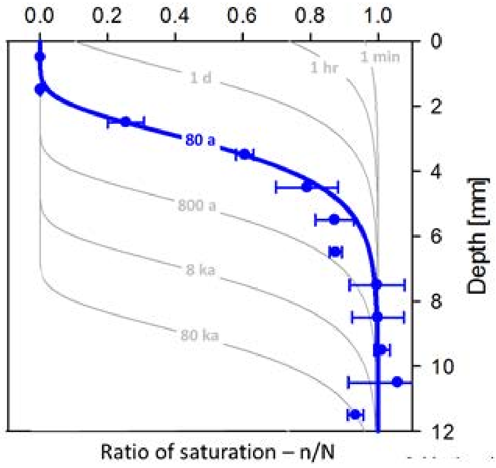
Development of spatially-resolved luminescence imaging to study bedrock exposure durations and weathering rates
Type: MSc project
ECTS credits: 30



Alpine (micro)climate is among the most sensitive to the industrially-increasing CO_2 levels, and its changes has already been documented instrumentally over the past hundred years (e.g. a later snow onset in winter). However, in order to predict future climate change and its impact on mountainous areas, one often lacks solid evidence of what the climate was like in the past. To this end, the formation of polished rock surfaces by sliding ice (glaciers), and the subsequent preservation of these surfaces after the ice is gone (glaciers melt), holds key information about past environmental conditions (ice thickness, snow cover, temperature, cloudiness), often inaccessible otherwise. DTU Nutech has recently pioneered two novel fields in radiation physics, which could be of particular value in addressing past climate (change):

1) Surface exposure dating. When freshly polished rock surfaces are exposed to sunlight, photons that penetrate into the rock (following a Beer-Lambert law) may interact with trapped electrons, effectively causing the progressive removal of the latter from the uppermost crystals. Consequently, the longer a rock is exposed to sunlight, the thicker the uppermost luminescence-free zone becomes:
http://onlinelibrary.wiley.com/doi/10.1029/2012JB009383/full
Thus, the description of luminescence gradients in exposed glacially-polished rocks provides unprecedented information about the duration of ice- (and snow-)free periods, sky cover, and micrometer-scale weathering of rock surfaces (after the glacial retreat).

2) Infrared Photoluminescence (IRPL). The recent discovery of a direct and non-destructive way of probing (quantifying) metastable electrons (i.e. electrons trapped within lattice defects) in the feldspar mineral, is an important breakthrough in solid state physics:
https://www.nature.com/articles/s41598-017-10174-8
and has immediate bearings on almost all fields of retrospective dosimetry of common natural materials. The IRPL signal, which arises from the recycling of trapped electrons between their ground and excited states due to optical stimulation, has an unprecedentedly high intensity and holds promise for defect mapping at nanometer scales, thus potentially allowing the mapping of luminescence gradients in exposed bedrock at an unprecedented precision.

Tasks
In the current project, we seek to investigate IRPL depth profiles in a suite of glacially-polished surfaces from a famous high-Alpine pass (Gotthard), where the last meltdown of the European Ice Cap (and hence the subsequent duration of bedrock exposure) are known precisely from independent techniques. The aim of this project is twofold. The development and testing of a new instrument (the spatially-resolved infrared photoluminescence reader), will go hand in hand with investigating an ideal case study (Gotthardpass), where abundant independent information on rock exposure time, surface roughness, post-exposure snow cover, temperature, insolation etc., puts maximum constraints on the expected IRPL profiles. Alongside the development of the new instrument, you may find yourself working on a

broad array of veteran/novel equipment (low-level gamma spectrometers, Risø TL/OSL readers, X-ray fluorescence spectrometers, and the CryOgenic LUminescence Research facility), participating in the development of new instruments (e.g. the spatially-resolved infrared photoluminescence reader), analyzing surface roughness data from an optical 3D scanner (ATOS Core), researching insolation models and developing/refining the kinetic model of feldspar luminescence.

The project is of strong multidisciplinary nature, and is thus sufficiently flexible to follow your own personal interest(s) and areas of competence. Primarily, we seek to clarify and improve our understanding of the basic physical processes occurring inside natural crystals exposed to radiation, light and heat with a motivation to develop concrete applications in glacial geology and climate research. DTU Nutech has >30 years of research in developing new instruments to facilitate cutting edge research in ionising radiation dosimetry.

Learning objectives

- Recognising the environmental processes that affect luminescence gradients in exposed rock.
- Describing present-day environmental parameters at the Gotthardpass (Switzerland).
- Characterising actual luminescence gradients from Gotthardpass (Switzerland) using a multitude of radiation measurement techniques.
- Analysing the quality and reproducibility of results, in light of the various environmental and radiation factors.
- Evaluating the credibility/uncertainties of the obtained environmental parameter reconstructions.
- Participating in the development of novel equipment (spatially-resolved IRPL reader).

REQUIREMENTS

Curious mind
Enjoys handiwork/engineering
Experimentalist mentality (try – fail – try again)
Comfortable with math and modelling (MATLAB)

KEYWORDS

Luminescence
Luminescence dating
Geochronology
Infrared photoluminescence (IRPL)
Retrospective dosimetry
Geology
Geography
Glacial polish
Ice

TAGS

Nutech

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