Date of Submission	14/12/2022

IPL Project (IPL - 237) Biennial Report Form 2022

Period of activity under report
from 1 January 2020 to 31 December 2021

1. Project Number and Title:

IPL-237 (2018) Title "The role of time-dependent rock mass deformations and landscape evolution rates as predisposing factors for massive rock slope failures"

2. Main Project Fields

Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides

3. Name of Project Leader

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Core members of the Project: Francesca Bozzano / Sapienza University of Rome – CERI Research Centre; Marta Della Seta / Sapienza University of Rome – CERI Research Centre; Salvatore Martino / Sapienza University of Rome – CERI Research Centre; Francesco Troiani / Sapienza University of Rome – Department of Earth Sciences, Michele Delchiaro / Sapienza University of Rome – Department of Earth Sciences

4. Objectives (5 lines maximum)

The research project, framed within an international agreement between Sapienza University of Rome and Kharazmi University of Teheran, has a two-fold objective: 1) back-analyze by means of a multi-modelling approach a representative case history to provide hints about the long-term evolution of mass rock creep (MRC) processes leading to catastrophic landslides; 2) assess the residual risk conditions in the present morpho-climatic setting, to properly address the forecasting of potential further failures resulting from the evolution of such time-dependent processes.

5. Study Area

The project will be conducted in the outer Zagros Mountains (Iran), which host the largest massive rock slope failures ever recorded on Earth surface, the Seymareh landslide.

6. Project Duration

The estimated duration of the research activity is 36 months.

7. Report

1) Progress in the project (30 lines maximum)

Landscape evolution models (LEMs) of the medium-long term valley-slope evolution were performed for the study of gravitational deformations in the Zagros Mountains (Iran). Specifically, the model parameter settings (e.g., lithological erodibility, uplift rates, tectonic evolution and spatial pattern) were based on the results of morpho-evolutionary reconstructions related to three case studies, as representative of the different evolutions of the Mass Rock Creep (MRC) process.

The selected case studies were: i) the Seymareh rock avalanche; ii) the Loumar deep-seated gravitational deformation; iii) the ongoing lateral spread of Siah-kuh.

Then, the strain and displacement rate computation were performed on the real landslide profiles to evaluate through a sensitivity analysis on the viscosity parameter the possible strain rate value range in the case studies related to a secondary phase of the MRC process. Subsequently, the values compared with typical strain yielding value for secondary-tertiary phase transition, were used to hypothesize the time spans of the transition for each case study, in agreement with the morphoevolutive reconstructions of each case study. In this regard, since the aim of this procedure was to test a methodological approach, it was decided to apply a simplified model such as the Newtonian (viscous) behavior model which implies the proportionality between the stress and the strain rate through a constant parameter called viscosity. After that, it was also implemented in the LEMs to define the deformation history linked to the MRC process of the simulated slopes.

2) Planned future activities or statement of completion of the Project (15 lines maximum)

The project already accomplished most of the expected results, that we already published or are going to submit soon in international peer-reviewed journals. In the next months (starting on January 2022) we plan to better refine and evaluate the results of previous activities in order to get some hints on the implications of such results for forecasting purposes (i.e, shifting from the back analysis to the forward analysis).

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

The methodology tuned in this project could be implemented by the technical/scientific community dealing with geo-hazard (and related risk) to better address hazard zoning and/or land-use planning in mountain environments affected by MRC processes.

4) Results (15 line maximum, e.g. publications)

DELCHIARO, M., DELLA SETA, M., MARTINO, S., NOZAEM, R., & MOUMENI, M. (2022). Tectonic deformation and landscape evolution inducing mass rock creep driven landslides: The Loumar case-study (Zagros Fold and Thrust Belt, Iran). *Tectonophysics*, 229655.

https://doi.org/10.1016/j.tecto.2022.229655

DELCHIARO, M., IACOBUCCI, G., TROIANI, F., DELLA SETA, M., BALLATO, P., & ALDEGA, L. (2022). Morphoevolution of the Seymareh landslide-dam lake system (Zagros Mountains, Iran): Implications for Holocene climate and environmental changes. *Geomorphology*, *413*, 108367. https://doi.org/10.1016/j.geomorph.2022.108367

ROUHI, J., DELCHIARO, M., DELLA SETA, M., & MARTINO, S. (2022). New Insights on the Emplacement Kinematics of the Seymareh Landslide (Zagros Mts., Iran) Through a Novel Spatial Statistical Approach. Front. *Frontiers in Earth Science*, *10*, 869391. https://doi.org/10.3389/feart.2022.869391

DELCHIARO, M., ROUHI, J., VALIANTE, M., DELLA SETA, M., ESPOSITO, C., & MARTINO, S. (2021). Bivariate landslide susceptibility analysis in the Lorestan Arc (Zagros Mountains, Iran). *Italian journal of engineering geology and environment*, 53-66. https://doi.org/10.4408/IJEGE.2021-01.S-05

DELCHIARO, M. (2021). Time-dependent rock-mass deformations, geological aging and landscape evolution as predisposing factors for large rock landslide triggering. *Doctoral dissertation*, Sapienza University of Rome.

DELCHIARO M., MELE E., DELLA SETA M., MARTINO S., ESPOSITO C., & MAZZANTI P. (2020). Quantitative investigation of a Mass Rock Creep deforming slope through A-Din SAR and geomorphometry. V. Vilímek et al. (eds.), *Understanding and Reducing Landslide Disaster Risk, ICL Contribution to Landslide Disaster Risk Reduction*, https://doi.org/10.1007/978-3-030-60319-9_18

DELCHIARO M., ROUHI J., DELLA SETA M., MARTINO S., NOZAEM R., & DEHBOZORGI M. (2020). The Giant Seymareh Landslide (Zagros Mts., Iran): A Lesson for Evaluating Multi-temporal Hazard Scenarios. In *Applied Geology* (pp. 209-225). Springer, Cham. https://doi.org/10.1007/978-3-030-43953-8_13

ROUHI, J., DELCHIARO, M., DELLA SETA, M., & MARTINO, S. (2019). Emplacement kinematics of the Seymareh rock-avalanche debris (Iran) inferred by field and remote surveying. *Italian journal of engineering geology and environment*, 99-104. https://doi.org/10.4408/IJEGE.2019-01.S-16

DELCHIARO, M., DELLA SETA, M., MARTINO, S., DEHBOZORGI, M., & NOZAEM, R. (2019). Reconstruction of river valley evolution before and after the emplacement of the giant Seymareh rock avalanche (Zagros Mts., Iran). *Earth Surface Dynamics*, *7*(4), 929-947. https://doi.org/10.5194/esurf-7-929-2019

Note:

1) If you will change items 2-7 from the proposal, please write the revised content in Red.
2) Please fill and submit this form by 30 March XXX (nex year of the activity report) to ICL Network <icl-network@iclhq.org>
3) Reporting year must be one or two years (Maximum).