INSTITUTE OF ROCK STRUCTURE AND MECHANICS
The Czech Academy of Sciences

DEPARTMENT OF APPLIED ROCK MECHANICS

THEMATIC RESEARCH FOCUS

- EXPLORING HOW EXTERNAL FACTORS, SUCH AS TEMPERATURE, PRECIPITATION, AND CLIMATE EXTREMES, INFLUENCE CHANGES IN ROCK PROPERTIES
- STUDYING THE IMPACTS OF CLIMATE CHANGE ON ROCK WEATHERING AND SLOPE STABILITY
- INVESTIGATING HOW TEMPERATURE ACTS AS AN INDICATOR OF CHANGES IN ROCK PROPERTIES AND AS A DRIVER OF ROCK EVOLUTION ACROSS DIFFERENT SCALES
- UNCOVERING THE COMPLEX BEHAVIOURS OF ANISOTROPIC ROCKS UNDER VARYING CONDITIONS

Block of sandstone disrupted by cyclical temperature changes in the High Arctic, Svalbard.

MAIN SCOPE OF RESEARCH

- Conducting basic and advanced laboratory tests in rock mechanics.
- Investigating how climate-driven mechanical weathering alters rock properties over time.
- Analysing rock anisotropy under diverse pressure-temperature (P-T) conditions to reveal its effects on rock strength and stability.
- Assessing the impacts of extreme heat on rock integrity, including wildfires and rising global temperatures.
- Utilising cutting-edge remote-sensing techniques, such as InfraRed Thermography (IRT), for precise, non-invasive characterisation of rock properties..
- Bridging the gap between field observations and laboratory results to better understand in-situ rock behaviour.
- Developing statistical and numerical models to simulate the behaviour of rock masses and slopes.
- Applying predictive models to assess and mitigate risks in landslide-prone terrains.

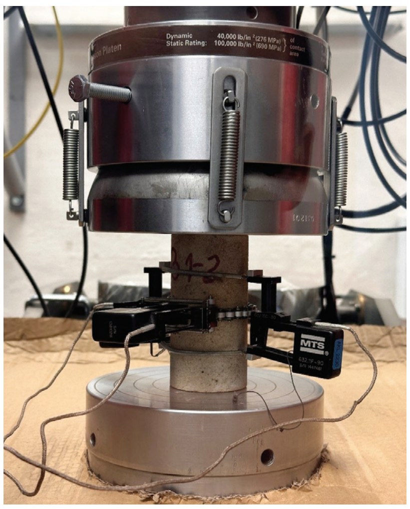
MONITORING SITES AND FIELD LABORATORY

- **RockTemp** – monitoring rock temperature and block deformation at various sites in Czechia and abroad. Sites in Czechia include Branická skála (Prague), Pastýřská stěna (Děčín), Tašovice (Karlovy Vary) and Labský důl (Krkonoše), while other sites include Cimaganda Rockslide in Italy; Fugleberget in Hornsund, Svalbard and two sites in Yosemite Valley, California, USA.
- **Požáry Field Laboratory** – Experimental laboratory in the former Požáry quarry (Prosečnice) near Prague, Czechia. Here, experimental measurements are carried out on variations in rock properties under natural conditions on a granodiorite rock slope.

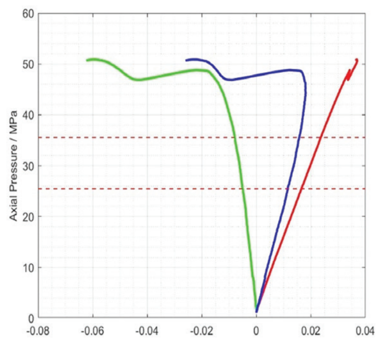
KEY RESEARCH EQUIPMENT – FIELD AND LAB

- **Laboratory Devices**

- **MTS 815 rock mechanics test system**
  Determination of elastic rock properties: Dynamic and static moduli (Young, shear, and bulk moduli, Poisson number) and Rock strength measurement:
  - Uniaxial loading
  - Triaxial loading
  - Pressure cell chamber - cylindrical samples (50 mm diameter, height approx. 120 mm)
  - “True“ triaxial loading - cube 15x15x15 cm
  - Fracture Toughness Mode II
- **High-pressure chamber (up to 400 MPa for spherical samples)**
  Ultrasound P, S1 and S2 measurement
- **Permeability measurement**
  Quizix 5000



- **Vallen – Acoustic Emissions** (24 channels + 8 parametric inputs)
- **Ultrasonic measurements of rock samples**:
  P and S wave velocities measurement, determination of dynamic elastic moduli at atmospheric pressure or during uniaxial loading
- **Hydraulic fracking**
- **Measurement of alkali-silica reaction**
- **Temperature/humidity loading** using climatic chamber (-42°C to 190°C) and humidity (RH 10%-98%) settings (Climate chamber CTC 256 Memmert)
- **Direct shear test**
- **Rheological lab and creep test**



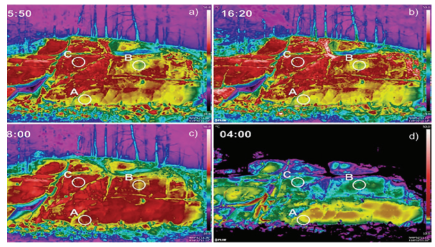
- **Field**

- **Core drilling of rocks**: Core rock drilling up to 250 mm in diameter and up to 3 m deep (Husqvarna DMS 240)
- **Infrared thermography measurements:**
  Single or repeated measurements (FLIR E95)
- **Geotechnical / Geological monitoring of rock masses:**
  Automatic crackmeter measurement with resolution of 0.05 mm. Hand-held dilatometer (Holle) with 0.1 mm resolution

ACHIEVEMENTS

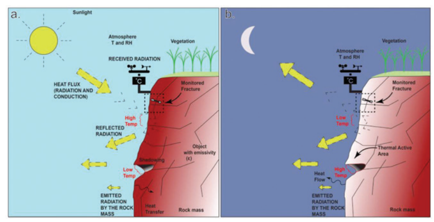
- **Studies on the thermal behaviour of slopes**

Loche M, Racek O, Petružálek M, Scaringi G & Blahůt J (2024) Infrared thermography reveals weathering hotspots at the Požáry field laboratory. Scientific Reports 14(1): 14682. https://doi.org/10.1038/s41598-024-65527-x



Thermograms were recorded at the slope scale where substantial thermal anomalies appeared, suggesting different behaviours within the rock mass. ROIs were selected based on the visual anomalies of the acquired images.

Racek O, Balek J, Loche M, Vích D & Blahůt J (2023) Rock Surface Strain In Situ Monitoring A¬ffected by Temperature Changes at the Požáry Field Lab (Czechia). Sensors 23(4): 2237. https://doi.org/10.3390/s23042237



A sketch of the temperature processes in the instrumented fractures at the test site in Požáry (Czechia). (a,b) Temperature propagates as cyclical input within the active superficial layer, primarily influenced by surface irregularities and exposure. Shadowing and the presence of vegetated areas lead to a possible mismatch between the simulation in the climate chamber and the natural environment, making the test not fully valid for representing the heterogeneity of the natural environment. The dashed rectangle indicates a detail of the instrumented sector of the rock mass. Thermal oscillation experienced by the rock mass in the study area, during the time interval from 16 October to 15 December, ranges from 0 to 18 °C

Loche M & Scaringi G (2025) Assessing the influence of temperature on slope stability in a temperate climate: A nationwide spatial probability analysis in Italy. Environmental Modelling & Software 183: 106217. https://doi.org/10.1016/j.envsoft.2024.106217

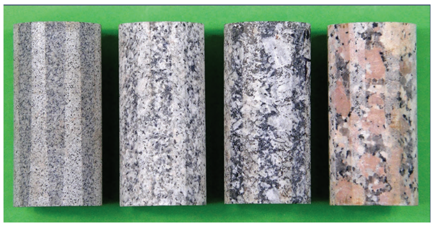
Loche M & Scaringi G (2023) Temperature and shear-rate effects in two pure clays: Possible implications for clay landslides. Results in Engineering 20: 101647. https://doi.org/10.1016/j.rineng.2023.101647

Racek O, Blahůt J & Hartvich F (2021) Observation of the rock slope thermal regime, coupled with crackmeter stability monitoring: initial results from three different sites in Czechia (Central Europe). Geoscientific Instrumentation, Methods and Data Systems 10: 203-218. https://doi.org/10.5194/gi-10-203-2021

Loche M, Scaringi G, Blahůt J, Melis MT, Funedda A, Da Pelo S, Erbì I, Deiana G, Meloni MA & Cocco F (2021) An infrared thermography approach to evaluate the strength of a rock cliff. Remote Sensing 13(7): 1265. https://doi.org/10.3390/rs13071265

- **Studies on the thermal and hydraulic evolution of rocks in the laboratory**

Petružálek M, Jechumtálová Z, Lokajíček T, Kolář P & Šílený J (2024) Micro-fracturing in granitic rocks during uniaxial loading: the role of grain size heterogeneity. Rock Mechanics and Rock Engineering 57(3): 1963-1981. https://doi.org/10.1007/s00603-023-03668-7

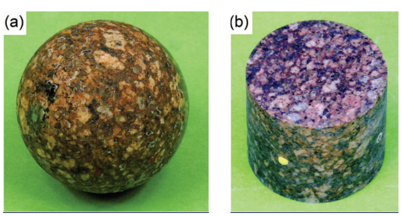


Four specimens before testing, from left to right: westerly granite, mrakotin granite, Brno syenite, and liberec granite

Petružálek M, Lokajíček T, Přikryl R & Vavryčuk V (2023) Velocity anisotropy measured on the spherical specimens: History and applications. Journal of Geodynamics 158: 102002. https://doi.org/10.1016/j.jog.2023.102002

Keppler R, Vasin R, Stipp M, Lokajíček T, Petružálek M & Froitzheim N (2021) Elastic anisotropies of deformed upper crustal rocks in the Alps. Solid Earth Discussions 12(10): 2303-2326. https://doi.org/10.5194/se-12-2303-2021

Ivankina TI, Zel IY, Petružálek M, Rodkin MV, Matveev MA & Lokajíček T (2020) Elastic anisotropy, permeability, and freeze-thaw cycling of rapakivi granite. International Journal of Rock Mechanics and Mining Sciences 136: 104541. https://doi.org/10.1016/j.ijrmms.2020.104541



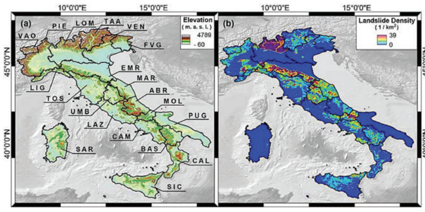
Rapakivi rock specimens: (a) – sphere, (b) – cylinder.

- **Application of advanced landslide susceptibility techniques**

Alvioli M, Loche M, Jacobs L, Grohmann CH, Abraham MT, Gupta K, ... & Rivera-Rivera JS (2024) A benchmark dataset and workflow for landslide susceptibility zonation. Earth-Science Reviews 258: 104927. https://doi.org/10.1016/j.earscirev.2024.104927

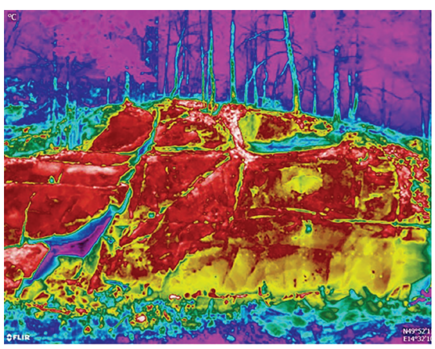
Tong ZL, Guan QT, Arabameri A, Loche M & Scaringi G (2023) Application of novel ensemble models to improve landslide susceptibility mapping reliability. Bulletin of Engineering Geology and the Environment 82: 309. https://doi.org/10.1007/s10064-023-03328-8

Loche M, Alvioli M, Marchesini I, Bakka H & Lombardo L (2022) Landslide susceptibility maps of Italy: Lesson learnt from dealing with multiple landslide types and the uneven spatial distribution of the national inventory. Earth-Science Reviews 232: 104125. https://doi.org/10.1016/j.earscirev.2022.104125



Administrative partition by region together with relative acronyms (a) and density map of the whole national landslide inventory (b).

Požáry Field Laboratory in Central Bohemia is located in former granodiorite quarry.



Thermal image of a rock face at the Požáry Field Laboratory showing spatially different thermal behaviour of the rock.

MAIN COLLABORATING PARTNERS

- Consiglio Nazionale delle Ricerche, Istituto di Ricerca per la Protezione Idrogeologica (Perugia, Italy)
- Faculty of Geo–Information Science and Earth Observation (ITC), University of Twente (Enschede, the Netherlands)
- Eurasia Institute of Earth Sciences, Istanbul Technical University, (Istanbul, Türkiye)
- Charles University (Prague, Czechia)
- Czech Technical University (Prague., Czechia)
- Instituto Geográfico Nacional de España (Santa Cruz de Tenerife, Spain)
- GNS Science (Wellington, New Zealand)
- University of Bayreuth (Germany)
- University of Utrecht (the Netherlands)
- University of Milan (Italy)
- U.S. Geological Survey (Moffet Field, California, USA)
- Yosemite National Park (California, USA)

Contact:

Institute of Rock Structure
and Mechanics
of the Czech Academy of Sciences
V Holešovičkách 94/41,
182 09 Praha 8,
Czech Republic
www.irsm.cas.cz

Department of Applied Rock Mechanics
Puškinovo nám. 447/9
160 00, Praha 6 – Bubeneč
Head of Department
Mgr. Jan Blahůt, Ph.D.
Phone: +420 266 009 394;
E-mail: blahut@irsm.cas.cz

INSTITUTE OF ROCK STRUCTURE AND MECHANICS
The Czech Academy of Sciences