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Pattern and rate of erosion inferred from Inca agricultural terraces in arid southern Peru

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Abstract

Earthworks of assumed age and their initial and current morphologies provide an ideal basis for developing and testing models for long-term landform erosion. Inca agricultural terraces abandoned at ~1532 A.D in the drylands of southern Peru may be used to document morphological changes since the abandonment. The objective of this research is to determine the erosion pattern and process to estimate the erosion rate.

The development of rills and channels on the Inca agricultural terraces is evidence for erosion by wash processes on slopes where the anchoring effect of vegetation is absent and loose material is available for removal. The pattern and amount of erosion from 1532–2005 A.D. is estimated by comparing elevation models of the observed morphology and reconstructed models of the original morphology of the Inca terraces. The results show that in areas of sediment accumulation surface elevation increased up to 0.5 m. Elevation lowering on the terrace treads was 0.7 m at maximum, and a temporally and spatially averaged lowering rate was 0.094 mm yr^{-1}. This gives insights about how the rate of erosion occurs on currently disturbed lands in arid environments where soil resources are scarce and lands are prone to desertification.
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1. Introduction

Change in morphology and development of erosion patterns on hillslopes can be predicated by knowing or reconstructing the initial slope geometry, if deformation by tectonic movement is negligible. This reconstruction is essential for geomorphological discussion because the initial terrain slope controls the distribution, extent and origin of erosional features such as gullies and rills (Desmet et al., 1999). This study uses prehistoric and historic Inca earthworks in southern Peru to quantify the pattern and rate of hillslope processes.

There is a distinct paucity of erosion studies on centennial timescales in arid environments. In drylands, transformation of the landscape results from erosion by wind and water, in contrast to humid regions where the vegetation cover is thick and continuous and the movement of debris downslope is dominated by mass movements (Carson and Kirkby, 1972). There is a continuum of slope processes from rill initiation by slope wash, to ephemeral gully incision and finally to river channel formation (Poesen et al., 2003). Thus, documented field evidence of the progression of erosion by wash processes on soil mantled slopes in different time scales is needed for better understanding the spatially and temporarily variable rates of hillslope processes.

Traditionally two strategies have been used to gain insights into hillslope erosion processes: experimental erosion plots and numeric simulations. There is a scaling problem with erosion plots often being too small to generalize observations to the catchment level (Poesen et al., 2003). Laboratory experiments have short durations, and it is often undesirable to extrapolate derived soil erosion rates to longer time scales. Another approach to estimate soil loss is to employ numeric simulations, particularly for predicting erosion on agricultural lands (e.g., Laflen et al., 1997; Peeters et al., 2006) and on mine spoil (e.g., Hancock et al., 2000; Hancock, 2004). Numeric simulations require known initial conditions and proper calibration of numerous model parameters.

Erosion studies at archaeological sites are advantageous because it is possible to determine the initial morphology and

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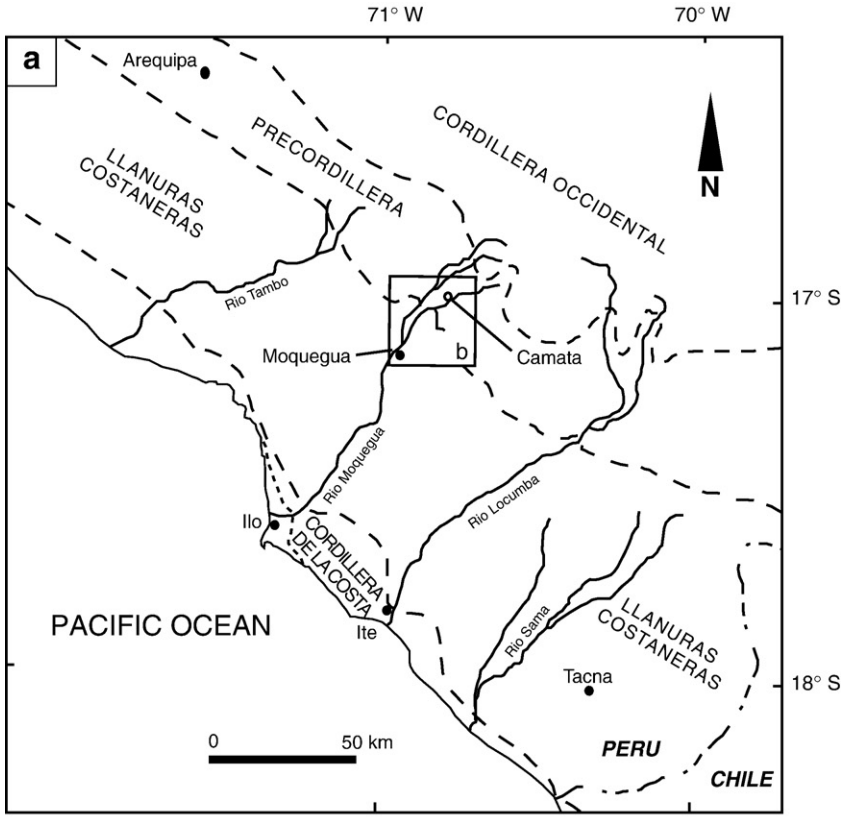
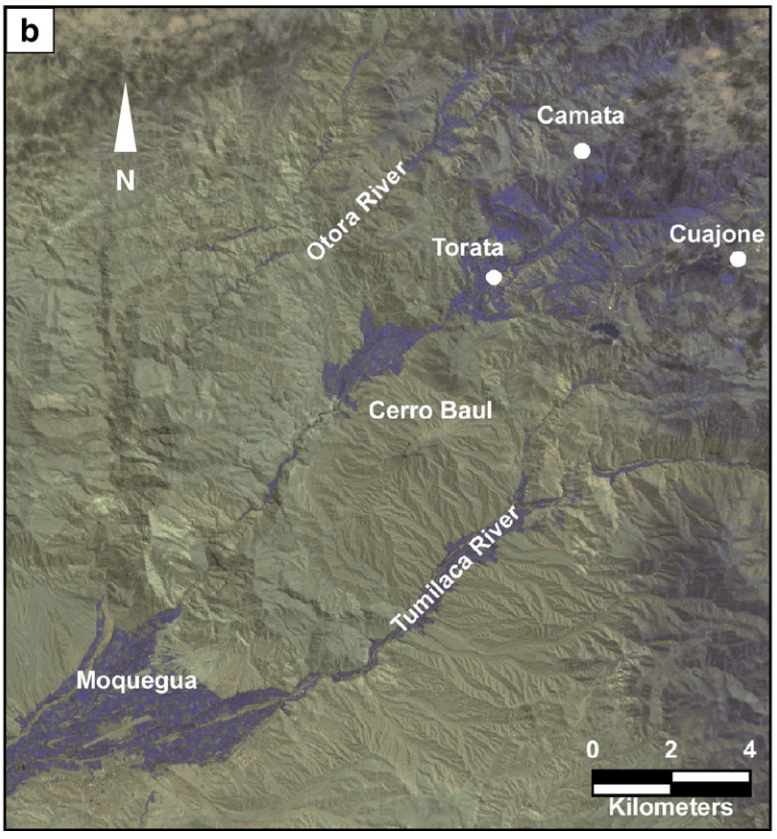
age of artificial landscape features. Agricultural terraces at archaeological sites provide a basis for constructing and calibrating erosion models because of their known initial morphology and age. In southern Peru there are extensive areas of prehistoric cultivation with field construction during two major periods: the first by the Wari (abandoned in ~1000 A.D) and





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