

The Fourth Italian Workshop on Landslides

Advances in geotechnical investigations and monitoring in
rupestrian settlements inscribed in the UNESCO's World Heritage
List.

Claudio Margottini^{a*}, Giovanni Gigli^b, Heinz Ruther^c, Daniele Spizzichino^a

^a ISPRRA – Dpt. Geological Survey of Italy, V. Branconi 60, 00143 Rome, Italy

^b Department of Earth Sciences, University of Florence, Largo Enrico Fermi 2, Arcetri, 50125, Florence, Italy

^c Geomatics Division, University of Cape Town, Cape Town, South Africa

Abstract

Rupestrian settlements were among the first man-made works in the history of humanity. The most relevant masterpieces of such human history have been included in the UNESCO World Heritage List. These sites and remains are not always in equilibrium with the environment. They are continuously impacted and weathered by several internal and external factors, both natural and human-induced, with rapid and/or slow onset. These include major sudden natural hazards, such as earthquakes or extreme meteorological events, but also slow, cumulative processes such as the erosion of rocks, compounded by the effect of climate change, without disregarding the role of humans, especially in conflict situations. Many rupestrian sites have been carved into soft rock, generally with UCS < 25 MPa (ISRM, 1981), in vertical cliffs, and show major conservation issues in the domain of rock slope stability and rock weathering. The present paper reports the experience of rock fall investigation and monitoring in rupestrian sites, mainly from the UNESCO World Heritage List (Bamiyan in Afghanistan; Lalibela in Ethiopia; Petra in Jordan and Vardzia in Georgia). The general approach, implemented in the activities, includes an interdisciplinary study with advanced methodologies and technologies, with the objective to understand degradation processes and causative factors, followed by low impact, but highly effective, rock slope monitoring.

© 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the organizing committee of IWL 2015

Keywords: Rupestrian site, rock mechanics, geological threats, investigations, monitoring.

* Corresponding author. Tel.: +39-06-50074000.

E-mail address: claudio.margottini@isprambiente.it

1. Introduction

Rupestrian settlements were among the first man-made works in the history of humanity. During almost 3 million years, human kind has survival relied on two basic activities: hunting (or fishing) and gathering edible items of all kinds (from fruit to insects). A radical change came roughly 10,000 years ago, after the last glacial age, when people first learned to cultivate crops and to domesticate animals, in what can certainly be considered one of the most significant development in human history. This process took place during the Stone Age, when tools were still made of stone rather than metal¹.

In order to ensure long term conservation, especially for sites affected by natural threats, detail investigations and monitoring techniques both related to internal parameters (mechanicals and physical) and external agents responsible of their conservation, are required. The most advanced and non invasive investigation and monitoring techniques (direct and remote) should be adopted to define the present conservation condition and the future trend. The general approach must follow different scales of analysis, depending from the site threat, from micro scale to general processes scale (e.g. landslide, floods) involving large areas. The provided results are the main pillar for the next step that is the sustainable mitigation strategy.

2. Major threats affecting rupestrian sites

The sites and remains are not always in equilibrium with the environment. They are continuously impacted and weathered by several internal and external factors, both natural and human-induced, with rapid and/or slow onset. These include major sudden natural hazards, such as earthquakes or extreme meteorological events, but also slow, cumulative processes such the erosion of rocks, compounded by the effect of climate change, without disregarding the role of humans, especially in conflict situations.

Many rupestrian sites have been carved into soft rock, generally with $UCS < 25 \text{ MPa}^2$, in vertical cliffs and show major conservation issues in the domain of rock slope stability and rock weathering. The low strength range of rock might be influenced by physical characteristics, such as size, saturation degree, weathering and mineral content. Finally, the investigations generally show that the strength reduces significantly with saturation³.

The previously described low strength of the rock, together with the discontinuity pattern in steep slopes and the weakening of the cliff produced by the man-made settlements, pose a serious concern for the long term stability of the sites.

As a confirmation, the following Fig.1 is reporting the relationship between UCS and porosity for some rupestrian sites discussed in this paper. It is evident that the low UCS value is generally coupled with high porosity, especially in volcanic materials (Lalibela and Vardzia). On the other hand, the continental/sedimentary geological formations of Bamiyan and Petra exhibit a relevant vertical heterogeneity, so values here reported are just rough estimates.

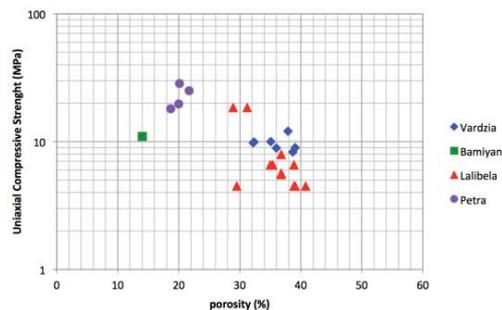


Fig. 1. The relationship between Uniaxial Compressive Strength and porosity for the case studies discussed in this paper.

Download English Version:

<https://daneshyari.com/en/article/4674633>

Download Persian Version:

<https://daneshyari.com/article/4674633>

[Daneshyari.com](https://daneshyari.com)