Date of Submission	12 August 2024

IPL Project (IPL - 262) Annual Report Form

Period of activity under report
from 1 January 2023 to 31 December 2023

1. Project Number (approved year) and Title:

   IPL – 262 Deciphering the sensitivity of rock faces to climatic changes and freeze-thaw cycles in permafrost-free regions

2. Main Project Fields: A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment

3. Name of Project leader: dr. Mateja Jemec Auflič

   Affiliation: Geological information Centre, Geological Survey of Slovenia

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   Core members of the Project: Names/Affiliations: Tina Peternel, PhD (GeoZS), Jernej Jež, PhD (GeoZS), Prof. Matjaž Mikoš (UL FGG), Assist. Prof. Nejc Bezak (UL FGG)

4. Objectives: The main objective of the proposed project is to decipher the sensitivity of rock faces to climatic changes and variations in freeze-thaw cycles in permafrost-free regions. In order to achieve this objective, we will apply a multi-method approach consisting of in-situ measurements, observations and monitoring that will allow us to determine the initial state of rock instability, the associated rockfall volume and its frequency, and the near-surface rock temperature.

5. Study Area: We study sensitivity of rock faces to climate changes and variations in freeze-thaw cycles in five pilot areas in eastern part of Slovenia.

6. Project Duration: 3 years (October 1, 2021 – September 30, 2024)

7. Report

1) Progress in the project: In the frame of Project »Development of research infrastructure for the international competitiveness of the Slovenian RRI space – RI-SI-EPOS the multi sensors network have been established at the selected monitoring areas early in 2021: rain gauges, sensors for air temperature and humidity, tiltmeters, kit for measuring rock stress and deformability, laser distance gauges, crackmeters and near surface rock temperature sensors. The sensors of temperature at the depth of 2, 25, 50 and 75 were drilled in homogenous, intact rock with at least 30 cm distance to

joints following the design of Gruber et al. (2004). This sampling strategy does not reflect the importance of nonconductive heat transfer through joints, but we will avoid complex micro-topography from surrounding bedrock to minimize shadowing or concentration of surface runoff (after snowmelt). The monitoring areas in eastern Slovenia were selected according to the following criteria: (a) frequency of rockfalls, (b) risk to the population and infrastructure, (c) diversity of rock composition (carbonate and igneous). Each individual rock type has different engineering properties and predisposing factors that can affect exfoliation, discontinuity formation, and fractures. However, the type of rock, its mineralogical nature, anisotropy or isotropy very often determine the susceptibility to the formation of fractures and their opening. The geotechnical sensors are wired using LoRa communication protocol and LoRa gateway and powered by a base station, which also serves as an in-situ data logger. The data captured by the sensor in the field is transmitted automatically to the servers or services of the device providers, or to the GeoZS servers. The data is then automatically harvested and stored in the database and are accessible to the end-users through the web application eTeren. eTeren is a centralized sensor network that enables the storage, processing and display of geological data, which are obtained in the field with different types of measuring instruments.

2) Beneficiaries of Project for Science, Education and/or Society: Civil protection administration, Slovenian Infrastructure Agency, local authorities, Slovenian Railways operator, Ministry for the Environment and Spatial Planning

3) Results: (15 line maximum, e.g. publications)

   By monitoring the precondition factors that can lead to rockfall, we have come one step closer to rockfall observatory in Slovenia. Monitoirng data will be used to understand the complex rock environment and help to drive numerical and statistical models to provide tools for predictions. The overall results can be in effective translation of this scientific advances into useful knowldege transforms which will be basis for political decision to better meet the societal and environmental needs.

   Published papers:

ŠEGINA, Ela, JEMEC AUFLIČ, Mateja, MIKOŠ, Matjaž, BEZAK, Nejc. A preliminary investigation of the small rockfall triggering conditions along a road network in Slovenia. Landslides : Journal of the international consortium on landslides. [Print ed.]. 2024, letn. xx, št. xx, 13 str., ilustr. ISSN 1612-510X. https://link.springer.com/article/10.1007/s10346-024-02302-z, DOI: 10.1007/s10346-024-02302-z.

JEMEC AUFLIČ, Mateja, BEZAK, Nejc, ŠEGINA, Ela, FRANTAR, Peter, GARIANO, Stefano Luigi, MEDVED, Anže, PETERNEL, Tina. Climate change increases the number of landslides at the juncture of the Alpine, Pannonian and Mediterranean regions. Scientific reports. 2023, vol. 13, 14 str. ISSN

2045-2322. DiRROS - Digitalni repozitorij raziskovalnih organizacij Slovenije, DOI: 10.1038/s41598-023-50314-x.

JEMEC AUFLIČ, Mateja, ŠEGINA, Ela, VIHTELIČ, Andrej, ŠINIGOJ, Jasna. Towards observatory for rockfalls in Slovenia. V: INTERPRAEVENT 2024 : Vienna, Austria : conference proceedings. Klagenfurt: INTERPRAEVENT, 2024. Str. 476-479. ISBN 978-3-901164-32-3.

JEMEC AUFLIČ, Mateja, ŠEGINA, Ela, PETERNEL, Tina, ZUPAN, Matija, JEŽ, Jernej, ŽEBRE, Manja, KRALJ, Polona, ZAJC, Marjana, MIKOŠ, Matjaž, BEZAK, Nejc, KOBAL, Milan. Monitoring of rockfall prone areas in eastern Slovenia. V: PERANIĆ, Josip (ur.), et al. Landslide modelling & applications : proceedings of the 5th Regional Symposium on Landslides in the Adriatic-Balkan Region : [23-26 March 2022, Rijeka]. Rijeka: Faculty of Civil Engineering, University of Rijeka; Zagreb: Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, 2022. Str. 75-79.