

Geology and Geophysics for the conservation in the Machu Picchu world heritage, Cusco-Peru

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The Inca citadel of Machu Picchu is affected by different natural phenomena and by human intervention. The more important geologic problems are the settlement and superficial landslides. The citadel is built on intrusive igneous rocks which are cut by faults and fractures. Recent deposits and Quaternary soils contain granite blocks that have broken away from the main rock body, forming what is known as “granitic chaos”. The Machu Picchu was built about 500 years ago on top of this granitic chaos of disordered blocks of different dimensions over a fairly unstable area atop the ridge.

The Incas built a series of terraced platforms and containment walls to stabilize the granitic chaos, and only after that started constructing houses, temples and palaces. During the Inca occupation, the terraced platforms and buildings were adequately preserved by gutters and ditches, which helped to evacuate the abundant rainwater. But the roofing of buildings is no longer intact and the drainage systems have not been maintained, allowing the waters to penetrate the soils. This water washes away the clays and silt that acts as a matrix between the blocks of granitic chaos, and also lowers the resistance to movement of the soils. This in turn causes the rocks to sink, as is evident in the Main Temple, the Temple of the Three Windows, the Turret and other structures. This settlement in turn causes an imbalance and separation of the joints, the areas between stone and built stone. These movements occur very slowly, but if this trend continues the structures will be seriously affected in 20 to 30 years. The city area has also experienced numerous superficial landslides, although many of the most susceptible areas were stabilized by Inca terraces. However, here too, the lack of adequate and operative drainage systems has caused the reactivation of landslides, as can be seen in the western and eastern slopes of the city.

The measurements obtained from the extensometers placed on site by Japanese geologists and the measurements from the dilatometers of the Czech Mission, record

the movements. All these data confirm the existence of superficial movements, which are related to settlement and superficial landslides. In addition, geophysics studies of Frequency-domain electromagnetic, Resistivity and Ground penetrating radar (GPR) methods have been made by INGEMMET and Geological Survey of Canada through PMA: GCA. The results show no major landslides planes were observed along any of the survey lines, although there are indications of minor fractures filled with water on the switchbacks and sanctuary line, the bedrock relief under the plaza is significant, and the plaza area appears to have been filled with debris and rubble.

In consequence, studies and budgets should be prioritized for the conservation and protection of the risk areas in the Machu Picchu citadel. Re-establishment of the Inca drainage system and the strict control of visitor affluence appear like some of the most important issues.