Geophysical Research Abstracts
Vol. 21, EGU2019-14179, 2019
EGU General Assembly 2019

Detection of rock bridges by infrared thermal imaging and modeling: application to exfoliation sheets in Yosemite Valley (California, USA)

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In the field of rock mechanics, the characterization of discontinuity persistence and intact rock bridges is needed to define stability conditions of fractured rock masses. Although methods for mapping these structural features have improved in recent years, remote imagery detection of intact rock bridges has not yet been performed. In steep exfoliating cliffs, such as El Capitan in Yosemite Valley (California, USA), rockfalls mainly occur along exfoliation joints (i.e. surface-parallel fractures separating exfoliation sheets) (Collins and Stock, 2016; Collins et al., 2018; Stock et al., 2018). Thus, we focused on the detection of rock bridges responsible for the stability of partially detached exfoliation sheets. We conducted InfraRed Thermography (IRT) monitoring, in conjunction with Terrestrial Laser Scanning (TLS) surveying to characterize the stability of two well-delimited granitic exfoliation sheets. By examining the final phase of diurnal cooling of these flakes with IRT, we found that they always remain colder than the surrounding rock walls. We interpret this colder thermal signature as a result of the air circulation that envelops and cools the detached parts from the cliff. Detailed analysis of each thermal image also revealed that the temperature patterns are not homogeneous – warmer thermal anomalies are visible on the surface of both monitored flakes. We interpret these warmer areas as a sign of the possible presence of rock bridges that would conduct heat from the rock mass located behind the exfoliation sheets. The detection of rock bridges from our IRT analysis is supported by the results of 2-D thermal modeling. These simulations reproduced the observed thermal signatures and improved our understanding of the temperature differences detected in the rock bridge area. By draping IRT images on TLS meshes, we were then able to measure the geometry of the potential rock bridge surfaces and subsequently evaluate the exfoliation sheet stability conditions using fracture mechanics analysis. This study demonstrates that thermal imaging combined with high-resolution 3D topography have great potential for rock failure hazard assessment.