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Anthropogenic hillslope terraces and swidden agriculture in Jiuzhaigou National Park, northern Sichuan, China

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ABSTRACT

Small, irregular terraces on hillslopes, or *terracettes*, are common landscape features throughout west central China. Despite their prevalence, there is limited understanding of the nature of these topographic features, the processes that form them, and the role humans played in their formation. We used an interdisciplinary approach to investigate the geology, ecology, and cultural history of terracette development within Jiuzhaigou National Park, Sichuan Province, China. Terracettes occur on south facing, 20° slopes at 2500 m elevation, which appears to coincide with places people historically preferred to build villages. Ethnographic interviews suggest that traditional swidden agricultural cycles removed tree roots, causing the loess sediments to lose cohesion, slump, and the terrace risers to retreat uphill over time. This evidence is supported by landslide debris at terracette faces. Archaeological analysis of terracette sites reveal remains of rammed spread soil structures, bones, stone tools, and ceramics dating from at least 2200 years before present within a distinct paleosol layer. Radiocarbon and optically stimulated luminescence dating of terracette sediments ranged in age from between 1500 and 2000 ^{14}C yr BP and between 16 and 0.30 ka, respectively. These multiple lines of evidence indicate a long history of human habitation within Jiuzhaigou National Park and, taken together, suggest strong links between terracette formation and human–landuse interactions.

Introduction

Humans are among the most prominent geomorphic agents (Hooke, 2000), and as the world's population continues to increase, it becomes increasingly important to understand the dynamics of human–landscape interactions. In order to understand such human–landscape interactions (e.g., Trac et al., 2007; Daily and Matson, 2008; Liu et al., 2008), our team focused on the relationship between hillslope terraces in northern Sichuan Province, China and human occupation. Specifically, we asked: (1) where are these features found; (2) what sediments do they form in; and (3) how do they form?

The terraces we studied are in and near Jiuzhaigou National Park (JNP) in Sichuan, China (Fig. 1). This park is in the Min Shan region of northern Sichuan province, spans from 1996 to 4764 m in elevation, and encompasses an area of 720 km^2. Although there are similarities to national parks in the United States, the emphasis in JNP is on environmental and cultural preservation despite the over 2.5 million visitors to the park annually. Tourists are spatially restricted to a system of buses and boardwalks that limit access to narrow zones in the bottom of the valleys and are temporally limited to visits between 0700 and 1800 h. In addition to park visitors, there are nine indigenous villages within the park, six of which are still inhabited. Of those inhabited villages, three are in relatively isolated valleys away from primary tourist locations, two of which are the focus of this research (Fig. 1). Farming and grazing were banned in JNP in 2001 and domesticated animals were officially removed from the park at the same time, so areas that were formerly pastures and farms are still relatively open meadows. Despite animal removal efforts, there are remaining feral yaks and horses that continue to graze in former pasture land. Most of these meadows are being restored with planted

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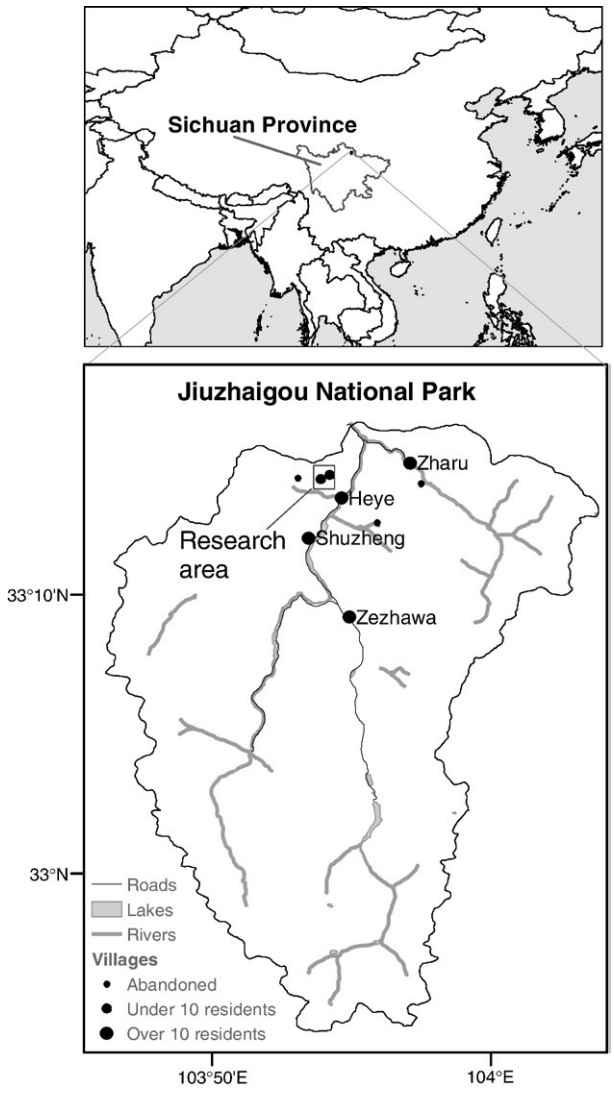

Figure 1. Location of Jiuzhaigou National Park (JNP) in Sichuan and China and detailed map of JNP. Detailed map of JNP shows rivers, roads, and villages with research area marked by a box. Villages with over 10 residents are labeled. The two villages in the research area are Panya and Jianpan. Location of Jianpan relative to terracettes studied is shown on Figure 3.

trees or native shrub species. Among these meadows are abandoned pastures and fields on irregular terraces.

These terraces generally coincide with fields or pastures now in disuse near villages. Unlike the rice terraces found in southeastern China, they have planar, but not flat, treads, do not have defined walls built around them, and do not appear to be maintained. Bushes, shrubs, and small trees grow on some terraces, while others are mostly meadow. With few exceptions, terrace faces are vertical and lack vegetation. They approximately parallel contours on the hillslopes and are 5–50 m high, 1–100 m wide, and 100–1000 m long (at right angles to the fall line). Similar features to the ones reported here are found in the Loess Plateau region of China, to the north of the study area. However, the research on Loess Plateau field terraces focuses on factors controlling erosion rather than on their genesis.

Odum (1922) identified terracettes as small irregular terraces on hillslopes. Identification and naming of this feature initiated a lengthy debate on the nature of these terraces, the processes that form them, and the role of humans in their formation. Terracettes have been described in various locations, such as the Loess Hills in Iowa (Bettis et al., 1986; Mutel, 1989; Dillon et al., 2006), the San Joaquin Valley in California (Bielecki and Mueller, 2002), eastern Washington (Rahm, 1961; 1962), the Himalaya (Byers, 1986, 1987; Watanabe, 1994; Byers, 1996, 2005; Barnard et al., 2006), Central and Eastern China (Rost, 1994, 1999, 2001), the Loess Plateau in northwestern China (Fang et al., 1999), and the Pyrenees (Gallart et al., 1993). In most of these areas, the terracettes described are several centimeters to a half a meter high, up to 60 cm wide, have bare treads, and steep, vegetated risers. The terracettes are normally parallel to the contours of the hillslope, but sometimes trend upwards at a slight angle causing some to intersect with one another. All terracettes are on slopes of about 15–25°. The most common of a wide range of explanations for terracette formation are landsliding, slumping, gelisolifluction, and animal grazing (Vincent and Clarke, 1979); however, no comprehensive descriptive study has been done of the characteristic features of terracettes formed by different processes. The terracettes described above are smaller than the terraces we describe in this paper, but the term terracette appropriately describes the general landscape feature discussed here.

In response to concerns, largely unsubstantiated with data, that deforestation in Nepal was causing increased flooding downstream areas, Ives and Messerli (1989) proposed an interdisciplinary approach relying in part on indigenous knowledge as a more appropriate way to address broad environmental research questions. Following these suggestions, interdisciplinary research on human–landscape interactions in Nepal (Byers, 1996, 2005), China (Rost, 1999; Trac et al., 2007), Bhutan (Roder et al., 2002), and the Andes (Moreno et al., 2009) show the importance and relevance of incorporating anthropological research methods into more traditionally scientific studies on landscapes. For example, landscapes in the Mt. Everest region were long thought to have been impacted by human activity only during the past 500 years with the arrival of the Sherpa from Tibet. However, interdisciplinary approaches that included soil profile analysis, ^{14}C dating of charcoal found at depth, and pollen analysis suggested that these landscapes have been under constant, human-induced modification since at least 1000 (Byers, 1996) and as much as 5000 years ago (Byers, 2005).

Other studies have used ethnographic research and field observations to understand the difference between government reports and quantitative data obtained during field work. In southern Sichuan, China, Trac et al. (2007) interviewed numerous farmers and locals involved in a reforestation project and determined that the areas being reforested were most likely not forested in recent history. Furthermore, the officially reported success rate of the reforestation project contradicts information obtained from ethnographic work and site observations.

Two studies examined official explanations for degradation and empirical and ethnographic evidence did not support these explanations. In Bhutan, Roder et al. (2002) observed that, although the official position was that grazing had degraded local forests, quantitative results demonstrated otherwise. In Wutaishan, China, historical documents, ethnography, and ecology were used to understand turf disturbance in the region and to put together an ecological history for the area (Rost, 1999). As with the research in Bhutan, the perception of extreme degradation turned out to be exaggerated when compared to quantitative indicators of disturbance. The integration of knowledge and research methods from multiple disciplines contributed to a more accurate understanding of the factors that shape landscape patterns.

Recent work in the Andes uses an interdisciplinary approach to understand how human settlements responded to a changing environment (Moreno et al., 2009). Moreno et al. (2009) used archaeological records, sediment cores, and regional paleoclimate and archaeological data to show that human settlements do not always respond in the logical, linear fashion expected of them in the face of extreme events such as volcanoes and floods. The integration