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The geology in the conservation of machupicchu world heritage

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The Historical Sanctuary of Machupicchu is located in the Eastern Cordillera of southern Peru. It is surrounded by the following snowed peaks: the Salcantay (6264 m), Huamantay (5459 m), Verónica (5750 msnm) and Bonanta (5024 msnm). The Inca city is located at an altitude of 2450 m, 500 m above the Urubamba River, which cuts through the Cordillera and originates a canyon with tropical mountain climate. The local substrate consists of granite outcrops and large irregularly-piled granite boulders -granitic chaos – over which the Inca city of Machupicchu was built.

The Plio-Quaternary geological evolution shows a very fast exhumation of the Cordillera which determined the geodynamic phenomena, the same that originated the current geomorphology and now affect the Inca city. The geodynamic processes affecting the Inca city of Machupicchu, are the settlement, suffusion, surface erosion, rock falls, and superficial landslides. During Inca occupation, the drainage system of terraces and thatched-roof buildings allowed an efficient evacuation of the abundant rainfall water. However; this is no longer the case: buildings have no roof and most of the terrace drainages are not functional, leading to strong infiltration, surface erosion, suffusion, settlement, etc. Detailed geological surveys and site-specific studies in several areas of the city allow to suggest recommendations for an adequate evacuation of rain water with drainages and impermeable surfaces to avoid infiltration and surface erosion. A map with the inventory of Inca drainages will help restore and implement an integrated drainage system.

Several publications and news in the media generated an international alarm when it was announced that the Inca city of Machupicchu was at risk of collapse amidst a large landslide. Several international and Peruvian research groups undertook studies to assess the alleged problem. We herein provide the results of this research, including the conclusions of an international workshop organized for this purpose, and which minimize the probability of these destructive phenomena.

The assessment of external geodynamic processes and landforms along the Traditional Inca Trail and the Sacred Trail identified landslides, alluvial fans (alluvion), rock falls, debris flows, soil creep, settlement, surface erosion, fluvial erosion, and suffusion. These phenomena originate partial destruction of the trail. We have also identified negative environmental impacts affecting the Traditional Inca Trail and the Inca city of Machupicchu. Using cause-effect matrices, we have then undertaken the environmental impact assessment of this trail, emphasizing geodynamic phenomena and human activities affecting the natural and cultural environment. We present mitigation and prevention measures to protect this Inca heritage.

The Historical Sanctuary of Machupicchu has numerous areas affected by external geodynamic processes. We present three examples which are important from the point of view of the population (Aguas Calientes), transportation (Runtumayo) and infrastructure (Aobamba). The town of Aguas Calientes is the closest and most important urban area around the historical sanctuary of Machupicchu. This town is located at the mouth of the Aguas Calientes and Alcamayo creeks, both with a high degree of alluvium hazard. In 1998, the Aobamba alluvium destroyed the hydroelectric plant of Machupicchu. The risk continues, so any further urbanization at the mouth of the Aobamba River must be prevented. Furthermore, we present the evaluation of the alluvium of the Runtumayo creek. This alluvium destroyed the access road and the railway, the only direct access to the Inca city of Machupicchu.