

# GEOPHYSICAL SURVEYS AT MACHU PICCHU, PERU: RESULTS FOR LANDSLIDE HAZARD INVESTIGATIONS

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## Abstract

Geophysical methods are being used more frequently to assess slopes for landslide hazard potential, especially in areas where traditional methods such as trenching and drilling are either difficult to employ or not allowed. This paper presents the results of joint DC resistivity and EM surveys to map fractures and zones of weakness in crystalline bedrock at Machu Picchu, Peru. DC resistivity surveys were carried out along the upper 8 switchbacks leading to the sanctuary as well as across the sanctuary. EM-34 surveys were carried out along the upper 3 switchbacks and across the sanctuary. Inversion of the resistivity data located several lower resistivity zones along the switchbacks. These zones were associated with water seeping out of the rock in ditches. The water is confined to the upper switchbacks which is consistent with the disappearance of lower resistivity zones in the lower switchbacks. EM-34 results along the switchbacks, although more subtle to recognize, located several coincident zones of lower resistivity. The DC resistivity data across the sanctuary located a lower resistivity zone on the east side of the main plaza. There is presently no information on whether any of these fractures have been active in the recent past. Consequently the results from this study are still under investigation.

## Introduction

The UNESCO World Heritage Site of Machu Picchu, Peru, the royal estate of the Inca ruler Pachacuti in the 1400's, remained covered by vegetation and abandoned in the jungle for hundred of years following the Spanish occupation of Peru (Wright and Zegarra, 2000). Discovered early in the last century, the site is now host to some 1 million tourists per year. Recent shallow translational landslides, rock falls and debris torrents in the area have drawn international attention to the region surrounding the site and the adjacent town of Aguas Calientes (Klimes et al. 2007). The impact of the failures has ranged from significant including the loss of life (11 individuals in 2004) to economic concerns involving closure of the only road access between the site and the outside world (Hiram Bingham Road in 1996).



**Figure 1** Map showing location of Machu Picchu, Peru.