The Ivar Giæver Geomagnetic Laboratory: A new national research infrastructure for paleo- and rock magnetism

Pavel V. Doubrovine (CEED, University of Oslo)
What is the IGGL

Host Institution:
Centre for Earth Evolution and Dynamics (CEED), Department of Geosciences, University of Oslo

National Partners:
Norwegian University of Science and Technology
University of Bergen
Geological Survey of Norway

Advisory Committee:
Prof. Trond H. Torsvik (CEED, UiO)
Prof. Harald J. Walderhaug (UiB)
Prof. Suzanne McEnroe (NTNU)
Dr. Morgan Ganerød (NGU)
Prof. Joseph G. Meert (Univ. Florida, USA)
IGGL Team: Who we are

Pavel Doubrovine
Mathew Domeier
Evgeniy Kulakov

Petter Silkoset (Engineer)
Trond Helge Torsvik (Project Coordinator)
Why the laboratory is named after Ivar Giæver?

Ivar Giæver, a Norwegian-American physicist who won the Nobel Prize in Physics in 1973 for his experimental discoveries regarding tunneling phenomena in superconductors.

Ivar Giæver - Facts

Ivar Giæver

Born: 5 April 1929, Bergen, Norway

Affiliation at the time of the award: General Electric Company, Schenectady, NY, USA

Prize motivation: "for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively"

Field: condensed matter physics, semiconductors
How it began: Oslo Geomagnetic Laboratory

- 2012: Established by the Earth Dynamics Group at the Physics of Geological Processes SFF (UiO) – a limited paleomagnetic setup
- March 2013: Became a part of CEED, Dynamic Earth
- November 2013: Awarded a NFR grant of 8 million NOK to establish a National Research Infrastructure for Geomagnetism – Ivar Giæver Geomagnetic Laboratory (IGGL)
**Vision:**
Establish a national laboratory **to serve the entire geomagnetic community** by providing access to state-of-the-art instruments and scientific expertise

**Paleomagnetism**
- Generating new, high-quality datasets of paleomagnetic directions/poles for paleogeographic reconstructions; implications for plate kinematics and mantle dynamics
- Magnetostratigraphy: correlating sedimentary sequences using the record of geomagnetic reversals

**Paleointensity**
- Constraining the intensity of the geomagnetic field in the geologic past through Thellier experiments; implications for geodynamo modelling and the core dynamics

**Rock and Mineral Magnetism**
- Magnetic mineralogy (Curie temperature analysis, characteristic low-temperature transitions in magnetic minerals)
- Magnetic domain states, distribution and interaction of magnetic carriers (magnetic hysteresis measurements, FORC analyses)
- Stability of remanence carriers and veracity of paleomagnetic record
- Magnetic fabric: Anisotropy of magnetic susceptibility and remanence
- Extraterrestrial magnetism: Magnetic properties of meteorites
- Biomagnetism and environmental magnetism
- Fundamental rock-magnetism (e.g., interactions in multiphase assemblages, exchange anisotropy)
- Magnetic properties of synthetic samples (material science)
Building the lab: 2014-2016

Finished in April 2016
Opened in September 2016
Paleomagnetism and paleogeography
Rock Magnetometers

2G Superconducting Rock Magnetometer

- High-sensitivity DC SQUID sensors (magnetic moment nose level $1 \times 10^{-12} \text{ Am}^2$)
- In-line AF demagnetizer and automatic sample manipulator
- Can measure very weakly magnetized rocks (e.g., sediments) and single crystals

AGICO JR-6A Spinner Magnetometer

- Most sensitive and accurate magnetometer in its class
- Fast, fully automated measurements
- Dual rotation speed for increased sensitivity (up to $2 \times 10^{-6} \text{ A/m}$)
- Ideal for strongly magnetized rocks
Demagnetizers

AGICO LDA-5 AF Demagnetizer & PAM-1 Anhysteretic/Pulse Magnetizer

• Automated, computer-controlled demagnetization/magnetization process
• Maximum AF field of 200 mT
• ARM in up to a 500 μT field
•IRM in a direct field up to 20 mT

Magnetic Measurements MMTD80A and MMTDSC Thermal Demagnetizers

• Advanced, microprocessor-controlled thermal demagnetizers with 4-layer Mu-metal shield protection
• Cryocooler for super fast cooling (MMTDSC)
• Internal solenoid for creating TRMs (Thellier paleointensity experiments)
Magnetic Measurements MMLFC Shielded Room

- 15 square coils, 5 in each of 3 directions, all automatically controlled by a 3 axis fluxgate magnetometer
- Cancels the Earth’s field and 50/60Hz mains generated magnetic fields
- Allows measurement and demagnetization to be carried out in a near zero field environment to avoid magnetic viscosity effects
- 2 rooms hosting AGICO JR-6A Spinner Magnetometer and 2G Superconducting Rock Magnetometer
Magnetic Susceptibility Measurements

**AGICO MKF-1 Kappabridge**

- Measurements of anisotropy of magnetic susceptibility (AMS) and bulk magnetic susceptibility
- High-sensitivity (up to $2 \times 10^{-8}$ SI)
- Variable measuring fields (2-700 A/m)
- 3D automatic sample rotator – full AMS tensor in 90 seconds
- CS-4 furnace for measuring the temperature variation of magnetic susceptibility up to 700 °C
- Curie temperatures, thermal stability of magnetic carriers
AMS and Thermomagnetic Analyses

Geographic coordinate system
Equal-area projection N=12

K1
K2
K3
4.11E-02 9.12E-02
Km [SI] 1.000 1.079

Geographic coordinate system
Equal-area projection N=11

K1
K2
K3
1.56E-03 2.09E-03
Km [SI] 1.000 1.024

Geographic coordinate system
Equal-area projection N=11

K1
K2
K3
2.68E-02 5.08E-02
Km [SI] 1.000 1.051

NGF Symposium, September 19, 2016
Magnetic Hysteresis Measurements

Lake Shore PMC MicroMag 3900 Vibrating Sample Magnetometer (VSM)

- Magnetic hysteresis measurements on rock and mineral samples
- Vide range (5 x 10^{-8} to 1 x 10^{-2} Am^2) and high accuracy (5 x 10^{-10} Am^2 STDV at 1 point/s)
- Maximum field of 1.8 T (18 kOe)
- Fast, computer-controlled data acquisition, including automated measurements of First Order Reversal Curves (FORC)
- High-temperature furnace: Measurements up to 800 °C
- Low-temperature LHe cryostat: Measurements from 10K to 473 K (-263 °C to +200 °C)
- First magnetic hysteresis measurement system with low-T capabilities in Norway
First-order Reversal Curve Analysis

NGF Symposium, September 19, 2016
Putting it to good use

Encourage Norwegian and foreign researchers to visit and use the laboratory infrastructure to explore fundamental questions at the frontiers of modern geomagnetism

**User Access Policies:**

- Any researcher in Norway or abroad is eligible to request instrument time
- Access is not restricted to paleo- and rock magnetists, prior experience is not a prerequisite
- Use of the lab facilities and technical assistance comes free of charge

**How to apply for a visit:**

- Contact IGGL staff to check instrument availability and request time
- Tell us a bit of about your project, instruments you’d like to use, and whether you need training
- More information at [www.iggl.no/visit.html](http://www.iggl.no/visit.html)
Visiting Fellowship Program

- **Ivar Giæver Visiting Fellowships**: Up to 10 researches per year will be awarded a visiting grant, up to 10000 NOK to cover travel expenses, and instrument running costs.

- Begins in the fall 2016.

- Fellowships will be awarded based on the evaluation of short proposals.

- Gives priority access to IGGL facilities for up to two weeks.

- Calls for proposals will be sent out twice a year (September and April).

- Prioritize our consortium partners from UiB, NTNU and NGU and other Norwegian institutions.

- Prioritize young scientists (PhD students and postdocs).

- Will be advertised at the IGGL, CEED, UiO and NFR websites, and through GPmag-1, EGU and AGU mailing lists.

- Instrument schedule and availability will be posted at the IGGL website (currently under construction).
Laboratory website: http://www.iggl.no
Software and Data Resources

Available at www.iggl.no