1. Research activity

INTRODUCTION AND STATE OF THE ART

In the hillslope evolution of tectonically active mountain landscapes Mass Rock Creep (MRC) process (CHIGIRA, 1992) may become a primary factor for damaging rock masses so leading to slope failures that generate huge rock avalanches; it acts on large time-space scale through a continuous and non-linear variation of the tensile-deformational state of entire portions of slopes, giving rise to deformation processes known in the literature as Deep Seated Gravitational Slope Deformation (DSGSD).

The MRC process is significantly related to the timing of landscape evolution (BOZZANO et al., 2012) and earthquakes are not to be neglected as a possible cause of acceleration of deformations already in progress although they are not the most widespread type of trigger (rains and tropical storms are in first place for the triggering effect on a global scale) (e.g., KEEFER, 1996; MALAMUD et al., 2004; OWEN et al., 2008; PARKER et al., 2011; HOVIUS et al., 2011; LI et al., 2014).

The limit of the theoretical schemes describing MRC is represented by the difficulty of precisely and accurately estimating the starting time of the process, of discriminating the distinct creeping phases, as well as determining the viscosity of the rocky matrix. In this context morpho-evolutionary analysis plays a key role, as it is an instrument through which it is possible to provide chronological constraints to the creep evolution of entire slopes (BOZZANO et al., 2016; DELLA SETA et al., 2017). In one hand, morpho-evolutionary analysis can highlight the presence of phenomena of gravitational instability that affect slopes in different evolutionary stages through the analysis of accessory forms (geomorphological markers) as a possible instrument of recognition. In the other hand, it allows to reconstruct the timing of the variation of interesting valley sections from the above phenomena providing important chronological constraints through the plano-altimetric analysis and the dating of the geomorphological markers. The morpho-evolutionary investigation allows in fact, through the identification and analysis of geomorphological markers, to reconstruct the geological, geomorphological and stress history of entire morpho-structures, especially in tectonically active areas (BURBANK & ANDERSON, 2012).

The morpho-evolutionary modeling is part of a broader multi-modeling approach that incorporates contributions from morpho-evolutionary modelling, detailed engineering-geological modelling and time-dependent stress-strain numerical modelling to analyze the rheological evolution of a river valley slope over approximately 10^2 kyr (MARTINO et al., 2017).

GENERAL OBJECTIVE

Quantifying the timing of geological aging processes through a transpositive analysis of current processes in space and time.

SPECIFIC OBJECTIVES

Methodological test along a transept oriented parallel to the direction of propagation of morphostructures in the Lorestan region, in the western Zagros Mountains (Iran).

IMPLICATIONS AND APPLICATIONS

- Enhancement in the knowledge about the contribution of MRC processes to landsliding;
- Refinement of a multi-modelling approach that incorporates contributions from morpho-evolutionary modelling, numerical landscape evolution modeling, engineering-geological modelling, time-dependent stress-strain numerical modelling;
- Definition of a more modern concept of risk, Dynamic Risk, variable over time as well as in space

WORKPLAN AND MILESTONES

- ***FIRST YEAR (2017/2018)***
  DECEMBER 2017 - MAY 2018 / JULY – SEPTEMBER 2018
  The first year, although it will always be necessary throughout the entire project, will be dedicated to an in-depth study of the scientific articles and of the cartographic works to collect information on both the area to be studied and the surrounding areas. In particular, it will be necessary to find remote sensing images, through which it will be possible to work for the photo-identification and the photo-interpretation of the massive rock slope failures already occurred (stereoscopic observation of optical images) and of the deformations in progress (interpretation of optical images and of SAR interferograms) along with the transect analyzed. Furthermore, an in-depth analysis of the globally available DEMs and eventually the construction of a high-resolution DEM from vector topographic data is planned. Such DEMs will allow to carry out an in-depth morphometric analysis of the hydrographic network of the study area in the GIS environment, to identify the major evidences of disequilibrium in the drainage network (i.e. anomalies along the river longitudinal profiles).
  JUNE 2018
  This period will be dedicated to the field surveying activities aimed at confirming what was hypothesized during the preliminary phases, to reconstruct the stratigraphic column of the sectors examined and to sample the datable Quaternary deposits pertaining to surveyed geomorphic markers. During the field work, therefore, geological, geomorphological and geological-technical surveys will be carried out, as well as sampling for datings. The dates

will be probably performed with the OSL method and with the ^{14}C method, given the prevailing silicoclastic nature of the deposits and the occasional presence of organic matter.

MILESTONES

MS1. 1 Check of the available DEMs and eventual construction of a high resolution DEM (< 30 m for the area crossed by the transept);

MS1. 2 High resolution hydrological model and detection of morpho-evolutionary evidences (like anomalies along the longitudinal profiles of rivers crossing the transept);

MS1. 3 Construction of landslide records database in the transept area (deposits characteristics and their absolute or relative ages).

- ***SECOND YEAR (2018/2019)***

OCTOBER – DECEMBER 2018

A research/training period abroad is planned at the Potsdam University (Germany). See the specific paragraph for further details.

JANUARY – MAY 2019 / JULY – NOVEMBER 2019

The data collected in the previous phases will be elaborated for the construction of a morpho-evolutionary model of the valley segments crossed by the transept. Particular attention will be focused on those in which large rock landslides that have already occurred have been detected and on those in which evidence of deformations occurring in the rock masses has been found. For the purposes of the morpho-evolutionary reconstruction of these valley stretches, an analysis of the plano-altimetric distribution of the identified and dated geomorphological markers will be carried out first. The results will be used as constraints for the implementation of numerical Landscape Evolution Models (GOREN et al., 2014; SCHWANGART & SCHERLER, 2014; TUCKER & HANCOCK, 2010).

JUNE 2019

If the field data are not complete, it will be necessary to perform further field work.

MILESTONES

MS2. 1 Geomorphological map along transept;

MS2. 2 Morpho-evolutionary models of the valley segments along the transept.

- ***THIRD YEAR (2019/2020)***

DECEMBER 2019 – SEPTEMBER 2020

Discussion and summary of relevant results, arrangement and final writing of the PhD thesis.

MILESTONES

MS3. 1 Landscape Evolution Model of the transept area;

MS3. 2 Refinement of landslide records database;

MS3. 3 PhD Thesis written in English.

DISSEMINATION PLAN

- ***FIRST YEAR (2017/2018)***
  Attendance at national and international seminars/meetings/workshops;
  Other meetings/conferences: SGI (Italian Geological Society), GIT, AIGEO – Young Geomorphologists.
  Scientific original paper will be prepared and published on peer-reviewed journals.

- ***SECOND YEAR (2018/2019)***
  Attendance at national and international seminars/meetings/workshops (i.e. Regional Conference of Geomorphology in Greece);
  Presentation of the main results;
  Writing and publishing of articles on peer-reviewed journals.

- ***THIRD YEAR (2019/2020)***
  Attendance at national and international seminars/meetings/workshops (i.e Regional Conference of Geomorphology in Iran);
  Presentation of the main results;
  Writing and publishing of articles on peer-reviewed journals.

RESEARCH PERIODS ABROAD

A research period abroad is planned for a total of three months at the Institute of Earth and Environmental Science of the Potsdam University, where I will certainly improve my knowledge about numerical Landscape Evolution Modeling in collaboration with Dr. Wolfgang Schwanghart. This research period will be useful also for the automatic extraction and geomorphometric analysis of fluvial landforms from DEMs using MATLAB tools. The development and application of a numerical LEM of the area covered by the transept in the Zagros Mts. can be the expected result of this research period.

TIME SCHEDULE

Research Activities	First Year		Second Year		Third Year	
	I semester	II semester	III semester	IV semester	V semester	VI semester
Bibliographic Study	X	X	X	X	X	X
Remote Sensing Data Acquisition	X					
Remote Sensing Images Analysis	X	X				
Morphometric Analysis on DEM	X	X		X		
MS1. 1		X				
MS1. 2		X				
MS1. 3		X				
Sampling and Surveying Campaign		X		X		
OSL and ^{14}C Datings			X		X	
Research Period Abroad (Potsdam University)			X			
Collected Data Processing			X	X		
Morphoevolutionary Modeling			X	X	X	
MS2. 1				X		
MS2. 2				X		
Seminars and Participation in conferences		X		X		X
PhD thesis drafting					X	X
Publications	X		X		X	X
MS3. 1						X
MS3. 2						X
MS3. 3						X

BIBLIOGRAPHY

BOZZANO, F., MARTINO, S., MONTAGNA, A., PRESTININZI, A. (2012). Back analysis of a rock landslide to infer rheological parameters. Eng. Geol. 131-132, 45–56.

BOZZANO, F., DELLA SETA, M., & MARTINO, S. (2016). Time-dependent evolution of rock slopes by a multi-modelling approach. Geomorphology, 263, 113-131.

BURBANK D.W.& ANDERSON R. S. (2012) Tectonic Geomorphology. Wiley-Blackwell, Second Edition.

CHIGIRA, M. (1992). Long-term gravitational deformation of rocks by mass rock creep. Engineering Geology, 32(3), 157-184.

DELLA SETA, M., ESPOSITO, C., MARMONI, G. M., MARTINO, S., MUGNOZZA, G. S., & TROIANI, F. (2017). Morpho-structural evolution of the valley-slope systems and related implications on slope-scale gravitational processes: New results from the Mt. Genzana case history (Central Apennines, Italy). Geomorphology, 289, 60-77.

HOVIUS, N., MEUNIER, P., LIN, C.-W., CHEN, H., CHEN, Y.-G., DADSON, S., HORNG, M.-J., LINES, M., (2011). Prolonged seismically induced erosion and the mass balance of a large earthquake. Earth Planet. Sci. Lett. 304 (3-4), 347–355.

KEEFER, D.K. (1996). The importance of earthquake-induced landslides to long-term slope erosion and slope-failure hazards in seismically active regions. Geomorphology 10, 265–284.

LI, G., WEST, A.J., DENSMORE, A.L., JIN, Z., PARKER, R.N., HILTON, R.G. (2014). Seismic mountain building: Landslides associated with the 2008 Wenchuan earthquake in the context of a generalized model for earthquake volume balance. Geochem. Geophys. Geosyst. 15 (4), 833–844.

MARTINO, S., DELLA SETA, M. & ESPOSITO, C. (2017). Back-analysis of rock landslides to infer rheological parameters. Rock Mechanics and Engineering, Vol. 3: Analysis, Modeling & Design 237-269.

OWEN, L.A., KAMP, U., KHATTAK, G.A., HARP, E.L., KEEFER, D.K., BAUER, M.A. (2008). Landslides triggered by the 8 October 2005 Kashmir earthquake. Geomorphology 94 (1-2), 1–9.

PARKER, R.N., DENSMORE, A.L., ROSSER, N.J., DE MICHELE, M., LI, Y., HUANG, R., WHADCOAT, S., PETLEY, D.N. (2011). Mass wasting triggered by the 2008 Wenchuan earthquake is greater than orogenic growth. Nat. Geosci. 4 (7), 449–452.