi, Soffian; Miller, Stephen A.. Constraints on density changes in the funnel-shaped caldera inferred from gravity monitoring of the Lusi mud eruption. Marine and Petroleum Geology 2018 ; 90. s. 91-103
65. **Mazzini, Adriano.** 10 years of Lusi eruption: Lessons learned from multidisciplinary studies (LUSI LAB). *Marine and Petroleum Geology* 2018 ;Volum 90. s. 1-9
66. **Mazzini, Adriano**; Scholz, Florian; **Svensen, Henrik;** Hensen, Christian; Hadi, Soffian. The geochemistry and origin of the hydrothermal water erupted at Lusi, Indonesia. Marine and Petroleum Geology 2018 ; 90. s. 52-66
67. **Medvedev, Sergei; Hartz, Ebbe Hvidegård; Faleide, Jan Inge**. Erosion-driven vertical motions of the circum Arctic: Comparative analysis of modern topography. Journal of Geodynamics 2018
68. Miller, Stephen; **Mazzini, Adriano**. More than ten years of Lusi: A review of facts, coincidences, and past and future studies. Marine and Petroleum Geology 2018 ; 90. s. 10-25
69. ***Minakov, Alexander**. Late Cenozoic lithosphere dynamics in Svalbard: Interplay of glaciation, seafloor spreading and mantle convection. Journal of Geodynamics 2018 ; 122. s. 1-16

70. **Minakov, A.,** Yarushina, V., **Faleide, J.I.,** Krupnova, N., Sakoulina, T., Dergunov, N., Glebovsky, V. (2018) Dyke emplacement and crustal structure within a continental large igneous province, northern Barents Sea. Geological Society Special Publication, Volume 460, Issue 1, 2018, Pages 371-395.

71. Moghadam, Fereshteh Ranjbar; Masoudi, Fariborz; **Corfu, Fernando**; Homam, Seyed Massoud. Ordovician mafic magmatism in an ediacaran arc complex, sibak, northeastern Iran: The eastern tip of the Rheic Ocean. Canadian journal of earth sciences (Print) 2018 Volume 55.(10) p. 1173-1182

72. **Mohn, Chris Erik.** Predicting cation ordering in MgAl2O4 using genetic algorithms and density functional theory. Materials and Manufacturing Processes 2018 ; 33.(2) s. 174-179

73. Moscariello, Andrea; Do Couto, Damien; Mondino, Fiammetta; Booth, Jacqueline; Lupi, Matteo; **Mazzini, Adriano**. Genesis and evolution of the Watukosek fault system in the Lusi area (East Java). Marine and Petroleum Geology 2018 ; 90. s. 125-137

74. Müller, D.R; J. Cannon; X. Qin; **R.J Watson**; M. Gurnis; S. Williams; T. Pfaffelmoser; M. Seton; S; H.J. Russell; S. Zahirovic (2018). GPlates: Building a Virtual Earth Through Deep Time. Geochemistry, geophysics, geosystems G³, Volume19, Issue7, 2243-2261

75. Nikishin, AM; **Gaina, Carmen**; Petrov, E.I.; Malyshev, NA; Freiman, SI. Eurasia Basin and Gakkel Ridge, Arctic Ocean: Crustal asymmetry, ultra-slow spreading and continental rifting revealed by new seismic data. Tectonophysics 2018 ; 746. s. 64-82. ‘

76. Obermann, Anne; **Karyono, Karyono**; Diehl, T; Lupi, Matteo; **Mazzini, Adriano**. Seismicity at Lusi and the adjacent volcanic complex, Java, Indonesia. Marine and Petroleum Geology 2018 ; 90. s. 149-156.

77. Oliveira, Benat; **Afonso, Juan Carlos**; Zlotnik, Sergio; Diez, Pedro. Numerical modelling of multiphase multicomponent reactive transport in the Earth's interior. Geophysical Journal International 2018 ; 212.(1) s. 345-388.

78. Osei Tutu, Anthony; Sobolev, Stephan V.; **Steinberger, Bernhard**; Popov, A.A.; Rogozhina, Irina. Evaluating the Influence of Plate Boundary Friction and Mantle Viscosity on Plate Velocities. Geochemistry Geophysics Geosystems 2018 ; 19.(3) s. 642-666

79. Osei Tutu, Anthony; **Steinberger, Bernhard**; Sobolev, Stephan V.; Rogozhina, Irina; Popov, Anton A.. Effects of upper mantle heterogeneities on the lithospheric stress field and dynamic topography. Solid Earth (SE) 2018 ; 9.(3) s. 649-668.

80. Owen-Smith, T.M.; Ganerød, Morgan; van Hinsbergen, Douwe J J; **Gaina, Carmen**; **Ashwal, Lewis D.; Torsvik, Trond Helge.** Testing Early Cretaceous Africa - South America fits with new palaeomagnetic data from the Etendeka Magmatic Province (Namibia). Tectonophysics 2018 s. 1-13

81. Panzera, Francesco; D'Amico, Sebastiano; Lupi, Matteo; Mauri, Guillaume; **Karyono, Karyono; Mazzini, Adriano**. Lusi hydrothermal structure inferred through ambient vibration measurements. Marine and Petroleum Geology 2018 ; 90. s. 116-124

82. Peral, Mireia; **Kiraly, Agnes**; Zlotnik, Sergio; Funiciello, Francesca; Fernandez, Manel; Faccenna, Claudio; Vergés, Jaume. Opposite Subduction Polarity in Adjacent Plate Segments. Tectonics 2018 ; 37.(9) s. 3285-3302

83. Pirli, Myrto; Hainzl, S.; **Schweitzer, Johannes**; Köhler, Andreas; Dahm, Torsten. Localised thickening and grounding of an Antarctic ice shelf from tidal triggering and sizing of cryoseismicity. Earth and Planetary Science Letters 2018 ; 503. s. 78-87

84. Pirli, Myrto; **Schweitzer, Johannes**. Seismicity along the Mohns—Knipovich Ridge Bend and its correlation to ridge spreading rate. Journal of Geodynamics 2018 ; 118. s. 182-196R

85. Plach, Andreas; **Nisancioglu, Kerim Hestnes**; Le clec'h, Sebastien; Born, Andreas; Langebroek, Petra; Guo, Chuncheng; Imhof, Michael; Stocker, Thomas F.. Eemian Greenland SMB strongly sensitive to model choice. Climate of the Past 2018 ; 14.(10) s. 1463-1485

86. Polteau, Stephane; **Mazzini, Adriano**; Hansen, Geir; **Planke, Sverre; Jerram, Dougal** Alexander; Millett, John; **Abdelmalak, Mohamed Mansour**; Blischke, Anett; Myklebust, Reidun. The pre-breakup stratigraphy and petroleum system of the Southern Jan Mayen Ridge revealed by seafloor sampling. Tectonophysics 2018

87. ***Prieur, Nils Charles; Rolf, Tobias**; Wünnemann, Kai; Werner, **Stephanie C..** Formation of simple impact craters in layered targets: Implications for lunar crater morphology and regolith thickness. Journal of Geophysical Research - Planets 2018 ; 123.(6) s. 1555-1578

88. Reiser, Fabienne; Schmelzbach, Cedric; Sollberger, David; Maurer, Hansruedi; Greenhalgh, Stewart; **Planke, Sverre**; Kastner, Felix; Flovenz, Olafur G; Giese, Rudiger; Halldorsdottir, Sæunn; Hersir, Gylfi Pall. Imaging the high-temperature geothermal field at Krafla using vertical seismic profiling. Journal of Volcanology and Geothermal Research 2018

89. Riel, Nicolas; Bouilhol, Pierre; van Hunen, Jeroen; Cornet, Julien; **Magni, Valentina**; Grigorova, Vili; Velic, Mirko. Interaction between mantle-derived magma and lower arc crust: quantitative reactive melt flow modelling using STyx. Geological Society Special Publication 2018

90. ***Robert, Boris**; Greff-Lefftz, Marianne; Besse, Jean. True Polar Wander: A Key Indicator for Plate Configuration and Mantle Convection During the Late Neoproterozoic. Geochemistry Geophysics Geosystems 2018 ; 19.(9) s. 3478-3495

91. ***Rolf, Tobias**; Capitanio, Fabio; Tackley, Paul J.. Constraints on mantle viscosity structure from continental drift histories in spherical mantle convection models. Tectonophysi. 2018

92. ***Rolf, Tobias**; Pesonen, L.J.. Geodynamically consistent inferences on the uniform sampling of Earth's paleomagnetic inclinations. Gondwana Research 2018 ; 63. s. 1-14

93. ***Rolf, Tobias; Steinberger, Bernhard; Uppalapati, Sruthi; Werner, Stephanie C..** Inferences on the mantle viscosity structure and the post-overturn evolutionary state of Venus. Icarus (New York, N.Y. 1962) 2018 ; 313. s. 107-123

94. Samankassou, Elias; **Mazzini, Adriano**; Chiaradia, Massimo; Spezzaferri, Silvia; Moscariello, Andrea; Do Couto, Damien. Origin and age of carbonate clasts from the Lusi eruption, Java, Indonesia. Marine and Petroleum Geology 2018 ; 90. s. 138-148

95. Schubert, Brian A; **Jahren, Anne Hope**. Incorporating the effects of photorespiration into terrestrial paleoclimate reconstruction. Earth-Science Reviews 2018 ; 177. s. 637-642

96. Sciarra, Alessandra; **Mazzini, Adriano**; Inguaggiato, S.; Vita, F.; Lupi, Matteo; Hadi, S.. Radon and carbon gas anomalies along the Watukosek Fault System and Lusi mud eruption, Indonesia. Marine and Petroleum Geology 2018 ; 90. s. 77-90

97. Sebastian T; K. Smart; **T.H. Torsvik**; M.Massuyeau; M. de Wit (2018) Geodynamics of kimberlites on a cooling Earth: Clues to plate tectonic evolution and deep volatile cycles. Earth and planetary science letters, 484, p.1-14.

98. ***Shephard, Grace**; Wiers, Steffen; Bazhenova, Evgenia; Perez, Lara F; Mejia, Luz Maria; Johansson, Carina; Jakobsson, Martin; O'Regan, Matt. A North Pole thermal anomaly? Evidence from new and existing heat flow measurements from the central Arctic Ocean. Journal of Geodynamics 2018 ; 118. s. 166-181

99. ***Shulgin, Alexey** A; Mjelde, Rolf; **Faleide, Jan Inge;** Høy, Tore; Flueh, Ernst; **Thybo, Hans**. The crustal structure in the transition zone between the western and eastern Barents Sea. Geophysical Journal International 2018 ; 214.(1) s. 315-330

100. Slagstad, Trond; Maystrenko, Yuriy; **Maupin, Valerie**; Gradmann, Sofie. An extinct, Late Mesoproterozoic, Sveconorwegian mantle wedge beneath SW Fennoscandia, reflected in seismic tomography and assessed by thermal modelling. Terra Nova 2018 ; 30.(1) s. 72-77

101. Sohrabi, Reza; Jansen, Gunnar; Malvoisin, Benjamin; **Mazzini, Adriano**; Miller, Stephen A.. Numerical modeling of the Lusi hydrothermal system: Initial results and future challenges. Marine and Petroleum Geology 2018 ; 90. s. 191-200

102. Spakman, Wim; Chertova, Mariya V.; Van Den Berg, Arie; van Hinsbergen, Douwe J J. Puzzling features of western Mediterranean tectonics explained by slab dragging. Nature Geoscience 2018 ; 11.(3) s. 211-216

103. Steiger, Nadine; **Nisancioglu, Kerim Hestnes**; Åkesson, Henning; de Fleurian, Basile; Nick, Faezeh M.. Simulated retreat of Jakobshavn Isbræ since the Little Ice Age controlled by geometry. The Cryosphere 2018 ; 12.(7) s. 2249-2266

104. **Steinberger, Bernhard**; Becker, Thorsten W.. A comparison of lithospheric thickness models. Tectonophysics 2018 ; 746. s. 325-338

105. ***Stokke, Ella Wulfsberg**; Gasser, Deta; Dalslåen, Bjørgunn Heggem; Grenne, Tor. Tectonic evolution of syn- to late-orogenic sedimentary- volcanic basins in the central Norwegian Caledonides. Journal of the Geological Society 2018 ; 175.(4) s. 605-618

106. Struijk, Erzsébet L.M.; Tesauro, Magdala; **Lebedeva-Ivanova, Nina N.; Gaina, Carmen;** Beekman, Fred; Cloetingh, Sierd A.P.L. The Arctic lithosphere: Thermo-mechanical structure and effective elastic thickness. Global and Planetary Change 2018

107. **Svensen, Henrik H**; S. Frolov, Grigorii G. Akhmanov, Alexander G. Polozov, **Dougal A. Jerram,** Olga V. Shiganova, Nikolay V. Melnikov, Karthik Iyer, **Sverre Planke (**2018). Philosophical Transactions of the Royal Society A, A, 376: 20170080, Not in cristin

108. **Svensen, Henrik**; Iyer, Karthik Herman; Schmid, Daniel Walter; **Mazzini, Adriano**. Modelling of gas generation following emplacement of an igneous sill below Lusi, East Java, Indonesia. Marine and Petroleum Geology 2018 ; 90. s. 201-208

109. **Svensen, Henrik; Torsvik, Trond Helge; Callegaro, Sara; Augland, Lars Eivind; Heimdal, Thea Hatlen; Jerram, Dougal Alexander; Planke, Sverre;** Pereira, Egberto. Gondwana large igneous provinces: plate reconstructions, volcanic basins and sill es. In: Large Igneous Provinces from Gondwana and Adjacent Regions. Geological Society Special Publication 2018 ; 463. s. 17-40

110. Sætre, Christian; Hellevang, Helge; Riu, Lucie; **Dypvik, Henning**; Pilorget, C; Poulet, Francois; **Werner, Stephanie C**.. Experimental hydrothermal alteration of basaltic glass with relevance to Mars. Meteoritics and Planetary Science 2018

111. ***Tan, Pingchuan;** Sippel, Judith; **Breivik, Asbjørn Johan**; Meessen, Chrisitian; Scheck-Wenderoth, Magdalena. Lithospheric Control on Asthenospheric Flow From the Iceland Plume: 3-D Density Modeling of the Jan Mayen-East Greenland Region, NE Atlantic. Journal of Geophysical Research - Solid Earth 2018 ; 123.(10) s. 9223-9248

112. Tappe, Sebastian; Smart, Katie; **Torsvik, Trond Helge**; Massuyeau, Malcolm; de Wit, Mike. Geodynamics of kimberlites on a cooling Earth: Clues to plate tectonic evolution and deep volatile cycles. Earth and Planetary Science Letters 2018 ; 484. s. 1-14

113. Tasianas, Alexandros; Bünz, Stefan; Bellwald, Benjamin; Hammer, Øyvind; **Planke, Sverre;** Lebedeva-Ivanova, Nina; Krassakis, Pavlos. High-resolution 3D seismic study of pockmarks and shallow fluid flow systems at the Snøhvit hydrocarbon field in the SW Barents Sea. Marine Geology 2018 ; 403. s. 247-261

114. Tauzin, Benoit; Kim, Seongryong; **Afonso, Juan Carlos**. Multiple Phase Changes in the Mantle Transition Zone Beneath Northeast Asia: Constraints From Teleseismic Reflected and Converted Body Waves. Journal of Geophysical Research - Solid Earth 2018 ; 123.(8) s. 6636-6657

115. Tetreault, JL; **Buiter, Susanne**. The influence of extension rate and crustal rheology on the evolution of passive margins from rifting to break-up. Tectonophysics 2018 ; 746. s. 155-172

116. Tork Qashqai, Mehdi; **Afonso, Juan Carlos**; Yang, Yingjie. Physical State and Structure of the Crust Beneath the Western-Central United States From Multiobservable Probabilistic Inversion. Tectonics 2018 ; 37.(9) s. 3117-3147

117. **Torsvik, Trond Helge**. Earth history: A journey in time and space from base to top. Tectonophysics 2018 s. 1-17

118. Tripathy, Gyana Ranjan; **Hannah, Judith L.; Stein, Holly J**.. Refining the Jurassic-Cretaceous boundary: Re-Os geochronology and depositional environment of Upper Jurassic shales from the Norwegian Sea. Palaeogeography, Palaeoclimatology, Palaeoecology 2018 ; 503. s. 13-25.

119. Van de Lagemaat, S.H.A., van Hinsbergen D.J.J., Boschman L.M., Kamp P.J.J. and **Spakman W**., Southwest Pacific absolute plate kinematic reconstruction reveals major mid- to Late Cenozoic Tonga-Kermadec slab dragging, Tectonics, 37, 2647–2674.

120. Van Der Meer, Douwe G.; van Hinsbergen, Douwe J J; **Spakman, Wim**. Atlas of the underworld: Slab remnants in the mantle, their sinking history, and a new outlook on lower mantle viscosity. Tectonophysics 2018; 723. s. 309-448

121. van Hinsbergen, Douwe J J; Lippert, Peter C.; Li, Shihu; Huang, Wentao; Advokaat, Eldert L.; **Spakman, Wim**. Reconstructing Greater India: Paleogeographic, kinematic, and geodynamic perspectives. Tectonophysics 2018

122. van Wyk de Vries, Ben; Byrne, Paul; Delcamp, Audray; Einarson, Pall; Göğüş, Oğuz; Guilbaud, Marie-Noelle; Hagos, Miruts; Harangi, Szabolcs**; Jerram, Dougal Alexander**, Matenco, Liviu; Mossoux, Sophie; Nemeth, Karoly; Maghsoudi, Mehran; Petronis, Michael; Rapprich, Vladislav; Rose, William; Vye, Erika. A global framework for the Earth: Putting geological sciences in context.. Global and Planetary Change 2018

123. Watkins, C. Evan; **Conrad, Clinton Phillips**. Constraints on dynamic topography from asymmetric subsidence of the mid-ocean ridges. Earth and Planetary Science Letters 2018 ; 484. s. 264-275

124. Yang, H; Z. Chemia; I.M Artemieva; .**H. Thybo** (2018). Control on off-rift magmatism: A case study of the Baikal Rift Zone. Earth and planetary science letters, 482, p.501-509.

125. **Zastrozhnov, Dmitrii**; Gernigon, Laurent; Gogin, I; **Abdelmalak, Mohamed Mansour; Planke, Sverre; Faleide, Jan Inge;** Eide, S.; Myklebust, R.. Cretaceous-Paleocene Evolution and Crustal Structure of the Northern V?ring Margin (Offshore Mid-Norway): Results from Integrated Geological and Geophysical Study. Tectonics 2018 ; 37.(2) s. 497-528

126. Zhang, Zhigang; Mao, Zhu; Liu, Xi; Zhang, Yigang; **Brodholt, John Peter.** Stability and Reactions of CaCO₃ Polymorphs in the Earth's Deep Mantle. Journal of Geophysical Research - Solid Earth 2018 ; 123.(8) s. 6491-6500

127. Zhao, Minghui; He, Enyuan; Sibuet, Jean-Claude; Sun, Longtao; Qiu, Xuelin; **Tan, Pingchuan;** Wang, Jian. Postseafloor Spreading Volcanism in the Central East South China Sea and Its Formation Through an Extremely Thin Oceanic Crust. Geochemistry Geophysics Geosystems 2018 ; 19.(3) s. 621-641

128. Åkesson, Henning; Morlighem, Mathieu; **Nisancioglu, Kerim Hestne**s; Svendsen, John-Inge; Mangerud, Jan. Atmosphere-driven ice sheet mass loss paced by topography: Insights from modelling the south-western Scandinavian Ice Sheet. Quaternary Science Reviews 2018 ; 195. s. 32-47

129. Åkesson, Henning; **Nisancioglu, Kerim Hestnes**; Nick, Faezeh M.. Impact of fjord geometry on grounding line stability. Frontiers in Earth Science 2018 ; 6. s. -

Books and book chapters

1. Galland, O., Bertelsen, H.S., Eide, C.H., Guldstrand, F., Haug, Ø.T., Leanza, H.A., Mair, K., Palma, O., **Planke, S**., Rabbel, O. and Rogers, B. (2018) Storage and transport of magma in the layered crust — formation of sills and related flat-lying intrusions. In Volcanic and igneous plumbing systems, Elsevier, 113-138.

2. **Jerram, D.A.,** Katherine J. Dobson, Dan J. Morgan, Matthew J. Pankhurst (2018) The Petrogenesis of Magmatic Systems: Using Igneous Textures to Understand Magmatic Processes. In Volcanic and Igneous Plumbing Systems, Editor(s): Steffi Burchardt, Elsevier, Pages 191-229, ISBN 9780128097496

3. Marzoli, A; **Callegaro, S;** Dal Corso, J;Davies, J; Chiaradia, M; Youbi, N; Bertrtand, H; Reisberg, L. (2018). The Central Atlantic Magmatic Province (CAMP): A Review. In: Tanner, L. H. (ed.) The Late Triassic World: Earth in a Time of Transition. Topics in Geobiology. Springer International Publishing, 91–125.

4. **Mohn, Chris Erik;** Allan, Neil L. 2018 Local Environments in Inorganic Solids: From Fast-Ion Conduction to Radiation Damage in Oxides. Taylor & Francis (ISBN 9781771886826) 18 p.

5. **Svensen, Henrik.** Stein på stein. På sporet av den største masseutryddelsen i jordens historie. Aschehoug & Co 2018 (ISBN 978-82-03-29446-4) 239 p.

*PhD student Thea H. Heimdal received the CEED Young Scientist prize for the article **Heimdal, Thea H; Svensen, Henrik**; Ramezani, Jahandar; Iyer, Karthik H; Pereira, Egberto; Rodrigues, René; **Jones, Morgan T; Callegaro, Sara** (2018) Large-scale sill emplacement in Brazil as a trigger for the end-Triassic crisis. Scientific Reports 8 (1), 141. Photo: Siv Heimdal.*

Outreach activities and n the media (Newspaper, radio, TV, Web, Blog etc)

TV; radio; newspapers and magazines

1. Delsett, Lene Liebe; Svensen, Henrik; Sletsjøe, Arne Bernhard; Jemterud, Torkild. Abels tårn 23. mars 2018. NRK P2 Ekko [Radio] 2018-03-23
2. Jahren, A.H. Interview under the title Träd, kärlek och andra växter. By Svenska Dagbladet,
3. Jahren, A.H. Interview on Babel with Jessika Gedin (SVT television) February 17, 2018
4. Jahren, A.H. Interview under the title «Forskaeren vill ta makten» in Di Weekend, Sweden 23.3.
5. Jerram, Dougal Alexander. BBC World News/BBC News 24; interview about Hawaii Volcanic event.. BBC Offices, Birmingham UK [TV] 2018-05-05
6. Mazzini, A. The 2018 Baikal expedition. Interview on Russian TV
7. Trønnes, R. NRK - Alltid nyheter, Nyhetsmagasin, 23 Jaunuary. kl. 1303. Interview about the earch quacke south of Anchorage, m volcanic eruptions at Mayon Filipines, and Mt. Kusatsu-Shirane in Japan.
8. Trønnes, R. NRK - Alle kanaler, Dagsnytt, 23. januar kl. 1400. About the earch quacke south of Anchorage
9. Trønnes, R. NRK-P2, Studio 2, 10. april, kl. 1736.Interview about the East African and the Oslo Rifts (Related to the new Norwegian made film Skjelvet).
10. Magni, Valentina. Jordens indre sluker verdenshav. Apollon [Avis] 2018-02-05
11. Svensen, Henrik. Mellom forskning og formidling. NFFO jubileumsmagasin [Fagblad] 2018-04-01
12. Svensen, Henrik. Stein på stein, en ny bok. NRK Østfold [Radio] 2018-05-09
13. Svensen, Henrik. Tsunamien i Indonesia, 22. desember 2018. TV2 nyhetene [TV] 2018-12-23
14. Svensen, Henrik. Vulkanutbrudd skapte fimbulvinteren. Vårt Land [Avis] 2018-01-09
15. Svensen, Henrik. Øy i Stillehavet blir ubeboelig. dagbladet.no [Avis] 2018-04-22
16. Trønnes, R. NRK - Alltid nyheter, Nyhetsmagasin, 23. januar, kl. 1303. Studiosamtale med Amanda Strand Askeland om jordskjelvet sør for Anchorage (M7.9) og pågående vulkanutbrudd fra Mayon på Filippinene og Mt. Kusatsu-Shirane i Japan.
17. Trønnes, R. NRK - Alle kanaler, Dagsnytt, 23. januar kl. 1400. Utdrag fra tidligere intervju om jordskjelvet sør for Anchorage.
18. Trønnes, R. NRK-P2, Studio 2, 10. april, kl. 1736. Katastrofal kollaps av sedimenter over en sprekkesvrerm nordvest for Nairobi. Studiosamtale med programlederne om oppsprekning, tektonikk og platedrift i Øst-Afrika og Oslofeltet.
19. Trønnes, Reidar G. NRK - Alltid nyheter, Nyhetsettermiddag, 4. mai. kl. 1634. Studiosamtale med programleder Ulf Tannæs-Fjeld om vulkanutbruddet i Kileauea's østlige riftsone i Leilani-området, Hawaii, etter forberedelse av programinnslaget med journalist Eva Marie Bulai
20. Trønnes, Reidar G. TV2-Nyhetskanalen Nyhetsssending 23. mai, kl. 0800 - hovedinnslag etter nyhetsoversikten. Studiosamtale om det pågående utbruddet i Kileauea's østlige riftsone i Leilani-området, Hawaii.

Software development

1. **Crameri, F. (2018),** Scientific Colour-Maps 3.0.4: Perceptually uniform and colour-blind friendly, https://doi.org/10.5281/zenodo.1287763, code repository at www.fabiocrameri.ch/colourmaps <http://www.fabiocrameri.ch/colourmaps.php>

2. **Crameri, F. (2018**), StagLab 3.0.6: Geodynamic diagnostics and scientific visualisation, https://doi.org/10.5281/zenodo.1287674, code repository at www.fabiocrameri.ch/StagLab <http://www.fabiocrameri.ch/StagLab.php>

Web articles and blogs

1. Prieur, Nils Charles. Han er Norges første med doktorgrad i planetologi. Uniforum [Internett] 2018-03-26
2. Prieur, Nils Charles. Hvilke hemmeligheter skjuler kraterne på Månen?. Titan.uio.no [Internett] 2018-04-04
3. Jahren, A.H. & Hagopian, W.. Vil forbrede grantrær på klimaendringene. Interviwe in Forskning.no 9 March.
4. Jones, Morgan Thomas. Store mengder drivhusgass siger ut fra Katla. www.vg.no [Internett] 2018-09-27
5. Sekhar, A. Gender gaps in academia. Nature Correspondence 555, 8.3.2018.
6. Shephard, G.E. Editor for EGU Geodynamics Blog - edited 7 articles in 2018.
7. Shephard, G.E. Postcard from Tokyo: JpGU2018 conference. EGU Geodynamics Blog 23 May 2018 https://blogs.egu.eu/divisions/gd/2018/05/23/postcard-from-tokyo-jpgu2018-conference/
8. Shephard, G.E. Meeting, mentoring and awards at EGU18. EGU Geodynamics Blog 18 April 2018.https://blogs.egu.eu/divisions/gd/2018/04/18/egu18-gd-meeting-mentoring-and-awards/
9. Et forskerliv i stein og vilkaner. Interevju with E-R. Neumann in Titan

Twitter and Instagram accounts disseminating CEED research

1. The CEED twitter account CEED Univ. of Oslo@CEEDOslo - Centre for Earth Evolution and Dynamics at the University of Oslo, Norway – 96 enteries in 2017
2. The DEEP twitter account DEEP Research School@ResearchDEEP - a national research school in geosciences for dynamics and evolution of earth and planets. DEEP aims to educate solid earth and planetary scientists. - 37 enteries in 2017
3. Aswin Sekhar@aswinsek - Scientist+Speaker+Science Writer. Retweets & views NOT from employer or spouse or anyone else! :)
4. Bultel Benjamin@benjaminbejka_ Team member PhD Student It's all about rock...
5. Dr Volcano@dougalearth - DougalEARTH AKA Dr. Volcano, earth scientist. I am interested in all aspects of the great planet, its rocks and landscapes!!
6. Fabio Crameri@fcrameri - Geodynamics, numerical modelling & scientific visualisation
7. Grace Shephard@ShepGracie - Geodynamics, tectonics, Arctic and oceans
8. Hans Jørgen Kjøll@hans_j_k - Ph.D. student at the Center for Earth Evolution and Dynamics at University of Oslo. Working with continental break-up (volcanoes and stuff)
9. Henrik H. Svensen@henriksvensen - Geologiforsker (Univ. Oslo) og sakprosaforfatter. Research Professor in geology (mass extinctions), and writer.
10. Hope Hahren@HopeJahren - author of LAB GIRL, winner of the 2016 NBCC award in autobiography
11. Johannes Jakob @JoJakGeo - Postdoc at the Centre for Earth Evolution and Dynamics at the University of Oslo. I work on plate tectonics – a lot of it is schist, to be honest.
12. Király Ágnes @agi_a_kiraly
13. Morgan Jones@geomorganjones - volcanologist/geochemist working at CEED, expertise is the interaction between volcanic terrains and the climate
14. Nils Charles Prieur@nilscp - French, norwegian, civil engineer, hydrologist, basketball player and now planetary scientist
15. sruthi uppalapati@sruthisruthi
16. Susanne Buiter@susannebuiter - Researcher at the Geological Survey of Norway @nguweb and at Uni Oslo @CEEDOslo. Programme Committee chair #EGU18 @EuroGeosciences
17. Valentina Magni@valentinamagni
18. ceed_ashlantic by Jones&Stokke. Regular update of pictures from the Ashlantic project.

Other Outreach activities

1. Andersen, Torgeir Bjørge. Interview with school kids at Manglerud skole International Classes in Oslo regarding Plate Tectonics, Geology and Geohazards. Interview with schol class at Manglerud International Classes Oslo; 2018-09-25 - 2018-09-28
2. Jahren, A.H. Angry Angry Trees: Reconstruction of volcanic-induced seasonal climate perturbations via high-resolution tree ring stable isotope analysis . Asker International School 9 March
3. Jahren, A.H. Angry Trees: How old trees can tell us the effect of volcanoes on ancient climates and cultures. Asker International School 21 March
4. Shephard, G.E. on behalf of Association of Polar Early Career Scientists (APECS) Norway, co-organized "Polar MeetUp" and seminar at UiO Natural Sciences Library 22nd March 2018.
5. Shephard, G.E. on behalf of Association of Polar Early Career Scientists (APECS) Norway, organized Early Career Poster session at UiO 'Arktisk Dag' 30th October 2018.
6. Svensen, Henrik. Den største masseutryddelsen. Subsea Valley foredrag for skoleelever 5. trinn; 2018-03-22
7. Svensen, Henrik. Geologien i Slemmestad. Deltakelse på feltarbeid, 5. klasse Spikkestad barneskole; 2018-06-01
8. Svensen, Henrik. Geologien i Spikkestad. Foredrag for 5. klasse på Spikkestad barneskole; 2018-05-23
9. Svensen, Henrik. Jordens kriser. Unforsk 2018 (seks foredrag); 2018-09-26 - 2018-09-28
10. Svensen, Henrik. Menneskets tidsalder. Oslo billedkunstnere; 2018-09-04
11. Svensen, Henrik. Stein på stein. Foredrag; 2018-10-23
12. Svensen, Henrik. Verdens viktigste fagfelt. Seminar for nye studenter; 2018-08-14
13. Trønnes, Reidar G. Cinemateket og Oslo Society of Exploration Geophysicists (OSEG), 5. sept.: Fremvisning av spillefilmen "Skjelvet", etterfulgt av paneldebatt om jordskjelv i Oslo-riften, sårbarhet for infrastruktur, næringsbygg og boliger og sivilt beredskapTrønnes, Reidar G; Larsen, BT. NORSAR 50-års jubileumsutstilling om Oslo-riften på Rådhusplassen i Oslo. Utstillingsåpning 23. august.. [Kunstnerisk og museal presentasjon] NORSAR 50-års jubileumsutstilling om Oslo-riften på Rådhusplassen i Oslo. Utstillingsåpning 23. august. . 2018-08-23
14. Trønnes, Reidar G; Larsen, BT. NORSAR 50-års jubileumsutstilling om Oslo-riften på Rådhusplassen i Oslo. Utstillingsåpning 23. august.
15. van den Broeck, Joost: Excursion with a school class from Elvebakken Videregående to the cobalt mines in the Modum area. 27 April.

HELGEAVISA ANBEFALER

1

«STEIN PÅ STEIN»

av Henrik H. Svensen

For 252 millioner år siden forsvant mer enn 90 prosent av alt liv på jorda. Spørsmålet er hva som forårsaket den største masseutryddelsen i jordas historie. Svensen har en sjelden evne til å levendegjøre stoffet. Han får gråstein til å framstå som hieroglyfer, og gir oss innsikt i forskningens forunderlige verden. Denne boka er så underholdende, innsiktsfull og spennende at jeg nærmest vil kalle det en pageturner.

CATHRINE KRØGER

Top: ***Henrik H. Svensen****`s new book «stein på Stein» was launched at the Science Library at UiO 16 April. The book received numerous positive reviews, and was characterized as a «pageturner» by the national newspapaer Dagbladet.*

Above: «A research life in rocks and volcanoes». Interview with ***Else-Ragnhild Neumann*** *in Titan, 6 December. Photo: Gunhild M. Haugnes/UiO*

Abstracts (talks & posters at conferences)

1. Advokaat, E; D. van Hinsbergen, **W. Spakman**. Dragging and segmentation of the Burma and Sunda slabs caused by increasing curvature of the Sunda Trench. EGU Vienna 8-13.4.18 (Talk).
2. **Afonso, Juan Carlos**; Farshad Salajegheh, Wolfgang Szwillus, Jörg Ebbing, and **Carmen Gaina**. A reference global lithospheric and upper mantle model for 2 gravity and integrated geophysical studies. Tue, 10 Apr, 17:30–19:00, EGU Vienna 8-13.4.18 (Poster).
3. **Andersen, Torgeir B; Jakob, Johannes; Kjøll, Hans Jørgen; Corfu, Fernando; Planke, Sverre; Torsvik, Trond Helge;** Tegner, Christian; Labrousse, Loic; Mohn, Geoffroy. The Pre-Caledonian Margin of Baltica: overview and research in progress. Nordic geological wintermeeting 2018; 2018-01-10 - 2018-01-12
4. **Andersen, Torgeir B; Jakob, Johannes; Kjøll, Hans Jørgen; Corfu, Fernando; Torsvik, Trond Helge;** Tegner, Christian; Labrousse, Loic; Mohn, Geoffroy. Architecture and Palaeography of the per-Caldonian Margin of Baltica.**.** Conference GSL, New frontiers in Palaeogegraphy and Biogeography. Geological Society London. 21st September (Talk).
5. Antunes, V., Planès, T., Lupi, M., Carrier, A., Obermann, **A., Mazzini**, A., Ricci, T., Sciarra, A., and Moretti, M., 2018. Identification and location of seismic signals at the Nirano Mud Volcanic Field, Italy. EGU General Assembly 2018, Vol. 20, EGU2018-17534, Wien 8-13 April 2018.
6. Artemieva, Irina; Olga Barantseva, Hans Thybo, **Alexey Shulgin**, and Anna Makushkina. Anomalous topography and lithosphere structure of the North Atlantic region. Tue, 10 Apr, 15:30–15:45, Room D3 EGU Vienna 8-13.4.18 (Talk).
7. Atakan, **K., Maupin, V.** and the EPOS-Norway Consortium. 2018. Data acquisition in the North and e-infrastructure by the EPOS-Norway team. Oral presentation at 33 rd Nordic Geological Winter Meeting, Copenhagen, Denmark, 10-12 January 2018.
8. **Augland, Lars Eivind**; Lundmark, Anders Mattias & Bjerga, Audun Dalane (2018). Early mid-Devonian volcanism dates initiation of the Orcadian basin in the Orkney Islands, Scotland. Nordic geological wintermeeting 2018-01-10.12.
9. **Augland, L.E,** Lundmark, A.M., Brown, J.F., Bjerga, A.D, 2018. Early Mid-Devonian Volcanism in the Orkney Islands, Scotland - Implications for Mid-Upper Devonian Chronostratigraphy. Abstracts and Program, Goldschmidt 2018, Boston
10. Bellwald, Benjamin; Waage, Malin; **Planke, S;** Lebedeva-Ivanova, Nina; Polteau, S.; Tasianas, Alexandros; Bünz, Stefan; Plaza-Faverola, Andreia; Berndt, Christian; Stokke, H.H.; Millett, John; Myklebust, R. Monitoring Of CO2 Leakage Using High-Resolution 3D Seismic Data – Examples From Snøhvit, Vestnesa Ridge And The Western Barents Sea. Fifth CO2 Geological Storage Workshop; 2018-11-21 - 2018-11-23
11. Biggin, A.J; M. Hounslow; **M. Domeier**. Subduction flux modulates the geomagnetic polarity reversal rate AGU Fall meeting, Washington DC 10-14.12. (Talk).
12. Bingen, Bernard; Anne-Magali Seydoux-Guillaume, **Fernando Corfu**, Martin J. Whitehouse, Valérie Bosse, Axel Müller, and Damien Guillaume. Low temperature alteration of monazite megacrysts in pegmatite, Evje-Iveland, Norway. EGU Vienna 8-13.4.18 (Poster).
13. Blischke, A; Ögmundur Erlendsson, Pierpaolo Guarnierie, Bryndís Brandsdóttir, **Carmen Gaina,** Structural links between the Jan Mayen Microcontinent and the central East Greenland coast prior to, during, and after breakup, 33rd Nordic Geological Winter Meeting - 10-12. January 2018, KGS. Lyngby, Denmark (Talk)
14. **Breivik, A.B; P. Tan, P**; Mjelde, R. Development of the Igneous Logi Ridge, NE Atlantic, From Seismic Reflection Data. AGU Fall meeting, Washington DC 10-14.12. V23L-0215:
15. **Breivik, Asbjørn Johan**. Along-Margin Variability in Breakup Magmatism, NE Atlantic. MagellanPlus Workshop (IODP); 2018-05-29 - 2018-05-30
16. **Broek, Joost van den; Carmen Gaina, Susanne Buiter, Torgeir B. Andersen**. Subduction-related continental rifting and microcontinent formation. EGU Vienna 8-13.4.18 (Poster).
17. Brombin, Valentina; Andrea Marzoli, Guido Roghi, Fred Jourdan, Massimo Coltroti, Costanza Bonadiman, Laura Webb, **Sara Callegaro**, Giuliano Bellieni, Roberto Sedea, and Gianpaolo De Vecchi. The temporal evolution of the Cenozoic Southalpine magmatic activity in North-East Italy: evidence from 40Ar/39Ar geochronology. EGU Vienna 8-13.4.18 (Poster).
18. Brydon, RJ; McLeod, C; Shaulis, B; Haley, M; **Trønnes, Reidar G.** Accessory phases as tracers of magmatic processes in plutonic environments: insights from apatite. Geol. Soc. Am. Ann. Mtg., Abstr. 233-7. Geol. Soc. Am. Ann. Mtg.; 2018-01-01
19. **Buiter, Susanne**. Subduction initiation failure in numerical Wilson Cycle models. Thu, 12 Apr, 17:30–19:00, Hall X2, X2.177 EGU Vienna 8-13.4.18 (Poster).

20. **Bultel, Benjamin; Stephanie Werner,** Vera Fernandes, and **Tobias Rolf**. Spectral mapping and crater statistics reevaluated for all Apollo landing sites. EGU Vienna 8-13.4.18 (Poster).

21. **Bultel; B; S. C. Werner**, C. Quantin. Selection of units to obtain reliable calibration of the Martian cratering chronology: lessons learned from Lunar Science. 4th Workshop for Mars2020 Landing Site selection.

22. **Bultel; B; S. C. Werner,** V. A. Fernandez, **T. Rolf** Spectral mapping and crater statistics reevaluated for all Apollo landing sites, European Lunar Symposium, 2018, Toulouse.

23. **Callegaro, Sara**; Andrea Marzoli, Hervé Bertrand, Janne Blichert-Toft, Laurie Reisberg, Giancarlo Cavazzini, Fred Jourdan, Joshua Davies, Urs Schaltegger, and Massimo Chiaradia. Enriched lithosphere overprint on the isotope geochemistry of the CAMP-related Freetown Layered Complex (Sierra Leone). EGU Vienna 8-13.4.18 (Poster).

24. **Callegaro, Sara;** Don R Baker, Andrea Marzoli, Angelo De Min, Martin Whitehouse, Paul R Renne, and **Henrik H Svensen**. A crystal/melt partitioning study for sulfur and halogens: pyroxenes as probes for assessing gas loads in LIP magmas. EGU Vienna 8-13.4.18 (Poster).

25. Celli, N.L; S. Lebedev, A. J Schaeffer; **C. Gaina**. African cratonic lithosphere carved by mantle convection . AGU Fall meeting, Washington DC 10-14.12. (Talk).

26. Celli, Nicolas Luca; Sergei Lebedev, Andrew Schaeffer, and **Carmen Gaina**. African cratonic lithosphere carved by mantle plumes. EGU Vienna 8-13.4.18 (Talk).

27. Celli, Nicolas Luca; Sergei Lebedev, Andrew Schaeffer, Matteo Ravenna, and **Carmen Gaina**. Imaging the lithosphere and underlying mantle of the South Atlantic, South America and Africa using waveform tomography with massive datasets. EGU Vienna 8-13.4.18 (Poster).

28. Chen, Fangqin; Gordon Lister, and **Wim Spakman**. Evolution of the Bolivian Megakink in the Nazca Slab beneath South America. EGU Vienna 8-13.4.18 (Poster).

29. Chotalia, Kiran; Carolina Lithogw-Bertelloni, **John Brodholt**, Juan Rodriguez-Gonzalez, Jeroen van Hunen, and Takashi Nakagawa. Water, viscosity and convection modelling: the effects of weakening and heterogeneity. EGU Vienna 8-13.4.18 (Poster).

30. **Conrad, Clinton; Mathew Domeier**. Tracing the Edges of the LLSVPs in the Spatial Distribution of Seamount Volcanism. EGU Vienna 8-13.4.18 (Poster).

31. **Crameri, Fabio**; Carolina Lithgow-Bertelloni. Abrupt and continental-wide upper-plate tilting induced by slab–transition-zone collision. EGU Vienna 8-13.4.18 (Talk):

32. **Crameri, Fabio; Conrad, Clinton Phillips;** Montesi, L.; Lithgow-Bertelloni, C. "`Ocean-Plate Tectonics': The importance of the mantle framework. Earth dynamics and the development of plate tectonics; 2018-03-08

33. Creighton, Reuben; G. Lister, **Wim Spakman**. Rollback and decapitation of a south-facing subduction beneath the Tadjik Basin and the Hindu Kush. EGU Vienna 8-13.4.18 (Talk).

34. Dalslåen, B.H; Gasser, D; Grenne, Tor; **Augland, Lars Eivind; Corfu, Fernando;** Andresen, Arild. Chemistry, age and tectonic evolution of the western Trondheim Nappe Complex in the Oppdal area, Central Norway. Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

35. **Domeier, M.** Full plate modelling of the early Paleozoic. New Frontiers in Paleogeography and Biogeography. 21st September, Geological Society in London (Talk).

36. _**Domeier**, M; C.P Conrad; K. Selway. A link between seamount volcanism and structures of the deep Earth. AGU Fall meeting, Washington DC 10-14.12.(Poster)

37. **Domeier, Mathew**; Biggin, Andrew J.; Hounslow, Mark W.. Subduction Flux and Seafloor Production: Estimations and Implications. European Geosciences Union; 2018-04-08-13.

38. **Domeier, Mathew**; Font, Eric; Youbi, Nasrrddine; Nemkin, Samantha; Van der Voo, Rob; Tohver, Eric. Paleomagnetism and geochronology of Permain extrusives from Morocco: Further insights on the paleogeography of the latest Paleozoic. 2nd International Congress on the Triassic and Permian; 2018-04-25 - 2018-04-27

39. Dryak, M.C; J.A. Rohde; **G.E. Shephard**; J. Holloway; A. C Bradley. Reflections on an international and interdisciplinary network through the Association of Polar Early Career Scientists (APECS) AGU Fall meeting, Washington DC 10-14.12.(Talk)

40. **Faleide, J.I** FORCE-meeting (Joining Forces 2018) Stavanger

41. **Fallahi, M**., Obermann, A., Lupi, M., **Karyono, K., Mazzini, A**., 2018. The feeding system of the Lusi eruption revealed by ambient noise tomography. EGU General Assembly 2018, Vienna, Austria. Vol. 20, EGU2018-9960, Wien 8-13 April 2018.

42. Fraters, Menno; **Wim Spakman**, Douwe van Hinsbergen, Lydian Boschman, and Cedric Thieulot. Coupling lithosphere-mantle dynamics to the Cenozoic tectonic evolution in the Caribbean region. EGU Vienna 8-13.4.18 (Poster),

43. Fraters, M; W. Bangerth, C. Thieulot, A. Glerum, **W. Spakman**. Efficient and Practical Newton Solvers for Nonlinear Stokes Systems in Geodynamic Problems. EGU Vienna 8-13.4.18 (Poster).

44. Freiman, Sergei; Anatoly Nikishin, **Carmen Gaina**, and Eugene Petrov. Cretaceous plate tectonic model of Russian Arctic shelf. Wed, EGU Vienna 8-13.4.18 (Poster).

45. **Gaina, C.** Microcontinents: Stories about complexities in the Wilson tectonic cycles, BHP, Houston, USA, January 2018 (Invited talk).

46. **Gaina, C**. Hot news from the cold Arctic: Crustal asymmetry and ultra-slow spreading in the Eurasia Basin revealed by new data, Bedford Institute of Oceanography, Canada, April 2018 (Invited talk).

47. **Gaina, C.** A plate kinematic model for the opening of the Fram Strait: Constraints and consequences, Magellan IODP workshop, CAGE/ University of Tromso, Tromso, 4-5 June 2018 (Invited talk)

48. **Gaina, C**. International conference on Arctic Margins (ICAM VIII) Stockholm 11 - 14 June 2018 as speaker and convener (Talk)

49. **Gaina**, C; A.J Schaeffer; A.M. Nikishin; S. Lebedev; A. Minakov; **F. Breyer**. The Crust and Upper Mantle of the Eurasia Basin Revealed by Geophysical data and Mantle Tomography Models AGU Fall meeting, Washington DC 10-14.12. (Talk).

50. **Gaina, C**; Andrew J. Schaeffer, A. M. Nikishin, Sergei Lebedev, **Alexander Minakov**, The crust and upper mantle of the Eurasia Basin revealed by geophysical data and mantle tomography models, 36th General Assembly of European Seismological Commission, ESC, Malta, 3-7 September 2018 (Talk)

51. **Gaina, Carmen**; Anatoly M. Nikishin, Eugene I. Petrov, Nikolay A. Malyshev, and Sergey I. Freiman. The eastern Gakkel Ridge: Crustal asymmetry and ridge segmentation revealed by geophysical data. Wed, 11 Apr, 17:30–19:00, EGU Vienna 8-13.4.18 (Poster).

52. Gasser, Deta; Grenne, Tor; **Augland, Lars Eivind; Corfu, Fernando**. The Støren Group of the Trondheim Nappe Complex revisited: rift-related early/middle Ordovician volcanism and turbidite sedimentation at the onset of westward subduction?. 33rd Geological Winter Meeting; 2019-01-07 - 2019-01-09

53. Gawthorpe, R; T.B. Phillis; H.F. Khani; H. Fossen; R.E Bell; C.A.-L. Jackson; T. Wrona; .J. S. Claringbould; A. Lenhart; **J.I. Faleide**. Structural style and evolution of multi-phase rifts: Examples from the northern North Sea Rift AGU, Washington DC 10-14.12. (Talk).

54. Ghosh, J. Paul**; C.P Conrad**.. The Relation Between Tractions and Strain Rate at the Base of the Lithosphere: Key to Understanding Cratonic Stability. AGU Fall meet; Washington DC .

55. Gibbons, Steven J; **Valérie Maupin**, Christian Grude Kolstad, Tormod Kværna, and **Asbjørn Johan Breivik**. Improved location estimates for seismicity along the northern North Atlantic Ridge. Wed, 11 Apr, 14:30–14:45, Room -2.47 EGU Vienna 8-13.4.18 (Oral).

56. Greff-Lefftz, M, J. Besse, S. Vicente de Gouveia, **B. Robert** (2018) Mantle dynamics and wander of the rotational axis in a reference frame described by hotspots since 200Ma. EGU General Assemby 2018, Vienna, Austria. (Talk)

57. Greff-Lefftz, M; **B. Robert**, & J. Besse (2018). Rotational bulge and TPW in a reference frame described by hotspots since 200Ma: influence of an elastic crust, AGU, Washington, United States (poster).

58. Greff-Lefftz, Marianne ; Jean Besse, Sophie Vicente de Gouveia, and **Boris Robert.** Mantle dynamics and wander of the rotational axis in a reference frame described by hotspots since 200Ma. Fri, 13 Apr, 08:30–08:45, Room D3 EGU Vienna 8-13.4.18 (Talk).

59. Grima, A.G; C.R Lithgow-Bertollini; **F. Crameri**. . Deep slab flattening and temporary stagnation within the lower mantle transition zone. AGU Fall meet;Wash. DC 10-14.12.(Poster)

60. Grima, Antoniette; **Fabio Crameri**, and Carolina Lithgow-Bertelloni. Mid-mantle slab break-off as a mechanism for slab remnants in the lower mantle. EGU Vienna 8-13.4.18 (Poster).

61. Guilmette, Carl; Matthijs Smit, **Douwe Van Hinsbergen**, Derya Gurer, **Fernando Corfu**, Marco Maffione, and Dany Savard. Forced subduction initiation in Oman revealed by ophiolite-sole couple geochronology. EGU Vienna 8-13.4.18 (Talk).

62. Gundersen, Ingar Mørkestøl; **Bostic, Joshua Neilson.** The Fimbulwinter of AD 536-538: Crisis, adaptation or decline?. 25th Annual Meeting of the European Association of Archaeologists. Beyond paradigms.; 2018-09-05 - 2018-09-09

63. Gürer, Derya; Douwe J.J. van Hinsbergen, and **Wim Spakman**. Reconstructing oceans lost: the fate of the eastern Mediterranean Paleo- and Neotethys. EGU Vienna 8-13.4.18 (Talk).

64. Haas, Peter; Jörg Ebbing, and **Carmen Gaina** (Poster). Unveiling signs of old supercontinents by satellite gravity gradients and curvature attributes with special focus on Antarctica. Wed, 11 Apr, 17:30–19:00, Hall X2, X2.268 EGU Vienna 8-13.4.18 (Poster).

65. Hartman, Robert; Ebbing, Jörg; **Conrad, Clinton Phillips**. Influence of upper mantle viscosity variations on sea level change and GIA - A case study for Antarctic deglaciation models. German-Swiss Geodynamics Workshop; 2018-08-19

66. **Hartz, E., Medvedev, S**., Schmid, D., **Faleide, J.,** Iyer, K., Scheirer, A. H., Hartwig, A., Geodynamic

Gamechangers in Petroleum System Models, 80th EAGE Conference , Copenhagen, 11-14.6.2018.

67. **Heimdal, Thea Hatlen; Svensen, Henrik**; Ramezani, Jahandar; Iyer, Karthik Herman; Pereira, Egberto; Rodrigues, René; **Jones, Morgan Thomas; Callegaro, Sara**. Large-scale sill emplacement in Brazil as a trigger for the end-Triassic crisis. 33rd Nordic Geological Winter Meeting; 10-12 Oct.

68. Heron, P; J. Dannberg, Rene Gassmöller, **Grace Shephard**, Jeroen van Hunen, and Russell Pysklywec. Impact of thermo-chemical pile size in the generation of upwellings: insights from mantle convection models featuring paleo-subduction history. EGU Vienna 8-13.4.18 (Poster).

69. Hertgen, Solenn; Philippe Yamato, Benjamin Guillaume, Nicholas Schliffke, **Valentina Magni**, and Jeroen van Hunen. How does overriding plate control convergence zone dynamics? Fri, 13 Apr, 17:30–19:00, Hall X2, X2.141 EGU Vienna 8-13.4.18 (Poster).

70. **Heyn, Björn; Clinton P. Conrad, Reidar G. Trønnes**. Stabilization of thermochemical piles by compositional viscosity contrasts, EGU Vienna 8-13.4.18 (Poster).

71. Hinsbergen, Douwe J. J. van; Marco Maffione, Kalijn Peters, Carl Guilmette, **Bernhard Steinberger, Carmen Gaina**, Alexis Plunder, Derya Gürer, Eldert L. Advokaat, Peter J. McPhee, and Wim Spakman. Plume-induced subduction initiation across the Cretaceous Neotethyan ocean. Thu, 12 Apr, 09:15–09:30, Room D2 EGU Vienna 8-13.4.18 (Talk).

72. Hosseini, Kasra; Kara J. Matthews, Karin Sigloch**, Grace E. Shephard, Mathew Domeier**, and Maria Tsekhmistrenko. SubMachine: Web-based tools for exploring seismic tomography models. Mon, 09 Apr, 08:44–08:46, PICO spot 1 EGU Vienna 8-13.4.18 (Pico talk)

73. Hosseinzadehsabeti; E; C. Ferre; J.W Geissman; S.A Friedman; **T.B Andersen**; E. Spagnuolo; G. Di Toro. Seismic rupture kinematics along the crust-mantle boundary of a subducted slab: insights from ultramafic pseudotachylytes in Corsica. AGU Fall meeting, Washington DC 10-14.12.(Poster)

74. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Seeking Signs of Life on Mars: A Strategy for Selecting and Analyzing Returned Samples from Hydrothermal Deposits. Second International Mars Sample Return 2071, 6046.

75. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Constraining Our Understanding of the Actions and Effects of Martian Volatiles Through the Study of Returned Samples. Second International Mars Sample Return 2071, 6054.

76. iMOST Teamincluding **Werner, S.C.** (2018) High Priority Samples to Characterize the Habitability of Groundwaters and Search for Rock-Hosted Life on Mars. Second International Mars Sample Return 2071, 6051.

77. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Introduction to the 2018 iMOST Study. Second International Mars Sample Return 2071, 6120.

78. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Introduction to the 2018 iMOST Study. Second International Mars Sample Return 2071, 6089.

79. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Potential High Priority Subaerial Environments for Mars Sample Return. Second International Mars Sample Return 2071, 6043.

80. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) Relevance of Mars Samples to Planning for Potential Future In-Situ Resource Utilization. Second International Mars Sample Return 2071, 6042.

81. iMOST Teamincluding **Werner, S.C.** (2018) Seeking the Signs of Life: Assessing the Presence of Biosignatures in the Returned Sample Suite. Second International Mars Sample Return 2071, 6102.

82. iMOST Teamincluding **Werner, S.C.** (2018) Seeking Signs of Life on Mars: The Importance of Sedimentary Suites as Part of Mars Sample Return. Second International Mars Sample Return 2071, 6045.

83. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) The Importance of Mars Samples in Constraining the Geological and Geophysical Processes on Mars and the Nature of its Crust, Mantle, and Core. Second International Mars Sample Return 2071, 6055.

84. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018) The Importance of Returned Martian Samples for Constraining Potential Hazards to Future Human Exploration. Second International Mars Sample Return 2071, 6049.

85. iMOST Team including **Werner, S.C.** (2018) The Use of Returned Martian Samples to Evaluate the Possibility of Extant Life on Mars. Second International Mars Sample Return 2071, 6053.

86. iMOST Team including **Werner, S.C.** (2018) What Could be Learned About the Geochronology of Mars from Samples Collected by M-2020. Second International Mars Sample Return 2071, 6041.

87. iMOST Team, and 68 colleagues including **Werner, S.C.** (2018)The Search for Life's Organic Carbon in Returned Samples from Mars. Second International Mars Sample Return 2071, 6052.

88. Incel, S; L. Labrousse; N: Hilairet; T. John; J. Gasc; F. Shi; Y. Wang; **T. B. Andersen**; F. Renard; B. Jamtveit; A. Schubnel. Reaction-induced faulting in granulite causes earthquakes in the lower continental crust. AGU Fall meeting, Washington DC 10-14.12.(Talk)

89. Incel, Sarah; Loïc Labrousse, Nadège Hilairet, Timm John, Julien Gasc, Yanbin Wang, Feng Shi, **Torgeir B. Andersen**, François Renard, Bjørn Jamtveit, and Alexandre Schubnel. Reaction-induced faulting in granulite: New insights for the generation of intermediate-depth earthquakes in lower continental crust. EGU Vienna 8-13.4.18 (Talk).

90. Incel, S.; Labrousse, L; Hilairet, M; John, T; Gasc, J; Shi, F; Wang, Y**; Andersen, T. B**; Renard, F; Jamtveit, B; Schubnel, A. Reaction-induced faulting in granulite causes earthquakes in the lower continental crust. AGU annual meeting 2018; 2018-12-10 - 2018-12-14

91. Ivins, Erik; Surendra Adhikari, Lambert Caron, **Bernhard Steinberger**, John Reager, Kristian Kjeldsen, Ben Marzeion, and Eric Larour. Toward a Unified Theory for 20th Century Secular Polar Motion. Wed, 11 Apr, 11:45–12:00, Room -2.32 EGU Vienna 8-13.4.18 (Talk).

92. **Jakob, Johannes; Corfu, Fernando; Andersen, Torgeir B**. Evidence pre-Scandian deformation and metamorphism in the Caledonian margin of Baltica: U-Pb zircon ages from the Tronfjell Gabbro and related mafic intrusives in the Hummelfjell Group, Central Scandinavian Caledonides. Norwegian Geological Society Wintermeeting; 2019-01-07 - 2019-01-09

93. **Jakob, Johannes**; Mohn, Geoffroy; **Closset, Pierre; Andersen, Torgeir B**. The lithostratigraphy of a hyperextended domain in the magma-rich to magma-poor transition zone in the southern Pre-Caledonian LIP, Scandinavian Caledonides, Norway. Nordic geological winter meeting 2018; 2018-01-10 - 12

94. **Jakob, Johannes; Torgeir B. Andersen**. The Rift-inherited structural architecture of the South and South -Central Scandinavian Caledonides. EGU Vienna 8-13.4.18 (Talk)

95. **Jakob, Johannes; van den brook, Joost M.; Andersen, Torgeir B**. Remnants of the pre-Caledonian Baltica rifted margin preserved in a lithologically mixed unit between Bergen and Tynset, Scandinavian Caledonides, South and Central Norway. Nordic geological winter meeting 2018; 2018-01-10 - 12

96. **Jahren. A.H.** Keynote speaker at: NIBIO meeting (Norsk Institutt for Bioøkonomi) February 13, 18

97. Jerkins, Annie; Steven Gibbons, Tormod Kværna, and **Johannes Schweitzer**. Location and Depth Estimation of the North Sea Earthquake EGU Vienna 8-13.4.18 (Talk).

98. **Jerram, Dougal Alexander; Svensen, Henrik; Planke, Sverre**; Millett, John M; Jones, **Morgan Thomas; Augland, Lars Eivind; Abdelmalak, Mansour**. Types and styles of volcanism in the North Atlantic Igneous Province: Implications towards understanding their potential climatic impact.. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

99. **Jerram, Dougal Alexander; Svensen, Henrik; Planke, Sverre**; Millett, John M; Jones, **Morgan Thomas; Augland, Lars Eivind; Abdelmalak, Mansour**. Types and styles of volcanism in the North Atlantic Igneous Province: Implications towards understanding their potential climatic impact.. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

100. **Jerram, Dougal; Henrik Svensen, Sverre Planke**, John Millett, Ben Manton, and Reidun Myklebust. How to recognise sill induced hydrothermal vent structure in large igneous provinces: key observations from outcrop to seismic. EGU Vienna 8-13.4.18 (Talk).

101. **Jones, Morgan T**. Sedimentologic record of the PETM. MagellanPlus Workshop; 29-30.5.

102. **Jones, Morgan T; E. Wulfsberg**; Schultz, Bo; **Augland, L.-E; Planke, S;** Tegner, C; Mather, Tamsin; P; L; **Svensen, H.** Fur Island in Denmark: A window into Paleocene-Eocene hyperthermals and North Atlantic volcanism. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

103. **Jones, Morgan**; L Percival, **Ella Stokke**, Joost Frieling, Tamsin Mather, Lars Riber, Brian Schubert, and **Henrik Svensen**. Investigating mercury as a large igneous province proxy: Insights from the Palaeocene-Eocene Thermal Maximum. EGU Vienna 8-13.4.18 (Talk).

104. Kaatz, Lisa; Sascha Zertani, Evangelos Moulas, Timm John, Loic Labrousse, Stefan Schmalholz, and **Torgeir B. Andersen**. Evolution of hydrous shear zones during incipient eclogitization of metastable dry and rigid lower crust (Holsnøy, Western Norway). Thu, 12 Apr, EGU Vienna 8-13.4.18 (Poster).

105. **Karlsen, Krister S; Clinton Conrad, Valentina Magni**. Deep Water Recycling and Cyclic Sea Level Change on a Supercontinental EGU Vienna 8-13.4.18 (Poster).

106. **Karlsen, Krister Stræte; Conrad, Clinton Phillips; Magni, Valentina.** Deep water cycling and sea level changes on a supercontinental time scale. German-Swiss Geodynamics Workshop; 2018-08-19

107. Katz, Liza; Zertani, Sascha; Moulas, Evangelos; John, Timm; Labrousse, Loic; Schmalholz, Stefan Markus; **Andersen, Torgeir B.** Evolution of hydrous shear zones during incipient eclogitization of metastable dry and rigid lower crust (Holsnøy, Western Norway). EGU 2018-04-09 - 2018-04-13

108. **Kiraly, Agnes**; Anna Makushkina, Tithi Ghosh, Kirstie L. Haynie, Benjamin H. Chilson-Parks, Daniel E. Portner, Kathryn Metcalf, Michael Manga, Margarete A. Jadamec, Keely A. O'Farrell, Louis N. Moresi, and Robert J. Stern. Understanding the Effects of Slab Holes on Mantle Flow and Surface Dynamics. EGU Vienna 8-13.4.18 (Talk).

109. **Kiraly, Agnes; Clinton P. Conrad**, and Lars Hansen. Geodynamic consequences of anisotropic mantle viscosity. EGU Vienna 8-13.4.18 (Poster).

110. **Kiraly, Agnes; Conrad, Clinton** Phillips; Hansen, L. Geodynamic consequences of anisotropic mantle viscosity. German-Swiss Geodynamics Workshop; 2018-08-19

111. **Kjøll, Hans Jørgen; Andersen, Torgeir B;** Tegner, Christian; Labrousse, Loic**; Corfu, Fernando; Planke, Sverre.** Defining a magma-rich rifted margin fossil analogue in the Scandinavian Caledonides. EGU 2018; 2018-04-09 - 2018-04-13

112. **Kjøll, Hans Jørgen; Torgeir B. Andersen**, Christian Tegner, Loic Labrousse, **Fernando Corfu, Sverre Planke**. Defining a magma-rich rifted margin fossil analogue in the Scandinavian Caledonides. EGU Vienna 8-13.4.18 (Talk).

113. **Kjøll, Hans Jørgen**; Galland, Olivier; Labrousse, Loic; **Andersen, Torgeir B**. Dyke emplacement mechanisms across the brittle-ductile transition. Norwegian Geological Society Wintermeeting; 2019-01 -07 - 2019-01-09

114. Köhler, Andreas; Pierre Marie Lefeuvre, Christopher Nuth, **Johannes Schweitzer**, Giusi Buscaino, Christian Weidle, Jack Kohler, Etienne Berthier, and Michal Petlicki. Monitoring and quantification of frontal ablation at Kronebreen, Svalbard, using records of seismic calving signals. EGU Vienna 8-13.4.18 (Talk).

115. **Kolstad C.G., Maupin V**., Kværna T., Gibbons S. and Breivik A., 2018.Relative relocation of earthquakes along the northern North Atlantic ridge using Rayleigh waves. Oral presentation at 33 rd Nordic Geological Winter Meeting, Copenhagen, Denmark, 10-12 January 2018.

116. Krueger, M., **Mazzini, A**., 2018. Deep versus shallow origin of hydrocarbon degrading microorganisms in sediments from the active Lusi eruption site, Indonesia. EGU General Assembly 2018, Vol. 20, EGU2018-17026, Wien 8-13 April 2018.

117. **Kulakov**, **E; P.V Doubrovine; T.H. Torsvik; S.C. Werner; P. Silkoset.** Paleomagnetism of Late Jurassic – Early Cretaceous coast-parallel dykes in SW Greenland. AGU Fall meeting, Washington DC 10-14.12.(Talk)

118. **Kulakov, Evgeniy V**; Aleksey V. Smirnov, Andy J. Biggin, Louise Hawkins, Courtney Sprain, Greig A. Paterson, and Luke Fairchild. The long-term history of the Mesozoic geodynamo: A paleointensity perspective. EGU Vienna 8-13.4.18 (Poster).

119. Lantz, C., and 10 colleagues including **Werner S.C. (2018)** Spectral Characterization of H2020/PTAL Mineral Samples: Implications for In Situ Martian Exploration and Mars Sample Selection. Second International Mars Sample Return 2071, 6090 (poster).

120. Kulakov, Theodore J. Bornhorst; Chad Deering. The youngest magmatic activity of the Midcontinent Rift at Bear Lake, Keweenaw Peninsula, Michigan. Institute on Lake Superior Geology, 2018 Annual conference.At: Iron Mountain, Michigan. May 2018.

121. Kusznir, Nick; Gianreto Manatschal, Julia Gomez-Romeu, and **Leanne Cowie**. Palaeo-datum and Tectonic Context of Salt Deposition at Rifted Margins: The N Angolan Example. EGU Vienna 8-13.4.18 (Poster).

122. Lazar, Michael; Luca Gasperini, Matteo Lupi, **Adriano Mazzini**, Alina Polonia, Marion Alcanie, Yaron Be'eri-Shlevin, Antonio Caracausi, Christian Hensen, Guy Lang, Claudia Romagnoli, Naama Sarid, and Yoseph Yechieli. Mapping active faults in the Sea of Galilee, Israel – a multi-disciplinary approach. EGU Vienna 8-13.4.18 (Poster).

123. Lundmark, A. Mattias; **Augland, Lars Eivind**; Bjerga, Audun Dalane Syn-collisional Scandian extension and magmatism on the Orkney Islands, Scotland. Nordic geological wintermeeting 2018; 2018-01-10.12.

124. Lundmark, A. Mattias; **Augland, Lars Eivind**; Jørgensen, Simen Varkøy. How do digital tools influence geoscience students learning experience in the field?. Nordic geological wintermeeting 2018; 2018-01-10 -12

125. Lupi M., **Fallahi, M., Mazzini A**., Polonia., A., D'Alessandro, A., D'Anna, G., Gasperini, L., 2018. Seismic activity of mud volcanoes in the Marmara Sea, Turkey. EGU General Assembly 2018, Vol. 20, EGU2018-14482, Wien 8-13 April 2018.

126. Lupi M., Sciarra A., **Mazzini A**., Carrier A., **Husein A., Karyono K**., 2018. Geophysical and soil degassing observations at the Kalang Anyar mud volcano, East Java. EGU General Assembly 2018, EGU2018 -13402, Wien 8-13 April 2018.

127. **Magni Valentina**, The influence of mantle flow on subduction-related volcanism, AGU Fall meeting, Washington DC 10-14.12. (Invited talk).

128. **Magni Valentina**, The role of mantle flow in subduction-related volcanism, German-Swiss Geodynamics Workshop; 2018-08-19 (Invited talk)

129. **Magni Valentina**, The role of mantle flow on the tectonic and magmatic evolution of the central Mediterranean subduction zone, SGI Catania 12-14.09 (Invited talk)

130. **Magni, V;** P. Bouilho J. Van Hunen; M. Domeier. The role of subduction velocity in slab dehydration and arc magmatism. AGU Fall meeting, Washington DC 10-14.12. (Invited talk).

131. **Magni, Valentina**. The influence of mantle flow on the interaction between arc and back-arc melts. Mon, 09 Apr, 17:30–19:00, Hall X2, X2.263 EGU Vienna 8-13.4.18 (Poster).

132. **Magni, Valentina**. The influence of mantle flow on the interaction between arc and back-arc melts. Mon, 09 Apr, 17:30–19:00, Hall X2, X2.263 EGU Vienna 8-13.4.18 (Poster).

133. Mallard, Claire; **Tobias Rolf**, and Nicolas Coltice. Evolution of the layout of tectonic plates through global reorganisation. EGU Vienna 8-13.4.18 (Talk).

134. Manassero, Maria Constanza; **Juan Carlos Afonso**, Fabio Zyserman, Sergio Zlotnik, Marina Rosas-Carbajal, and Stephan Thiel. Including magnetotelluric data into multi-observable probabilistic inversion: implications for the physical state and water content of the continental lithosphere. EGU Vienna 8 -13.4.18 (Poster)

135. Maunde, B-L; .S.D.B. Goes: J. Van Hunen; J. Prytulak; **.V. Magni**; .P. Bouilho. The Decoupling Depth and Slab Thermal Structure. AGU Fall meeting, Washington DC 10-14.12. (Poster).

136. **Maupin, Valerie**. 3-d sensitivity kernels of the Rayleigh wave ellipticity. Thu, 12 Apr, 08:30–08:45, Room D3 EGU Vienna 8-13.4.18 (Talk).

137. **Mazzini A**., Sciarra A., Lupi M., and **Husein A**., 2018. Subaqueous and subareal mud volcanism at Kalang Anyar, Java, Indonesia. EGU General Assembly 2018, Vol. 20, EGU2018-10363, Wien 8-13 April 2018.

138. **Mazzini, A**., Khlystov, O., Poort, J., Akhmanov, G., Minami, H., Hachikubo, A., and De Batist, M. 2018. A special type of mud volcanism in Lake Baikal. EGU General Assembly 2018, Vol. 20, EGU2018-15747, Wien 8-13 April 2018.

139. McLeod, C; Shaulis, B; Brydon, RJ; Haley, M; Angi-O'Brien, M; **Trønnes, Reidar G**. Assembly of Magmas in Earth's Upper Crust: Insights at the micro and macro scale from granitic batholiths. Goldschmidt Conf. Abstr. 041-110.. Goldschmidt Conf.; 2018-01-01

140. **Medvedev, Sergei.** Notes on thin sheet approximation for continental deformations. Le Studium Conference: Balance laws in fluid mechanics, geophysics, biology; 2018-11-19 - 2018-11-21

141. Midtkandal, I; J.M. Holbrook; **J.I. Faleide**; C. Myer; A.E. van Yperen; **G.E Shephard**; J.P. Nystuen. Early Cretaceous Arctic Palaeotopography as Constrained by Barents Sea Sediment Budget AGU Fall meeting, Washington DC 10-14.12. (Poster).

142. Miljkovic, K., Gerrick-Bethell, I., **Werner, S.C.** (2018) Shock and Deformation History of the Ancient Lunar Crust Based on Numerical Impact Modelling and Impact Statistics. LPI Contributions 2067, 6078 (talk).

143. Mikhaltsov; Nikolai; **Evgeniy Kulakov**. Absolute Geomagnetic Paleointensity as recorded by ~ 250 Ma Kuznetsk Traps. Preliminary results. EGU Vienna 8-13.4.18 (Poster).

144. **Minakov, Alexander**. Late Cenozoic geodynamics in Svalbard: interplay of glaciation, seafloor spreading and mantle convection. EGU Vienna 8-13.4.18 (Poster).

145. **Minakov, Alexander**. Thermochemical Structure of Upper Mante Beneath Hotspot Swells. Tue, 10 Apr, 17:30–19:00, Hall X2, X2.316 EGU Vienna 8-13.4.18 (Poster).

146. **Mironova, A; Alexander Minakov, Carmen Gaina, Jan Inge Faleide**. Development of open-access web-based interface for seismic data analysis, 36th General Assembly of European Seismological Commission, ESC, Malta, 3-7 September 2018 (Poster)

147. **Mohn, Chris Erik; Trønnes, Reidar G.** Partitioning of the FeSiO3, FeAlO3 and Al2O3 components between bridgmanite and post-bridgmanite. Goldschmidt Conf. Abstr. 02d, 1530, Tu.. Goldschmidt Conf.; 2018-01-01

148. Mohn, Geoffroy; **Jakob, Johannes; Andersen, Torgeir B**. How are the Alpine ophiolites different from the Caledonian ophiolitic mélanges?. Norwegian Geological Society Wintermeeting; 7-9 Jan.

149. Moulas, Evangelos; Stefan Schmalholz, Lisa Kaatz, Timm John, **Torgeir B. Andersen**, and Loic Labrousse. Impact of weak zone geometry on pressure variations and potential implications for variation of mineral assemblages. EGU Vienna 8-13.4.18 (Poster).

150. **Myhre, Ragnhild A; Valerie Maupin**, and Graziella Devoli. Identification of seismic records left by different landslide types in Norway. EGU Vienna 8-13.4.18 (Poster).

151. Naliboff, John; **Susanne Buiter**. Numerical simulations of complex normal fault interaction during continental extension. EGU Vienna 8-13.4.18 (Talk).

152. Oliveira, B; **J.C. Afonso**; R.Tilhac. Multiphase Multicomponent Reactive Transport Formalism for Disequilibrium Melt-Rock Processes and Geochemical Geodynamics. AGU Fall meeting, Washington DC 10-14.12. (Talk).

153. Ortega, O; S. Zlotnik, **J. C. Afonso**, P. Díez. Ultra-fast solution of Stokes problem via Model Order Reduction within 3D inversion of lithospheric structure. EGU Vienna 8-13.4.18 (Poster).

154. **Prieur, N. C., T. Rolf and S. C. Werner**, The European Planetary Sci. Congress Berlin, 16-21.09.2018, Testing impact numerical model setups for simple craters (poster).

155. **Quintela, Orlando; Jakob, Johannes; Andersen, Torgeir B**. Serpentinite-bearing metasedimentary complex near Lesja and relationship with the hyperextended pre-Caledonian margin of Baltica. Norwegian Geological Society Wintermeeting; 2019-01-07 - 2019-01-09

156. **Robert, B**; M. Greff-Lefftz, & J. Besse (2018). True Polar Wander: a key indicator for plate configuration and mantle convection during the late Neoproterozoic, AGU, Washington, United States (poster).

157. **Rolf, T., Steinberger, B., Werner, S., Sruthi, U** (2018) Inferences on the mantle viscosity structure and the post-overturn evolutionary state of Venus. European Planetary Science Congress 12, EPSC2018-215 (invited talk).

158. Schaeffer, Andrew; Sergei Lebedev, Pascal Audet, Javier Fullea, and **Carmen Gaina**. Seismic and thermal lithospheric structure of the North American-Greenland Arctic realm. EGU Vienna 8-13.4.18 (Poster).

159. Schliffke N., van Hunen J., Allen M., **Magni V.,** Arcuate subduction – a fragile structure, German-Swiss Geodynamics Workshop; 2018-08-19

160. Schliffke, Nicholas; Jeroen van Hunen, **Valentina Magni**, and Mark Allen. Horizontal vs. Vertical Slab Tearing during Subduction and Continental Collision. EGU Vienna 8-13.4.18 (Poster).

161. Schobben, Martin; Elsbeth E. van Soelen, **Arve Sleveland**, Wolfram M. Kürschner, **Henrik Svensen, Sverre Planke**, David P.G. Bond, Robert J. Newton, Paul B. Wignall, and Simon W. Poulton. Towards a mechanistic understanding of marine anoxia development during the end-Permian mass extinction. EGU Vienna 8-13.4.18 (Talk).

162. Schubert, B.A; Collin S. Moore, **A. Hope Jahren**, Nikita Zimov, Sergey A. Zimov. Monthly temperature reconstruction for a ~3,000 year-old Arctic site using fossil wood. 2018 AGU Fall Meeting, (Talk)

163. Schultz, Bo; Lindgren, Johan; Teichert, Barbara M.A.; **Jones, Morgan Thomas**; Tegner, Christian; Sylvestersen, Rene; Rasmussen, Jan Audun; Madsen, Henrik. Glendonite in an early Eocene Konservat-Lagerstätte (Fur Formation of Northern Denmark) and Palaeocene / Eocene formations on Svalbard are good climate and biosphere interpretive indicators.. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

164. Sciarra A., Ciotoli G., Finoia M.G:, **Hussein A., Mazzini A**., 2018. Investigating external perturbations for the Lusi mud eruption, NE Java, Indonesia. EGU General Assembly 2018, Vol. 20, EGU2018-14443, Wien 8-13 April 2018.

165. Sciarra, A., **Mazzini, A**., Inguaggiato, S., Vita, F., Lupi, A., 2018. Radon and carbon gas anomalies along the Watukosek fault system and Lusi mud eruption, Indonesia. SGI-SIMP Congress, 12-14 September, Catania, Italy

166. **Shephard, G.E**, Steffen Wiers, Evgenia Bazhenova, Lara F. Pérez, Luz María Mejía, Carina Johansson, Martin Jakobsson, Matt O'Regan. Heat flow measurements from central Arctic Ocean – considering the seafloor to the mantle. International conference on Arctic Margins (ICAM VIII) Stockholm 11 - 14 June 2018 (Talk)

167. **Shephard, Grace E., Carmen Gaina, Mansour Abdelmalak**, Karsten Piepjohn, **Jan Inge Faliede**. Preliminary reconstructions for the western Arctic and North Atlantic since the Devonian. International conference on Arctic Margins (ICAM VIII) Stockholm 11 - 14 June 2018 (Poster)

168. **Shephard, Grace .E**., Steffen Wiers, Evgenia Bazhenova, Lara F. Pérez, Luz María Mejía, Carina Johansson, Martin Jakobsson, Matt O'Regan. New heat flow measurements from central Arctic Ocean - reconciling observations and modelling via the surface, crust and mantle. EGU Vienna 8-13.4.18 (Poster).

169. **Shephard, Grace** .E., K.J. Matthews, K. Hosseini**, M. Domeier**. A simple 'vote maps' methodology for imaging mantle features across alternative tomography models. JpGU Meeting Chiba, Japan 20-24 May 2018. (Talk)

170. **Shephard, Grace E**. Mapping deep mantle structure – high latitude slabs and plate reconfigurations. GSL New Frontiers in Paleogeography and Biogeography. 21 September, London, UK (Invited Talk).

171. **Shephard, Grace .E.,** Steffen Wiers, Evgenia Bazhenova, Lara F. Pérez, Luz María Mejía, Carina Johansson, Martin Jakobsson, Matt O'Regan. New heat flow measurements from central Arctic Ocean. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12 (Talk)

172. **Shulgin, Alexey; Jan Inge Faleide**, Rolf Mjelde, Ritske Huismans, and Iselin Aarseth. The North-western Barents Sea: crustal structure from the recent seismic profiles? Tue, 10 Apr, 17:30–19:00, Hall X2, X2.210 EGU Vienna 8-13.4.18 (Poster).

173. Slagstad, T; Nick M.W. Roberts, **Evgeniy Kulakov**. Linking orogenesis across the North-Atlantic; the Grenvillian and Sveconorwegian orogens, different in style, but geodynamically coupled. 33rd Nordic Geological Winter MeetingAt: Copenhagen (Talk).

174. **Stokke, Ella W; Jones, Morgan T;** Hammer, Ø; **Svensen, Henrik**. Geochemical variations during the PETM and later Eocene hyperthermals: investigating a new drill core from Fur, Denmark. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

175. **Stokke, Ella Wulfsberg**; J. Whiteside, Ø. Hammer, **Henrik Svensen, Morgan Jones**. Linking warming, environmental changes, and volcanic ash falls from onset to recovery of the PETM: new insights from the island of Fur, Denmark. EGU Vienna 8-13.4.18 (Poster).

176. **Svensen, H**. Invited talk, University of Lausanne, Switzerland

177. **Svensen, Henrik**. Travels to the end of the world. Årsmøte Norsk petroleumsforening, Stavanger; 2018-12-29

178. **Straume, E., Gaina, C**., LaCasce, J., **Medvedev, S**., Gjermundsen, A., Klocker, A., Nikurashin, M., 2018. NE Atlantic Cenozoic Paleobathymetry: Oceanic Gateway Formation and Paleo-ocean Circulation, AGU Fall meeting, Washington DC 10-14.12.2018.

179. **Svensen, Henrik; Jerram, Dougal Alexander;** Polozov, Alexander; **Jones, Morgan Thomas; Augland, Lars Eivind; Planke, Sverre**. Volcanic causes for the PETM and other past hothouse climates. 33rd Nordic Geological Winter Meeting; 2018-01-10 - 2018-01-12

180. **Svensen, Henrik**; Percival, Lawrence; **Jones, Morgan Thomas**; Mather, Tamsin. Release of mercury from black shale during contact metamorphism and the implications for mercury as a volcanic proxy. EGU General Assembly 2018; 2018-04-08 - 2018-04-13

181. Szwillus, Wolfgang; **Juan Carlos Afonso**, Jörg Ebbing, and Peter Haas. Estimating lithospheric density structure using probabilistic joint inversion of satellite gravity gradients and topography. Tue, 10 Apr, 11:00–11:15, Room -2.47 EGU Vienna 8-13.4.18 (Talk)

182. **Tan, Pingchuan; Asbjørn Johan Breivik**, and Rolf Mjelde. Development of the igneous Logi Ridge, NE Atlantic, from seismic reflection data. Tue, 10 Apr, 17:30–19:00, Hall X2, X2.402 EGU Vienna 8-13.4.18 (Poster).

183. Tegner, Christian; **Andersen, Torgeir B; Kjøll, Hans Jørgen**; Brown, Eric L.; Hagen-Peter, Graham; **Corfu, Fernando; Planke, Sverre; Torsvik, Trond Helge**. The pre-Caledonian Scandinavian Dyke Complex and 600 Ma plate reconstructions of Baltica. Nordic geological wintermeeting 2018; 2018-01-10 - 2018-01-12

184. Thybo, Hans; Helene Kraft, **Alexey Shulgin**, and Lev P. Vinnik. Lithospheric structure and topography in Central-Eastern Greenland. Tue, 10 Apr, 16:15–16:30, Room D3 EGU Vienna 8-13.4.18 (Talk).

185. **Torsvik, T.H.** The Burkian Earth. AGU Fall meeting, Washington DC 10-14.12. (Talk).

186. **Trønnes, Reidar G; Mohn, Chris Erik; Eigenmann, KR.** He and Ne diffusion in bridgmanite and lower mantle structure. Goldschmidt Conf. Abstr. 2018-01-01

187. **Uppalapati, Sruthi; Tobias Rolf, Fabio Crameri, Clinton P. Conrad, Stephanie C. Werner.** How Venus' young surface came to be: New insights from 2D and 3D modelling. Fri, 13 Apr, 17:30–19:00, Hall X2, X2.320 EGU Vienna 8-13.4.18 (Poster).

188. Valeriani, Lucrezia; Andrea Marzoli, Joshua Davies, Jacopo Dal Corso, Nereo Preto, Simonetta Cirilli, Eleonora Vasconcellos, Marcia Ernesto, **Henrik Svensen**, Nasser Youbi, Herve Bertrand, and **Sara Callegaro**. CAMP intrusive and extrusive activity and its influence on the end-Triassic mass extinction. EGU Vienna 8-13.4.18 (Poster).

189. **van den Broek, Joost Martijn; Gaina, Carmen; Buiter, Susanne; Andersen, Torgeir B**. Subduction-related continental rifting and microcontinent formation. EGU 2018; 2018-04-09 - 2018-04-13

190. Veneranda, M., Negro, J.~I., Medina, J., Rull, F., Lantz, C., Poulet, F., Cousin, A., Dypvik, H., Hellevang, H., **Werner, S.C.** (2018) PTAL Database and Website: Developing a Novel Information System for the Scientific Exploitation of the Planetary Terrestrial Analogues Library. Second International Mars Sample Return 2071, 6069 (poster).

191. Verónica Antunes, Thomas Planès, Aurore Carrier, Anne Obermann, **Adriano Mazzini**, Tullio Ricci, Alessandra Sciarra, Milena Moretti, and Matteo Lupi, 2018. Locating drumbeat signals generated at the Nirano Mud Volcano, Italy. The European Seismological Commission, 36th General Assembly, 2-7 Sepetember, Valletta, Malta.

192. **Werner, S.C**; H Dypvik, F Poulet, F Rull Perez, J-P Bibring, **B Bultel**, C Casanova Roque, J Carter, A Cousin, A Guzman, V Hamm, H Hellevang, C Lantz, G Lopez-Reyes, JA Manrique, S Maurice, J Medina Garcia, R Navarro, JI Negro, ER Neumann, C Pilorget, L Riu, C Sætre, A Sansano Caramazana, A Sanz Arranz, F Sobron Grañón, M Veneranda**, J-C Viennet**, PTAL Team. The Planetary Terrestrial Analogues Library (PTAL). Second International Mars Sample Return, 2018 (Poster).

193. Wagner, R.~J., Stephan, K., Schmedemann, N., **Werner, S.C.,** Hoffmann, H., Roatsch, T., Kersten, E., Jaumann, R., Palumbo, P(2018)The large bright ray crater Osiris on Ganymede: its age, role as a potential time-stratigraphic marker, and target for detailed imaging by the JUICE/JANUS Camera. European Planetary Science Congress 12, EPSC2018-855 (Poster).

194. Wagner, R.J., Schmedemann, N., **Werner, S.C.**, Ivanov, B.A., Roatsch, T., Kersten, E., Jaumann, R. (2018) Double and Multiple Craters on the Satellites of Saturn and Jupiter and their Implications on Impactor Size Distributions. EGU General Assembly Conference Abstracts 20, 8210 (poster).

195. **Werner, SC; B Bultel**, Vera Fernandes, **Tobias Rolf**. Lunar Cratering Chronology – Review and Revision. AGU, 2018

196. Wessel; P; **C.P Conrad**. Absolute Plate and Plume Motions and Implications for True Polar Wander

197. Wrona, Thilo; Haakon Fossen, Robert L. Gawthorpe, Christopher A-L. Jackson, Rebecca E. Bell, Craig Magee, **Jan Inge Faleide**, and Marit Stokke Bauck. Deep crustal structures in the northern North Sea rift: observations from new 3-D seismic reflection data. Tue, 10 Apr, 15:30–15:45, Room D2 EGU Vienna 8-13.4.18 (Talk).

198. **Zaputlyaeva A., Mazzini A.**, Blumenberg, M., Scheeder, G**., Svensen H**., 2018. The sources of oil erupted at Lusi, NE Java, Indonesia. EGU General Assembly 2018, Vol. 20, EGU2018-6468, Wien 8-13 April 2018.

199. **Zaputlyaeva A., Mazzini A.,** Caracausi A., **Svensen H**., and Sciarra A., 2018. Mantle-derived fluids in the oil and gas fields around the Lusi mud eruption, NE Java, Indonesia. EGU General Assembly 2018, Vol. 20, EGU2018-579, Wien 8-13 April 2018.

200. **Zaputlyaeva, Alexandra; Adriano Mazzini**, Antonio Caracausi, **Henrik Svensen**, and Alessandra Sciarra. Mantle-derived fluids in the oil and gas fields around the Lusi mud eruption, NE Java, Indonesia. EGU Vienna 8-13.4.18 (Poster).

201. Zertani, Sascha; Timm John, Frederik Tilmann, Loic Labrousse, **Torgeir B. Andersen**. The effect of eclogitization and associated deformation on the petrophysical properties of lower continental crust. EGU Vienna 8-13.4.18 (Talk).

202. Zwaan, Frank; Guido Schreurs, **Susanne Buiter**, John Naliboff, and Jürgen Adam. Comparing various analogue set-ups for modelling extensional tectonics. Fri, 13 Apr, 10:34–10:36, PICO spot 3 EGU Vienna 8-13.4.18 (Pico talk).

PhD student Joost van den Broek leading an excursion with a school class from Elvebakken Videregående to the cobalt mines in the Modum area , South Norway.

Professors, Researchers and Adjunct Professors

Name & title	Funding source	Contract from	Contract to	Working months	% posi- tion	Citizenship
Andersen, Torgeir B. Prof.	UiO-IG	01.03.13	30.04.22	6	50	Norwegian
Breivik, Asbjørn, Associate Prof.	UiO-IG	01.03.13	28.02.23	6	50	Norwegian
Corfu, Fernando. Prof.	UiO-IG	01.03.13	22.09.19.	3,6	30	Swiss
Dypvik, Henning. Prof.	UiO-IG	01.03.13	11.09.20	2,4	20	Norwegian
Faleide, Jan Inge. Prof.	UiO-IG	01.03.13	28.02.23	3,6	30	Norwegian
Kruger, Kirstin, Prof.	UiO-IG	01.11.18	28.02.23	0,03	10	German
Maupin, Valerie	UiO-IG	01.03.13	28.02.23	6	50	French
Neumann, Else R. Prof. Emerita	UiO-IG	01.03.13				Norwegian
Torsvik, Trond H. Prof	UiO-IG	01.03.13	28.02.23	6	50	Norwegian
Trønnes, Reidar. Prof.	UiO-IG	01.03.13	28.02.23	6	50	Norwegian
Werner, Stephanie, Prof	UiO-IG	01.03.13	28.02.23	6	50	German
Afonso, Juan C. Adjunct Prof.	690471	01.06.17	30.03.18	2,4	20	Brazilian
Afonso, Juan C. Adjunct Prof.	SFF	01.09.18	30.08.19			
Brodholt, John, Adjunct Prof.	SFF	01.03.18	28.02.20	2	20	British
Buiter, Susanne, Researcher	SFF	01.05.16	28.02.20	2,4	20	Dutch
Caracas, Razvan Researcher	SFF	01.09.18	31.08,20	0,8	20	Romanian
Conrad, Clinton Professor	SFF	01.18.16	31.07.19	12	100	American
Domeier, Mathew, researcher	144312	07.08.16	06.02.19	12	100	American
Doubrovine, Pavel, Researcher	SFF	1.10.16	28.02.23	7,6	80	Russian
Doubrovine, Pavel	143997	01.10.16	31.12.18	2,4	20	
Hannah, Judith, Researcher	421048	01.07.12	30.06.18	3	50	American
Gaina, Carmen	SFF	01.03.13	28.02.23	12	100	Romanian
Jahren, Anne Hope Wilson Prof.	SFF	01.09.16	31.08.19	12	100	American
Jerram, Dougal. Researcher 20%	SFF	01.03.13	28.02.20	2,4	20	British
Jones, Morgan. Researcher	144450	18.09.17	02.12.20	12	100	British
Mazzini, Adriano. Reseacher	650129	01.03.13	31.12.18	7,6	80	Italian
Mazzini, Adriano. Reseacher	UiO-IG	01.03.13	31.12.18	2,4	20	
Medvedev, Sergei Researcher	SFF	15.11.17	15.01.18	2,4	20	Russian
Mohn, Chris Researcher	SFF	01.06.13	28.02.23	12	100	Norwegian
Niscancioglu Kerim H. Prof	144151	01.08.15	31.07.20	2,4	20	Norwegian
Planke, Sverre, Adjunct Prof..	SFF	01.03.13	28.02.18	0,03	20	Norwegian
Planke, Sverre.	190648	01.07.18	28.02.23	1,2	20	
Polozov, Alexander. Associate P.	SFF	01.03.13	28.02.18	0,4	20	Russian
Rolf, Tobias, Researcher	144657	01.12.18	20.10.23	1		German
Schweizer, Johannes Adjunct Prof.	NORSAR	01.09.15	31.08.19	2,4	20	German
Sekhar, Aswin Researcher	SFF	01.03.18	30.08.18	1,2	20	Indian
Shephard, Grace Researcher	SFF	01.05.18	28.02.23	8	100	Australian

Red: new, grey: left CEED

Professors, Researchers and Adjunct Professors

Name & title	Funding source	Contract from	Contract to	Working months at CEED	% position	Citizenship
Spakman, Wim Adjunct Prof.	SFF	01.03.13	28.02.20	2,4	20	Dutch
Stein, Holly	421048	01.07.12	30.06.18	3	50	Ameican
Steinberger, Bernhard	SFF	01.05.16	28.02.20	2,4	20	German
Svensen, Henrik H. Researcher	SFF	01.05.16	28.02.23	12	100	Norwegian
Watson, Robin	SFF	01.12.18	31.12.19		10	British

PhD candidates

Name & title	Funding source	Contract from	Contract to	Working months at CEED	% position	Citizenship
Ballo, Eirik	UiO IG KD	24.09.18	23.09.23	1	100	Norwegian
Bosttic, Joshua	UiO IG KDF143	04.09.17	03.09.20	12	100	American
Heimdal, Thea H.	SFF	03.08.17	02,.1,18	11	100	Norwegian
Heyn, Björn H.	UiO IG KDF144	15.09.16	14.11.19	12	100	German
Karlsen, Krister S.	UiO IG KDF73	01.08.17	30.07.21	12	100	Norwegian
Kjøll, Hans Jørgen	SFF	01.05.16	20.07.19	12	100	Norwegian
Stokke, Ella W.	144450	03.07.17	02.07.19	12	100	Norwegian
Straume, Eivind O.	UiO IG KDF214	15.08.16	14.08.20	12	100	Norwegian
Tan, Pingchuan	UiO IG KD	01.11.14	31.10.18	10	100	Chinese
Uppalapati, Sruthi	UiO IG KDF142	19.09.16	18.09.19	12	100	Indian
Van den Broek, Joost M.	651025	22.08.16	21.08.19	121	100	Dutch
Zaputlyaeva, Alexandra	UiO IG KDF104	19.09.16	18.09.19	12	100	Russian

Postdoc fellowships

Name & title	Funding source	Contract from	Contract to	Working months at CEED	% position	Citizenship
Augland, Lars Eivind	SFF	01.10.15	31.06.19	12	100	Norwegian
Bajard, Manon	152200-144656	01.09.18	31.08.21	4	100	French
Bultel, Benjamin	143899 + SFF	15.01.16	14.01.19	12	100	French
Callegaro, Sara	SFF	01.02.16	28.02.19	12	100	Italian
Cowie, Sara	144256	13.06.16	12.06.18	6	100	British
Crameri, Fabio	SFF	01.02.16	28.02.19	12	100	Swiss
Jakob, Johannes	144252	12.11.16	30.09.19	12	100	German
Király, Ágnes	SFF	01.08.17	30.07.20	12	100	Hungarian
Krzesinska, Agata M.	651021	15.10.18	14.10.21	2,5	100	Polish
Kulakov, Evgeniy	SFF	01.05.16	28.02.23	12	100	Russian

Postdoc fellowships (continuation)

Name	Funding source	Contract from	Contract to	Working months	% position	Citizenship
Lavecchia, Alessio	SFF	24.07.17	31.12.18	12	100	Italian
Løken, Andreas	SFF	14.03.17	31.05.18			Norwegian
Magni, Valentia	SFF	01.03.16	28.02.19	12	100	Italian
Minakov, Alexander	SFF	16.11.17	30.09.20	12	100	Russian
Prieur, Nils C.	690477	01.10.17	31.03.20	12	100	Frensh
Robert, Boris	144312	29.09.17	28.09.20	12	100	Frensh
Sekhar, Aswin	143899	01.09.15	28.02.18	2	100	Indian
Shephard, Grace	Vista	01.05.16	30.04.18	4	100	Australian
Shulgin, Alexey	190647	09.06.15	08.06.18	12	100	Russian

Techinical-administrative staff

Name & title	Funding source	Contract from	Contract to	Working months at CEED	% position	Citizenship
Birkelund, Anniken R.	144251	07.03.16	28.02.23	6	100	Norwegian
Gørbitz, Trine-Lise K.	SFF	01.03,13	28.02.23	12	100	Norwegian
Hagopian, William	SFF	01.01.17	31.12.19	12	100	American
Haugland, Vanja	144251	14.08.17	17.06.18	6	100	Norwegian
Mironova, Anna	SFF	01.11.17	02.10.18	2	75	Russian
Murray, Leight	152240-000500	01.04.18	31.18.19	8	100	Australian
Silkoset, Petter	152200	01.01.16	28.02.23	12	100	Norwegian
Sørlie, Anita	SFF	15.06.16	28.02.23	9	75	Norwegian

Short term / hour based salary

Name & title	Funding source	Contract from	Contract to	Working months at CEED	% position	Citizenship
Busengdal, Marte	SFF	01.01.18	31.08.18			
Müller, Philipp	650129	01.08.18	30.11.18	4	100	
Minetto, Riccardo	650129	01.09.18	31.12.18	4	100	
Uehara, Dan	SFF	01.12.17	31.05.18	4	75	

Guest researchers in 2018

Name	Title	from	to
Basto.Lucas	PhD student, Rio de Janeiro, Brasil	03.09.18	28.02.19
Breyer, Floriane	Master student, Bretagne, France	03.04.18	10.09.18
Bulut, Nevra	PhD student, Istanbul, Turkey	01.10.18	31.03.19
Closset, Pierre	Master student, Strasbourg, France	13.02.18	18.06.18
Gac, Sebastien	Guest researcher, Norway	24.08.18	31.12.18

Guest researchers in 2018 (continuation)

Name	Title	from	to
Halvorsen, Erik	Dr. Philos	01.01.18	01.01.18
Janin, Alexandre	Guest Master student from Bretagne, France	01.04.18	01.04.18
Lu, Laiyu	Researcher, China Earthquake admin, Beijing ,China	03.08.18	30.09.18
Medvedev, Sergei	Guest researcher, Norway	16.01.18	30.11.18
Schaffer, Andrew	University of Ottawa, Canada	01.08.18	13.08.18
Tonti-Filippini, Justin	Erasmus+ student from Iceland	07.11.18	01.03.19
Wang, Kaiming	PhD guest student from Beijing, China	16.09.17	15.09.18

Stipend to stay abroad (longer term):

Name	Gender	Visiting country	from	to
Straume, Eivind O.	M	IMAS, Tasmania Australia	04.11.18	01.12.18
Shephard, Grace E.	F	ELSI, Tokyo Japan	04.05.18	07.06.18
Uppalapati, Sruthi	F	ETH, Zurich Switzerland	05.05.18	04.06.18
Zaputlyaeva, Alexandra	F	INGV, Palermo Italy	20.10.18	16.12.18

CEED: A CENTRE OF EXCELLENCE 2013-2023

Basic research relevant to society and industry

CEED
University of Oslo
PO Box 1028 Blindern
N-0315 Oslo
Norway

Contact:
ceed-post@geo.uio.no
phone: +47 22 85 64 35

www.mn.uio.no/ceed