

# The NJORD-Centre

For studies of the Physics of the Earth

*A Geoscience-Physics Centre  
hosted by the  
Faculty of Mathematics and Natural Sciences, UiO*

We propose a new cross-disciplinary geoscience-physics centre at the Faculty of mathematics and natural sciences (FMN), UiO. It will be named ‘*NJORD*’ after the God of the sea and wealth in the Old Norse mythology. *Njord* is a male equivalent to the (female) Germanic precursor *Nerthus* and the Roman *Terra mater* (“Mother Earth”). The NJORD-Centre will accommodate researchers from the former CoE ‘Physics of Geological Processes’ and the UiO node of the new CoE ‘Porous Media Laboratory’ which is currently part of the Condensed Matter physics section at the Departments of Geosciences and Physics at FMN.

Our goal is to develop an already leading research and education environment to become *the top* European research environment focused on the fundamental physics of geological processes related to: Transport and reactions in deformable porous media, fracturing and fragmentation processes, interface dynamics during geophysical flows, and intermittency and pattern formation in geological systems far from equilibrium. We will conduct research on Earth Systems that range in scale from atoms to continents and apply methods where fieldwork, numerical modelling, experiments and theory act in concert.

NJORD will become one of the main UiO cross-disciplinary ‘drivers’ for the future development of Physical Sciences in general, and Earth and Space related research in particular.

While the prime products of our centre will be high quality basic research and education, we will also focus considerable efforts on outreach and innovation through collaboration with media, renowned artists and industry partners. Our research is directly relevant to a wide range of applications, including transport of water, pollutants and hydrocarbons in porous and fractured rocks, carbon sequestration and storage, avalanche dynamics, earthquakes, and other geohazards,

## **Introduction**

*Physics of Geological Processes (PGP)* was a first generation Norwegian Centre of Excellence (CoE) running in the period 2003-2013 and has roots back to the mid-90s as a Strategic University Program. A PGP precursor project lead by B. Jamtveit (‘Dynamics of fluid-rock interfaces’) also spent year at the Centre of Advanced Studies at the Norwegian Academy of Science and Letters in 2000-2001.

At the end of the CoE period, PGP was ‘phased-into’ the host departments as one small section in the Department of Geosciences (named PGP), whereas the physics part of PGP became part of the Condensed Matter section of the Department of Physics.

*Porous Media Laboratory (PoreLab)* is a fourth generation CoE and will run in the

period 2017-2027. It is directed by professor Alex Hansen at NTNU, but a major component of the staff and activities will be located at UiO and coordinated by Knut Jørgen Måløy and Eirik Flekkøy. The goal of PoreLab is the development of theories, principles, tools and methods to reduce the trial and error approach to porous media with relevance in biology, chemistry, geology and geophysics based on fluid mechanics, non-equilibrium thermodynamics and statistical mechanics. The goals and methods of PoreLab is highly cross-disciplinary and show considerable overlap with ongoing PGP activities. Several PGP staff members are already collaborators in the PoreLab project (Dysthe, Angheluta, Jamtveit).

*We believe there is an obvious and considerable potential for increased synergies between physics and geoscience at UiO by merging PGP and PoreLab/UiO onto a joint organizational platform.*

## **Strategy and goals**

### **Goals**

- Maintain and develop a world leading cross-disciplinary research center in physical sciences at UiO with focus on a fundamental understanding of the dynamics of fluid-solid systems with Earth-like complexity.
- Build the next generation of computational competences and experimental laboratory facilities for the study of processes in fluid-rock / fluid porous-media systems in 4D from molecular to field scales.
- Provide a unique basis for making predictions relevant for CO<sub>2</sub>-sequestration, exploration and exploitation of natural resources, transport of contaminants in geo-systems, avalanches, landslides, and other geohazards.
- Generate an outstanding environment for research-based education at the Masters and PhD levels.
- Make complex Earth systems visible in the public sphere.
- Submit one successful ERC Advanced or Synergy grant and one ERC Startup or Consolidator grants within the first 5 year period, and establish a new CoE with a NJORD PI within the next 10 years.

### **Research strategy**

- To create an interactive co-localized organization of geoscientist and physicists conducting field geology, theory, numerical modeling and experiments in concert
- Be an active and often leading partner in international collaborations
- Participate in international projects (IODP, ICDP, Inter-Reg MAXIVESSFUN) and be a user of large-scale national and international facilities where Norway is a partner (ESRF, ESS, IFE, IOR).

### **Education strategy**

- Research based education – learning by doing. Close collaboration with the Center for Computation in Science Education directed by Anders Malthe-Sørensen.
- NJORD staff members will normally participate in the education at all levels at

their respective Departments with the normal workload associated with teaching at UiO. Exceptions may apply to staff involved in CoE's and staff in leading roles.

### **Impact through outreach and innovation**

- Collaborations with leading artists, including composer Natasha Barrett and visual artist Ellen Karin Mæhlum, to produce joint exhibits and hosting artists in our laboratories.
- Frequent presence in the media.
- Extend existing collaborations with the private sector (Statoil, Total, VBPR, IRIS) through joint participations in research projects.
- Provide competences and resources to develop the Physical Sciences at UiO in the future.

### **Existing resources**

The 10 researchers entering the NJORD-Centre already runs projects that funds more than 40 PhDs and PostDocs. Ongoing projects include (project and PIs name in parenthesis): an ERC Advanced grant ('DIME' – Jamtveit); the coordination of a Marie Curie ITN project ('Nanoheal' –Dysthe), a Strategic Research Initiative (SRI) ('Earthflows' – Jamtveit/Angheluta), two infrastructure grants AVIT (Renard, Dysthe), ca 10 projects from the Norwegian Research Council (FRINATEK, PETROMAX, CLIMIT – Renard, Dysthe, Malthe-Sørensen, Røyne), partner in a Marie Curie ITN projects ('Abyss'- Jamtveit) and 4 KD-stipendiates from UiO (Galland, Angheluta, Dysthe, Renard).

Finally, Måløy and Flekkøy are UiO partners of the new CoE 'PoreLab' directed by Alex Hansen, NTNU. The CoE budget for PoreLab is approx. 15 MNOK per year, a significant fraction of this (ca 45%) will be spent at UiO.

In terms of laboratory facilities, NJORD will operate and further develop facilities from the PGP-CoE and Porelab in the Dept of Physics and also have access to the common laboratory facilities at both Departments of Geosciences and Physics, at internal department rates. Although PGPs period as a CoE ended in February 2013, about 13 MNOK has been invested in new laboratory equipment since then. This includes:

- • Atomic force microscope
- • White light interferometer
- • Triaxial rig at the European Synchrotron Radiation Facility (ESRF)
- • Microfluidics laboratory
- • Surface force apparatus
- • 3D graphics platform
- • Tensiometer
- • A newly renovated Friction & Interface lab

NJORD researchers and PhD and post-doctorate fellows will be co-localized on the two top floors of the western wing of the Physics Institute building, with laboratories both hosted by the Departments of Physics and Geosciences.

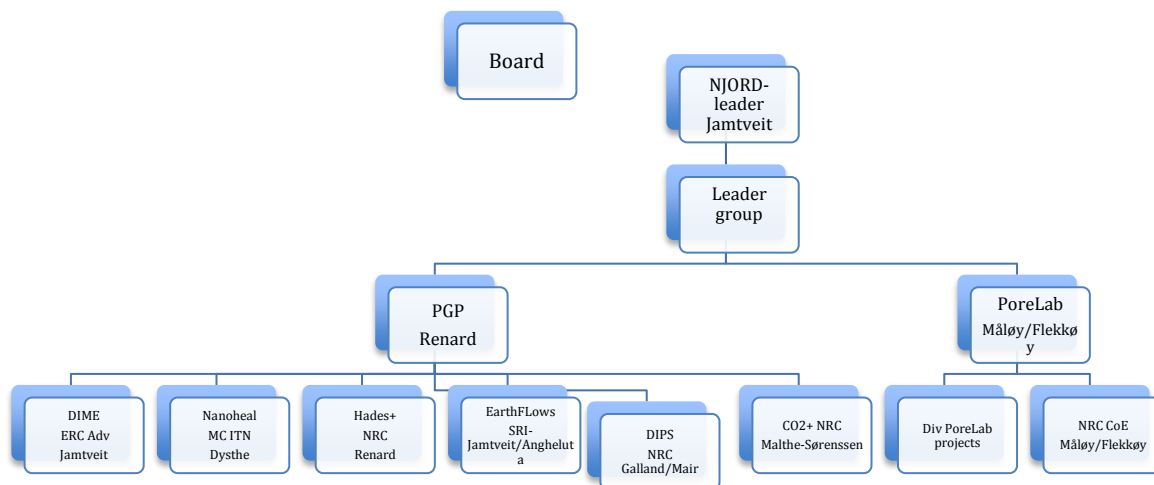
## Organization

The scientific staff of NJORD will include five permanent members from the PGP section of the Department of Geosciences (Jamtveit, Renard, Austrheim, Mair, and Galland) and five members from the Condensed Matter Physics section of the Department of Physics (Malthe-Sørenssen, Dysthe, Angheluta, Måløy, Flekkøy). Two technical staff, Dr. Yi Hu and Mihailo Jankov (part time) will be part of the Center.

NJORD will be directed by the NJORD leader. The leader will be hired for 4 years with possible extension for 4 more years, similar to the case for leaders in the UiO line-structure. The first NJORD leader will be Bjørn Jamtveit. During a change of NJORD leader, the new leader will be proposed among the NJORD staff members and then appointed by the Board. He/she will report to a Board comprised of the Vice Dean of Research at the Faculty of Mathematics and Natural Sciences and the Heads of Departments of Geosciences and Physics. The Chair of the Board will alternate between Departments of Geosciences and Physics every two years.

NJORD representatives will be part of the leader groups in both Department of Geosciences and Physics to ensure optimal communication with these department on issues related to teaching and research.

NJORD will comprise two main sections: *PGP* and *Porelab*. Section leaders will be Francois Renard for PGP and Knut-Jørgen Måløy & Eirik Flekkøy will co-lead the Porelab section. NJORD leadership will furthermore include a leader group comprised of the director and sections leaders as well as two representatives of the NJORD projects.



*Fig.1 Organization structure of NJORD, including existing major projects and PIs.*

## **Resource requirements**

Salaries of permanent staff members will be covered through the respective departments. Research projects will be funded from the individual external or internal project grants. NJORD income will be composed of a fraction of the overhead brought in by NJORD PI's/projects defined under the scope of the NJORD strategic goals.

In addition to the ten permanent staff members initially entering NJORD, effective running of the Centre requires the following resources:

- **Administrative support staff**

Effective running of NJORD requires a local admin person in 100% position. This person will also link NJORD to the admin support in the FMN and the respective departments.

- **Running costs**

NJORD requires approx. 0.5 MNOK/year funding for 'common' NJORD activities such as meetings, seminars, invited speakers, annual reports, and outreach which cannot be covered by regular project funding. This can be covered through the overhead income to the relevant departments from existing PGP projects and will later be covered from the overhead of future NJORD projects.