

Date of Submission	February 2016
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IPL Project Annual Report Form 2015

1. Project Title

The UNESCO initiative on Sustainable Monitoring Techniques for Assessing Instability of Slopes in the Siq of Petra, Jordan

2. Main Project Fields

(1) Technology Development

A. Monitoring and Early Warning, B. Hazard Mapping,

(2) Targeted Landslides: Mechanism and Impacts

B. Landslides Threatening Heritage Sites

(3) Capacity Building

A. Enhancing Human and Institutional Capacities

(4) Mitigation, Preparedness and Recovery

A. Preparedness, B. Mitigation

3. Name of Project leaders: **Dr. Arch Anna Paolini** (*General Coordination*)

Affiliation: (office and position)

UNESCO

Director, UNESCO office in Doha (UEA)

UNESCO Representative to the Arab States of the Gulf and Yemen

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Prof. Claudio Margottini (*Scientific Coordination*)

Affiliation: (office and position)

ISPRA - Dept. Geological Survey of Italy

**Responsible for Coordination and Development of International Affairs and Vice President
International Consortium on Landslides**

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Core members of the Project: Names/Affiliations: (4 individuals maximum)

Prof. (em) Heinz Ruther (*coordinator for laser scanning, 3D models and geomatic*)

**Principal Investigator "African Cultural Heritage Sites and Landscapes" project Zamani Project
Division of Geomatics (APG), University of Cape Town (South Africa)**

Prof. Talal Akasheh (*coordinator for Close Range Digital Photogrammetry and field surveys*)

Technical representative of Petra National Trust (PNT), Amman (Jordan)

Director of Cultural Technologies in Jordan

4. Objectives: (5 lines maximum)

The project will:

- **Identify potential detectable unstable areas in the Siq and other sites by means of field engineering geological techniques;**
- **Carry out long-term monitoring of selected unstable Siq slope portions, by means of a set of monitoring methods (from remote to field) to define the most suitable and reliable techniques for different geomorphological setting;**
- **Provide guidelines for sustainable landslide mitigation and management for the entire park;**
- **improve knowledge of local authorities for the identification of unstable areas, monitoring of the site, and design and implementation, following international standards, of landslide mitigation works/strategies (e.g. monitoring, field analysis).**

5. Study Area: (2 lines maximum)

Archaeological Park of Petra, Jordan

6. Project Duration (1 line maximum)

June 2012 – June 2015

7. **Report**

1) Progress in the project: (30 lines maximum)

This report summarizes field survey results and analysis in the framework of a UNESCO project (Siq Stability Project) for the implementation of remote and field integrated monitoring systems aimed at the detection and control of active deformation of the Siq slopes (petra, Jordan). Petra is

located on the eastern side of the Dead Sea-Wadi Araba tectonic depression, in SW Jordan. The Siq is a 1.2 km long natural deep gorge in the sandstone mountains that connects the urban area of Wadi Musa with the monumental area of Petra. Since Nabataean times, the Siq is the main narrow entrance for some thousands tourists that access the archaeological area every day. Discontinuities of various type (bedding, joints, faults), mainly related to stratigraphic setting, tectonic activity and geomorphological evolution of the slope can be recognized. Rock-fall potential activity can be catastrophic according to evolution of the movement (extremely rapid) and involved rock mass volumes. Slope instability, acceleration of crack deformation and consequent increasing of rock-fall hazard conditions could threaten the safety of people walking through the Siq.

An integrated set of direct and remote distinct monitoring systems and techniques has been implemented for the analysis of rock slope deformations in the Siq of Petra. The overall system has been designed and installed according to potential capability of the different techniques as well as cost/benefit and long-term sustainability, considering the specific geological and cultural environment of the Siq of Petra.

A regional scale analysis of the measurement points derived by SqueeSARTM technique has provided evidence of a general stability of the Petra area in the time span considered (2003-2010). The areas where some movement (>2 mm/year) occurred, are characterized by presence of incoherent material (e.g. debris, sands) removed by human activities and/or natural erosion and mostly located out of the Siq.

The crack, wire-gauge system and tiltmeters, based on 18 months observation data set, has provided a generally constant trend of movements, with negligible displacements (<1 mm), mostly related with daily temperature and humidity fluctuations. Only in one site, where a big block is located, there are evidences of slow movement up to 2 mm/y.

The total station reflectorless monitoring data are under evaluation.

Finally, all the collected data supported the realization of a Guidelines for the sustainable mitigation and management of landslides at the Siq - Petra World Heritage Site. The proposed consolidation techniques are now under implementation from Petra Archaeological Park

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

The project is finished on June 2015, with the delivering of the Guidelines for the sustainable mitigation and management of landslides at the Siq - Petra World Heritage Site. The proposed consolidation techniques are now under implementation from Petra Archaeological Park.

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

Please type here...

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

Please type here...

The list of publications in the frame work the project is as follows:

Alberti S., Ferretti A., Margottini C., Spizzichino D. (in printing) Surface deformation data in the archaeological site of Petra from medium-resolution satellite radar images. Journal of Cultural Heritage

Note:

- 1) If you will change items 1)-6) from the proposal, please write the revised content **in red**.
- 2) Please fill and submit this form by **28 February 2016** to the IPL and WCoE Network Committee: icl-network@iclhq.org