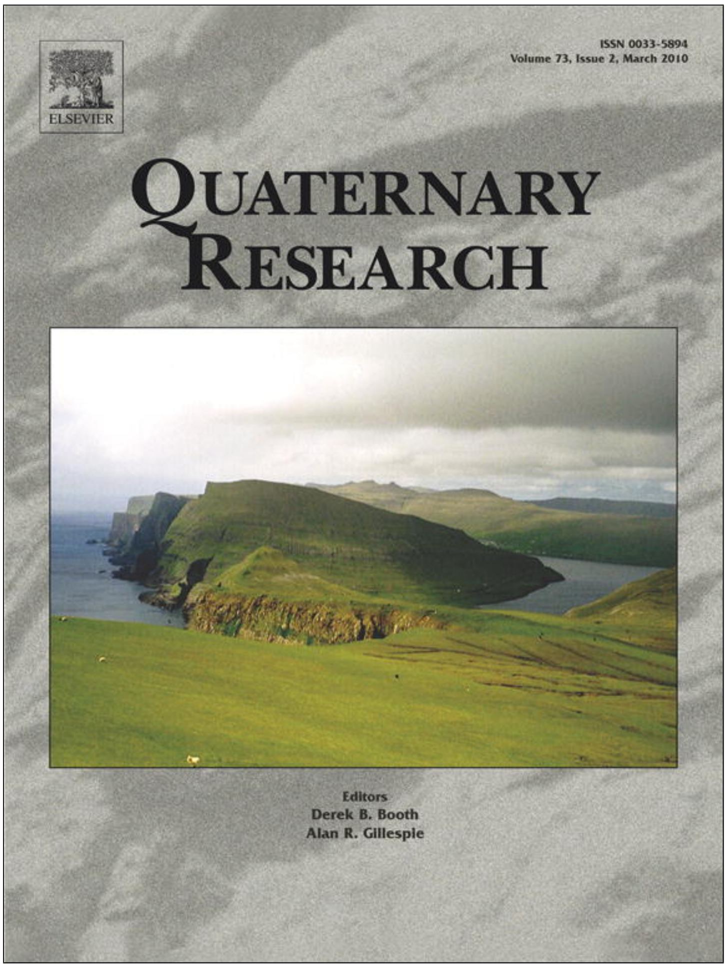
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# Anthropogenic hillslope terraces and swidden agriculture in Jiuzhaigou National Park, northern Sichuan, China

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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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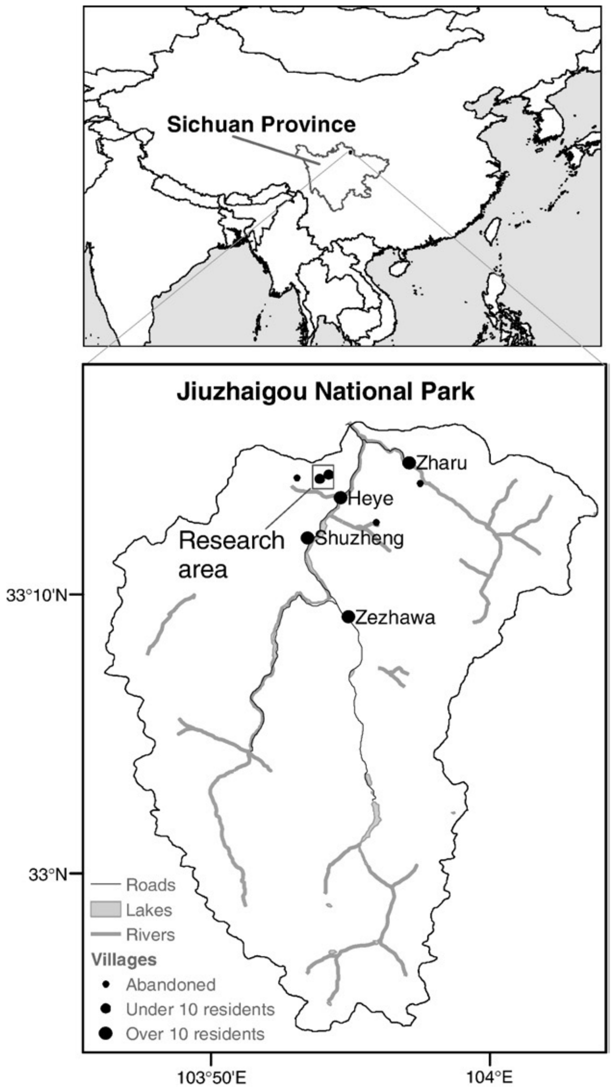


**Figure 1.** Location of Jiuzhaigou National Park (JNP) in Sichuan and China and detailed map of JNP. Detailed map of JNP shows rivers, roads, and villages with research area marked by a box. Villages with over 10 residents are labeled. The two villages in the research area are Panya and Jianpan. Location 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 paleocolimate 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 of these diverse fields was necessary to gain a fuller picture of how and when human settlements respond to changing climate.

## Methods

The human–landscape system dynamics we studied required interdisciplinary investigations. Most field work took place during a 2-week pulse field trip to JNP in June, 2007 in which a large team of researchers from a variety of disciplines collaborated intensively on one research topic but also relied on research carried out by the same group in 2006 and a follow-up trip in 2008. The geomorphologists in our group focused on mapping and spatial analysis of the terracettes at three spatial scales. We used a Quickbird 2.4 m satellite image to create a map of terracette locations. The elevations, slopes, and aspects of areas with terracettes in the entire park were extracted and frequency distribution curves created for each variable. A Monte Carlo simulation was used to determine if the elevations, slopes, and aspects of terracettes are a random subset of the elevations, slopes, and aspects of the entire park. There were a total of 3986 points of terracette data and 97,896, 97,920, and 97,824 points of slope, elevation, and aspect data, respectively. For each of elevation, slope, and aspect we ran an experiment 1000 times which generated a random list of 3986 numbers from a uniform distribution between 0 and 1. This list was scaled to be the length of the list of all elevations, slopes, or aspects and was used to sample a random set of those data. The probability distribution functions of these 1000 samples were smoothed into 20 bins to calculate the frequency of occurrence of each value and then plotted and compared to the probability distribution function of the terracette data.

To describe the topography of the terracettes in more detail, we mapped the surface of three sets of terracettes using a Trimble GX-GPS and measured cross-sections of the same terracettes using a stadia rod, hand-level, and a 50-m tape measure. In creating these cross-sections, we measured relative elevations at 1- to 5-m intervals along the surfaces of terracettes and measured width and height of terracette risers that could not be surveyed directly.

We collected sediment samples for radiocarbon dating and optically stimulated luminescence (OSL) dating. OSL dating constrains the time during which the sediment was buried and is the most effective way to date sediments that do not contain charcoal (for radiocarbon dating) and are too fine-grained for cosmogenic radionuclide dating. This method has proven particularly useful for dating deposits from the Loess Plateau, China (Roberts et al., 2001; Huang et al., 2003; Lu et al., 2004). We collected three samples in each of three terracettes: one above Jianpan Village and two below the village (see Fig. 3 for sample locations). At each terracette we collected an OSL sample in the top, middle, and bottom of the riser. The OSL samples were dated using pulsed OSL for fine-grained sediments (Feathers et al., 2008). To supplement the OSL dating, we described terracette stratigraphy, and collected samples for soil carbon and nitrogen analysis and for radiocarbon dating.

The terracettes are located near both occupied and abandoned villages. Likewise, vertical exposure left by terracette formation allows for subsurface investigations with little or no detrimental impacts upon the landscape. Consequently, they are ideal locations to survey for subsurface archaeological sites without utilizing intrusive probing or excavation. Although a more comprehensive archaeological survey will be required to determine the extent and exact nature of the sites, a preliminary survey was conducted as part of this research.

Our anthropology team focused on local people's traditional ecological knowledge (TEK) regarding terracette formation, fire use history, forest management and agricultural practices, and animal husbandry. Anthropologists in our team conducted ethnographic interviews of residents living in three villages near terracettes.

Ecologists on the team documented the presence, abundance, and coverage of forb, grass, herb, shrub, and tree species on former pastures in order to describe the dynamics of how terracettes revegetate either naturally or via human intervention. Another goal

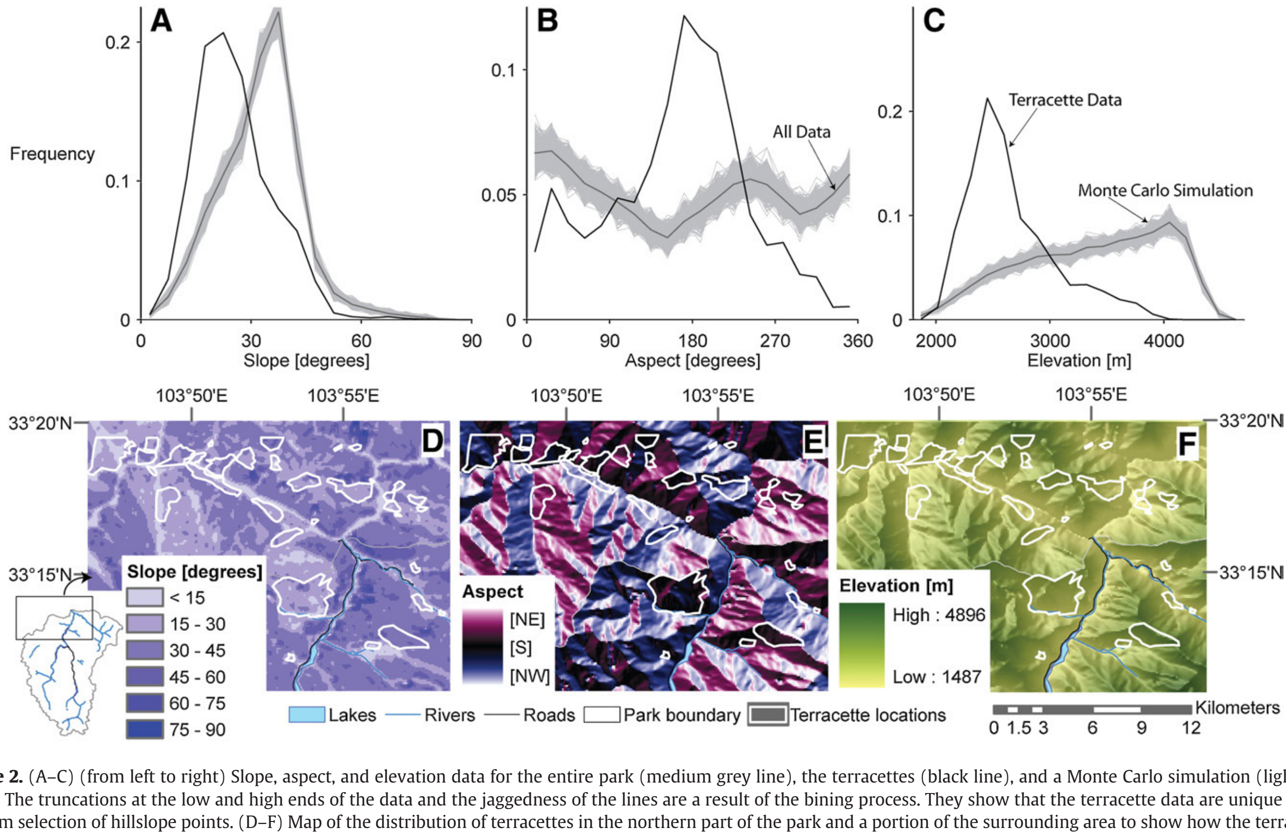


**Figure 2.** (A–C) (from left to right) Slope, aspect, and elevation data for the entire park (medium grey line), the terracettes (black line), and a Monte Carlo simulation (light grey lines). The truncations at the low and high ends of the data and the jaggedness of the lines are a result of the bining process. They show that the terracette data are unique from a random selection of hillslope points. (D–F) Map of the distribution of terracettes in the northern part of the park and a portion of the surrounding area to show how the terracettes are arranged over particular slopes, aspects, and elevations.

of this research team was to understand what happens to the features and meadows as they return to shrub and forest. We were able to examine terracettes at various stages of succession.

## Results

Terracette locations are strongly tied to certain slope aspects, hillslope angles, and elevations (Fig. 2). The modes of slope aspect, slope angle, and elevations for terracettes are 182°, 20°, and 2457 m, respectively (Table 1). The aspect, slope and elevation characteristicsof hillslopes with terracettes are unique from a random sampling of park hillslopes as shown by the Monte Carlo simulation in Figures 2A–C. There is additionally a strong coincidence between terracette location and villages; near existing and abandoned upland villages, we find terracettes. At a more detailed level, the cross-sections of individual sets of terracettes reveal clues about the way the features themselves form. The features mapped in detail ranged greatly in all dimensions. The terracettes were 1–100 m wide, 5–50 m high, and 100–1000 m long. All surfaces could be distinctly identified as being part of a terracette, although in some cases there are short slopes that connect several terracettes to one another or to the main hillslope. In addition, in some locations the riser of the terracette will split into two parts, forming an intermediate terracette between two larger ones.

**Table 1**
Summary of statistical information related to the topography where terracettes form.

| | Mode | 5% | 32% | 68% | 95% |
|---|---|---|---|---|---|
| Aspect (degrees) | 182.33 | 25.93 | 136.26 | 199.86 | 284.26 |
| Slope (degrees) | 20.19 | 11.33 | 19.73 | 28.96 | 53.65 |
| Elevation (m) | 2457 | 2165 | 2434 | 2733 | 3494 |

The OSL samples ranged in age from 0.30 ka (UW1696) to as old as 16 ka (UW1695) (Figs. 3A, D, and E; Table 2). Ages are almost entirely ordered stratigraphically and most directly correlated with the ratio of the distance below the surface of the next terrace up and the total height of the individual terrace. One anomalous OSL sample reports an age of 16 ka (UW1695) on top of an anthropogenic pit (Fig. 3E). This is the same age as the sample below and dates the original deposition of the loess rather than the younger paleosol sampled. The radiocarbon ages generally agree with the OSL ages, except for the one anomalous age discussed above. The four radiocarbon samples had two samples around 1500 $^{14}$C yr BP (232561 and 232559) and two around 2000 $^{14}$C yr BP (232558 and 232560) (Table 3).

The soils of the different terracette sites are relatively uniform. Most locations had an A horizon greater than 30 cm thick and a B horizon which extended beyond the maximum depth of the probe

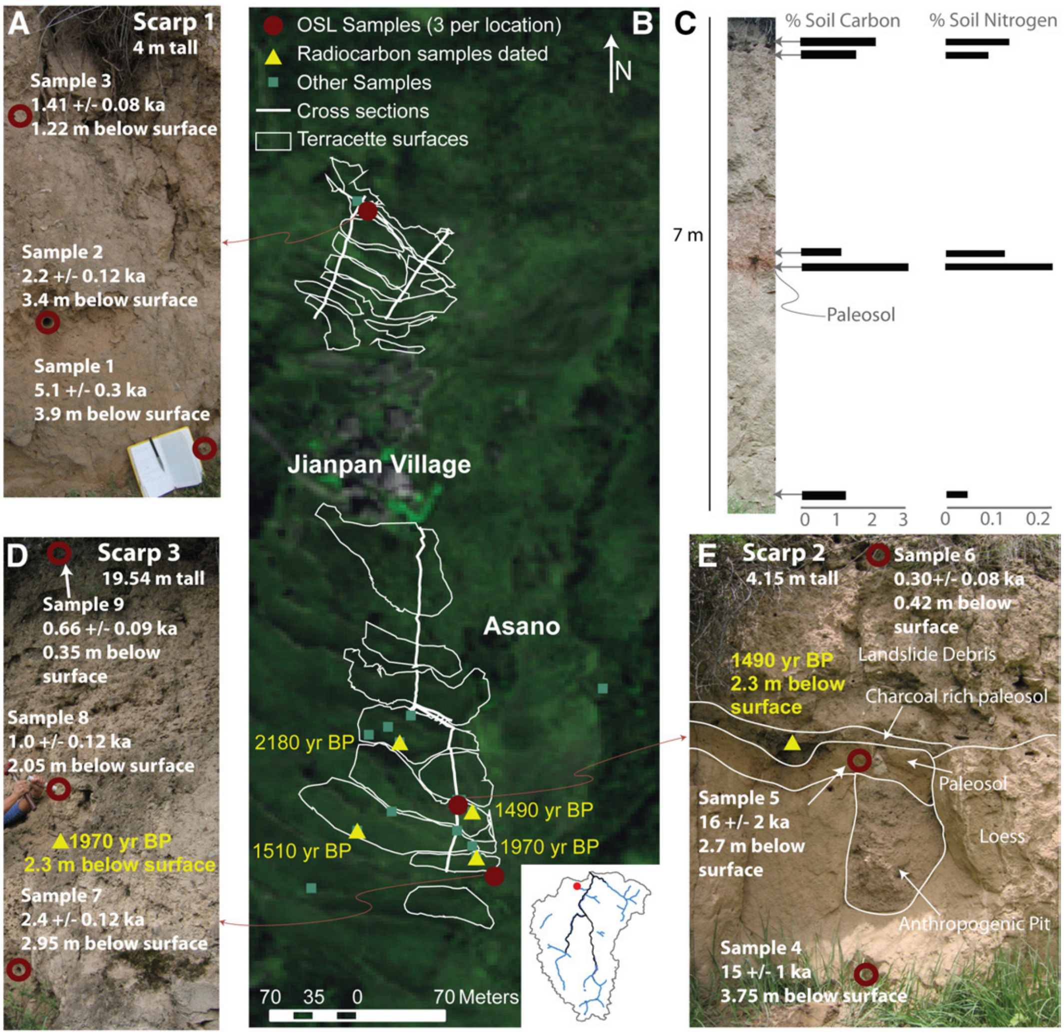


**Figure 3.** (A) OSL dates and sample locations from furthest uphill sample location. (B) Location of samples at *Asano*, terracettes shapes and profile locations, and radiocarbon ages in $^{14}$C years. $^{14}$C samples are from paleosol layers in the terracettes which yielded ceramics and other human artifacts. (C) Bar graph of soil carbon and nitrogen analysis, picture of scarp analysis was done on, and location of samples for analysis. Paleosol is noted. (D) OSL dates and sample locations from the furthest downhill sample location. (E) Stratigraphy of one of the terracettes which yielded large numbers of archaeological samples; OSL dates and sample locations from that scarp.

**Table 2**
Summary of OSL dates and sampling locations.

| UW lab # | Sample | Location in terrace | Age (ka) |
|---|---|---|---|
| UW1691 | 1 | 3.9 m below surface | 5.1 ± 0.3 |
| UW1692 | 2 | 3.4 m below surface | 2.2 ± 0.12 |
| UW1693 | 3 | 1.22 m below surface | 1.41 ± 0.08 |
| UW1694 | 4 | 3.75 m below surface | 15 ± 1 |
| UW1695 | 5 | 2.7 m below surface | 16 ± 2 |
| UW1696 | 6 | 0.42 m below surface | 0.30 ± 0.08 |
| UW1697 | 7 | 2.95 m below surface | 2.4 ± 0.12 |
| UW1698 | 8 | 2.05 m below surface | 1.0 ± 0.12 |
| UW1699 | 9 | 0.35 m below surface | 0.66 ± 0.09 |

They are corrected for fading. Sample 5 has statistically the same age as sample 4 but is in a paleosol, suggesting that it was deposited during the same event. The archaeological material below suggests it was not well bleached during human occupation. Data are shown in Figure 3.

(85 cm). Both A and B horizons are composed of fine-grained silt to silty clay, and contained significant amounts of charcoal; the lighter color of the B horizon suggests significantly lower carbon and nitrogen contents than in the A horizon. Given the uniformly fine-grained texture of the soils and the lack of any material larger than silt-sized in nearly all terracette scarps, the soils are most likely derived from eolian deposits. The location of the field site just south of the Loess Plateau suggests that these eolian deposits are primarily loess. The distribution of charcoal and the presence of two visible plow layers, one near the present surface and the other in association with the buried paleosol, suggests that some mixing may have occurred, otherwise it seems that these eolian deposits have primarily weathered in place. The OSL data confirms that the upper layers of sediment have been more recently disturbed than lower layers and that those below the paleosol are clearly older than those above.

The scarps of many of the terracettes are calving off in large blocks, but as the features retreat upslope, they tend to maintain a vertical face. This is likely a result of the large quantity of loess in the terracettes. To confirm that buried red layers in the terracettes are in fact paleosols, we measured the percent soil carbon and percent soil nitrogen at five places in one face, one from modern soil, one from immediately below the modern soil, one from the suspected buried soil, one from immediately above the suspected buried soil, and one from old loess. The soil carbon and nitrogen levels are significantly higher in the suspected buried soil than in the surrounding loess and similar in value to the modern soil sample; thus, we conclude that it is a paleosol (Fig. 3C), and that the suspected buried soils in other scarps are also paleosols.

The stratigraphy of the terracettes is remarkably uniform from feature to feature, with a few major exceptions. Most terracettes are fine-grained loess-like silt. In some cases the loess is topped with a paleosol and/or unsorted, well-mixed debris with angular large grains, and with more loess on top of the debris (Figs. 3C and E). This debris has the same composition as modern landslides that periodically bury the road from the valley floor up to the terracettes, so we assume that this debris is landslide debris. Some terracettes have extensive archaeological materials imbedded in the risers, including an anthropogenic pit (Fig. 3E), extensive ceramic and bone deposits (e.g., Fig. 3E), as well as rammed spread soil structures (not shown but in same riser as shown in Fig. 3E and elsewhere).

**Table 3**
Summary of radiocarbon ages.

| Sample | Lab number | $^{13}C/^{12}C$ ratio [‰] | $^{14}C$ yr BP | Cal. age (2 sigma) [cal yr BP] | Distance below surface (m) |
|---|---|---|---|---|---|
| 07JZGASN:2 | 232558 | −23.9 | 1970 ± 40 | 2010–1870 | 2.3 |
| 07JZGASN:4 | 232559 | −22.6 | 1490 ± 40 | 1520–1340 | 2.3 |
| 07JZGASN:31 | 232560 | −22.5 | 2180 ± 50 | 2340–2120 | 4 |
| 07JZGASN:32 | 232561 | −24.7 | 1510 ± 40 | 1520–1320 | 3.25 |

All of the terracettes mapped in detail for this project have yielded archaeological remains. One set of terracettes surrounds the relatively young *Yala* archaeological site (less than 550 yr BP, based on previous radiocarbon dating) among the ruins of the historic village by the same name. Although now abandoned, this area is still used for burials and grazing by feral yaks and horses. There are two other sets of terracettes at the *Asano* archaeological site (Fig. 3B). As the terracette risers retreat uphill, they have exposed the remains of rammed spread soil structures, bones, stone tools, and ceramics at great depths (sometimes 6 m or more) within a distinct paleosol and occasionally mixed into overlying deposits.

In the villages near the *Asano* site, Panya and Jianpan, local people reported that the terracettes were formed naturally and had existed for as long as they were aware. However, in a village in another valley, near a set of terracettes not included in this study, local people attributed the formation of the terracettes to swidden agricultural practices introduced by residents of other villages, including Panya and Jianpan, who came to farm when their villages experienced population growth. In order to clear land for farming, these seasonal residents clear-cut a potential field, let the wood dry for a year, burned it, and then planted the field. During the subsequent year, when the fields were employed as pasture, the terracettes formed. These results suggest that once cleared and devoid of tree roots, terracette formation can be relatively fast. Detailed studies of more recent sites as well as forest loess deposits are needed to independently determine the rates of formation.

These terracettes appear to be in locations formerly used as fields and then pasture. Following extensive clear-cutting and increases in land used for farming in the 1950s through the 1970s (Shapiro, 2001), many areas were allowed to fall into disuse, but have not yet completely revegetated to their pre-human settlement species composition. Today, terracettes within JNP exist in a range of conditions from extensive current grazing by ferals, indicated by the presence of fresh yak and horse dung, limited grazing, re-colonization by native shrub and tree species, especially along forest edges, and extensive reforestation and afforestation through the planting of coniferous species.

## Discussion

Terracettes in JNP form in areas where there are significant loess deposits. Although several regions in the park are mapped as loess on soil maps, the loess deposits are more extensive than shown on these maps. In areas where the loess deposit is associated with a particular suite of topographic features (i.e., aspect, slope, and elevation), one most frequently finds terracettes. Once terracettes have formed, they maintain themselves by calving angular blocks at the face and slumping at the uphill side. Because of the high loess content in the sediments, they are able to maintain nearly vertical faces, but will fail suddenly in extremely wet conditions, such as during the summer monsoon. This could lead to the landslide deposits seen in the terracette stratigraphy. The frequency and size of these landslides are not known.

The relatively uniform textural features and extensive vertical distribution of charcoal in the terracettes contrast with soils found at other slope and bottomland positions in JNP (Winkler, 1994). In addition, except for some very small stones, terracette soils are largely stone and rock free, again in strong contrast to other JNP soils. Due to the area's proximity to the Loess Plateau and the composition of the soils, they are derived from loess which weathered *in situ*. These soils are well developed and very deep. In addition, slope position, the relatively gentle grade of these slopes, and the loess content of the sediments indicates that they were probably ideal locations for growing crops and domesticate pasturing. These features, as well as the superior winter-time microclimates of these sites which are south-facing, off the valley floors, and relatively low-angle, thereby receiving maximum winter sunlight, indicate that villages developed and their presence then maintained these surfaces via the use of fire.

The coincidence of a major archaeological find and the terracettes appears to support the hypothesis that prehistoric and recent human activities have influenced the formation of these geologic features. Evidence for early anthropogenic terrace formation and erosional events has been demonstrated regionally and elsewhere (i.e., Huang et al., 2007; Leopold and Voekel, 2007; Thapa and Paudel, 2002). In at least one case from the nearby Loess Plateau of western China significant changes in sedimentation rates were noted starting at the same time as occupation at *Asano* and was associated with possible introduction of agriculture to this location, although agriculture has occurred for 6000–10,000 years elsewhere in China (Roberts et al., 2001; Lu, 2006). Additionally, because of the distinct topographic locations terracettes form in (Table 1, Fig. 2), we can use this information to identify other locations in this region of China which are likely to form terracettes. Importantly, this information may be used to predict future archaeological sites in these regions.

The villagers in Panya and Jianpan, near the *Asano* archaeological site, all claimed that the terracettes had always existed and were natural landscape features. However, when we conducted interviews with villagers who live in an area of a more recent agricultural expansion they were able to explain the anthropogenic steps that contributed to the formation of the terracettes. Tree removal and the introduction of a rotational cropping, pasturing, re-colonization and burning system helped us to understand the older terracettes near Yala, Panya and Jianpan and the ubiquitous presence of charcoal. Clearly human activity on the landscape encourages the formation of these features, which then become a persistent and important topographical characteristic for human and geological processes.

As a result of extensive forest clearing in the 1960s and 1970s for multiple purposes and the observation that terracettes seem to be well developed throughout the region, it is apparent that these features can form relatively rapidly and become a visible landscape component. In contrast, given the presence of paleosols, thus indicating a buried terracette, and a rammed spread soil structure in one terracette scarp, it is likely that some terracettes have been present for at least 2200 years based on limited charcoal and OSL dating. These two seemingly contradictory observations about the terracettes as well as substantial village-to-village differences in traditional knowledge regarding the formation and longevity of terracettes indicate that terracettes can form quickly and persist on the landscape and that the terracettes currently present in the landscape have a variety of ages.

We predict that whenever hillslopes dominated by loess deposits were cleared and farmed, they slumped to form terracettes. The exact mechanism which leads to terracette formation remains unconfirmed, but slumping as a result of rotational agricultural practices seems the most likely cause. These features then increase the utility of the location for supporting agricultural and animal husbandry practices of the local population. It is likely that local agricultural and animal husbandry practices encourage and maintain terracettes. Ethnographic evidence indicates that during agricultural expansion in the 1960s and 1970s, additional terracettes formed, most of which now lie in disuse or are being recolonized by shrubs and deciduous trees both through natural colonization and intentional replanting. Even areas that are becoming increasingly forested tended to have prominent loess cliffs between bands of trees, reflecting more widespread agricultural land use in the past.

## Conclusion and areas for future research

Our investigation, using an interdisciplinary approach, has led to a greater understanding of terracettes, their locations and the identification of some processes that contribute to their formation and persistence. They form where there are loess sediments and specific topographic features, especially when occupied by agrarian peoples. They are formed as a natural result of the local cycle of swidden agriculture and reflect both long-term human occupation of the region and relatively recent-term conversion of forests to agricultural production. They most likely form through facial sluffing and rotational slumping of loess deposits on shallow to moderated steep slopes where there has been tree removal of trees and destabilizing root loss.

Future research in the area would clarify the particular mechanisms for, as well as the rate of, terracette formation and to test our model predicting terracette locations to find archaeological sites. More extensive and additional archaeological excavations and associated soil and sediment analysis would provide insights into both the durability of these features, as well as the nature and timing of anthropogenic activity initiating or compounding the formation of these features. Such information will be critical in understanding the history of human habitation in the park as well as the relative spatial and temporal importance of these landscape features in providing unique floral and faunal habitats.

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