



## **Geological degradation and rock-slope structure stability of Aba Libanos Church in Lalibela, Ethiopia**

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Lalibela is located in the northern-central Ethiopia, approx. 600 km north of Addis Ababa in Northern Wollo, one of the most structural food deficit areas of the Ah-mara Region. The town is worldwide known for its unique complex of 11 rock-hewn churches cut out of the living volcanic rocks in the 12<sup>th</sup> century during the kingdom of King Lalibela of the Zagwe dynasty. The churches and their surroundings have been included in the UNESCO's World Heritage List.

The paper reports geological and geotechnical analyses carried out for the reconstruction of rock degradation and induced slope-structure instability that are affecting all the churches. Among them, the church of Biet Aba Libanos is exhibiting two major damaging phenomena: a severe degradation of volcanic tuff in the lower part of the edifice due to weathering and incipient slope instability of the façade and lateral walls due to structural and shear strength conditions of materials.

An in-situ engineering geological investigation has been done to reconstruct physical and mechanical characteristics of rocks, structural setting of the area and a kinematical analysis for the detection of the potential movement types. A slope structure stability modeling has been implemented for estimating the actual conditions of the church. In the meantime x-ray analysis has detected, in the wide presence of montmorillonite, as secondary product of weathering of rocks,, the main cause of degradation of materials and stability of structures.

The preliminary results of the research will be adopted by UNESCO as guideline to address new correct and sustainable conservation measures for the safeguard of the site.