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Pedogenic correlation of lateritic river terraces in central Taiwan

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Abstract

The Pakua, Chushan and Touliu terraces are three groups of lateritic river terraces resulting from different fluvial systems in central Taiwan. Their geomorphic features do not enable regional correlations to be made. In this study, an alternative scheme based on the quantification of a pedogenic development is proposed for this correlation. Four soil pedons from the Chushan and Touliu terraces are classified as Ultisols (CS-1, CS-2 and TL-1) and an Inceptsol (TL-4) following the *Soil Taxonomy*. An additional six soil pedons, including an Oxisol (PK-1), Ultisols (PK-2, -3, -4 and -5), and an Inceptsol (PK-6), from the Pakua terraces were included from a previous study [Tsai, H., Huang, W.S., Hseu. Z.Y., Chen, Z.S., 2006. A river terrace soil chronosequence of the Pakua tableland in Taiwan. Soil Science 171, 167–179.]. The weighted mean profile development indices (WPDI) for the pedons suggest a chronological order of I (PK-1), II (PK-2), III (PK-3), IV (PK-4, CS-1 and TL-1), V (PK-5 and CS-2), VI (PK-6) and VII (TL-4). The correlation suggests the Chushan and Touliu terraces correspond to the same surface of an anticline, separated by the Chinshui River. Surface deformation reflects the growth of the underlying structure in which uplift folding occurred in the hinge zone and tilted to the east along the fold limb, as a result of the southern extension of the Pakua anticline. However, the different geometries on both the surface and subsurface from southern Pakua Anticline indicate a mechanism of fault-bend folding for Touliu Hill.

Keywords: River terrace; Profile development index; Pedogenesis; Soil classification; Anticline; Quaternary

1. Introduction

River terraces are one of the most prominent geomorphic features in Taiwan, and constitute an excellent marker for the study of active tectonics. However, the absence of absolute datings and geochronological information means that ages are typically a problem in extracting information from deformed surfaces. Previous studies have correlated terraces mainly on the basis of geomorphic and pedogenic parameters such as altitude above sea level or present river channel, continuity and height of terrace scarp, surface gradient and color of topsoil (Lin, 1957; Ku, 1963; Yang, 1986). However, their results are usually inconsistent and are not satisfactory.

Jenny (1941) indicated that most soil properties are time-dependent chronofunctions, and some of them have been used to correlate Quaternary successions (Morrison, 1968; Leamy et al., 1973; Mulcahy and Churchward, 1973; Birkeland, 1984; Engel et al., 1996). The activity (Fe_o/Fe_d) and crystallinity $[(Fe_d - Fe_o)/Fe_t]$ ratios of free iron are good time-dependent indexes for

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red soils (Blume and Schwertmann, 1969; Nagatsuka, 1972), and have been successfully used in northern Italy (Arduino et al., 1984, 1986), southern California (MacFadden and Hendricks, 1985) and the Kikai Island of southwestern Japan (Maejima et al., 2002). Harden's (1982) profile development index (PDI) has been proven as another successful method in quantifying field attributes of soil in order to rank soil development (Alonso et al., 1994). Moreover, Harden and Taylor (1983) have demonstrated that the index may be suitable for correlating soil chronosequences on different parent materials and in different climates. Although Vidic (1998) questioned the validity of the chronofunction, it was agreed that the parent material composition does not affect the soil development index significantly.

There are many lateritic river terraces in central Taiwan. The Pakua, Chushan and Touliu terraces represent three different groups of river terraces developed in various drainage basins. No satisfactory regional correlation of terraces can be achieved based on the geomorphic parameters mentioned above. Tsai et al. (2006) reported a soil chronosequence of the Pakua terraces, and estimated the ages by the ratio of $(Fe_d - Fe_o)/Fe_t$. In this study, the weighted mean of the PDIs (hereafter termed WPDI) and the pedogenic iron are calculated and compared as a basis for regional terrace correlation. The rate of soil development based on the WPDIs is proposed as an effective chronological indicator.

2. Study area

2.1. Geologic background

Taiwan is geologically located at the convergent boundary between the Philippine Sea plate and the continental margin of the Eurasian plate (Fig. 1A). The Philippine Sea plate subducts beneath the Eurasian plate offshore eastern Taiwan, and overrides the South China Sea floor of the Eurasian plate south of Taiwan (Suppe, 1981; Tsai, 1986; Angelier, 1986; Ho, 1988). Active tectonics in Taiwan are manifested by continuing shortening and widespread seismic activity. A shortening rate of 8.5 cm/yr is revealed by GPS measurements across the 200-km-wide island (Seno et al., 1993; Yu et al., 1997). There are a series of active subparallel west-verging thrusts in the fold-and-thrust belt along the western Foothills of Taiwan, resulting from a thrust migrating westward by tectonic compression since the Plio–Pleistocene (Lee et al., 1996) (Fig. 1B). The largest inland earthquake ($M_w = 7.6$, $M_L = 7.3$) of the 20th century in Taiwan was caused by the displacement of the Chelungpu Fault (Ma et al., 1999; Kao and Chen, 2000).

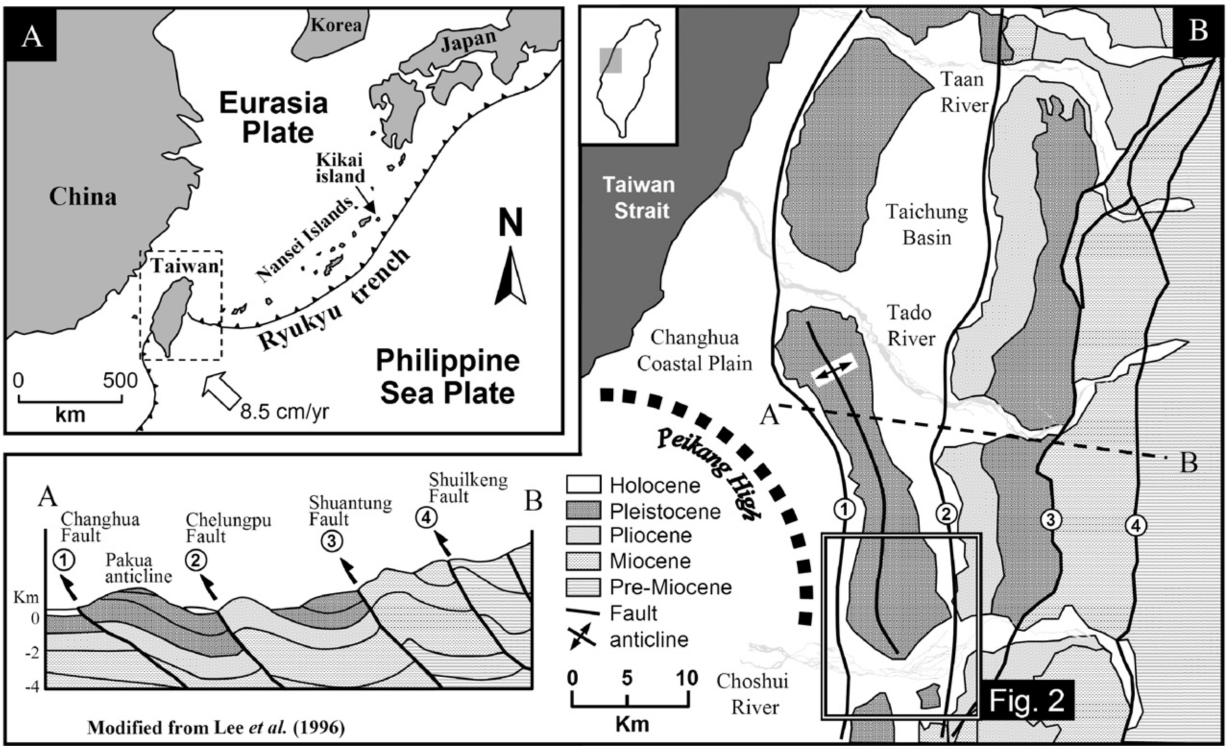

Fig. 1. (A) The tectonic setting of Taiwan. (B) Geological map and cross-section of the studied area in central Taiwan.