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Soilscape of west-central Taiwan: Its pedogenesis and geomorphic implications

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ABSTRACT

Five different soil types, including Entisol, Inceptisol, Alfisol, Ultisol and Oxisol, are distributed across west-central Taiwan. These soils cover the surfaces of three geological terrains, namely, the Pleistocene anticline, the Holocene coastal plain, and the modern alluvial fan. These soils developed from the similar parent materials, facilitating the analysis of soil diversity and the processes of pedogenesis. The soil chronosequence of Entisol → Inceptisol (Endoaquept) → reddish Inceptisol (Dystrudept) → Ultisol → Oxisol with increasing age is suggested for the progressive pathway of soil development. The degree of pedogenesis was quantified using a weighted profile development index (WPDI), which indicates that the soils from the tropics develop faster than those in temperate and/or Mediterranean climates, but was not as fast as those documented in the published literature. Moreover, the distribution of soils during pedogenesis conformed to the order of landform formation. Soil genesis and the way in which the different soils evolve illustrate the paleo-environments of the fluvial system in the area.

1. Introduction

Soils are earthy materials that are subjected to formation processes influenced by various factors, including climate, organisms, topography, parent material and time (Jenny, 1941). These factors cause major variations in the composition and structure of soils worldwide. At present, *Soil Taxonomy* lists a total of 12 Soil Orders (Soil Survey Staff, 2010), of which Taiwan contains 11 (with the exclusion of Gelisols, which mainly exist in the Arctic Circle, north of 60°N latitude), which are distributed on the surfaces of various landforms created as a result of active tectonics since the Plio-Pleistocene. In west-central Taiwan, various soils are distributed on the surfaces of three main geological landforms (or terrains; Fig. 1a), including a Pleistocene anticline, a Holocene coastal plain, and a modern alluvial fan (Fig. 1a) (Lin, 1957; Ho, 1988). These soils have a similar parent material, but have developed over different lengths of time and climate changes. The wide diversity of soils and landforms in this region of Taiwan provides an excellent environment and opportunity for the interdisciplinary studies of pedology and geomorphology.

A flow chart of "Soil Order" was developed to indicate the progressive pathway of soil development (Brady and Weil, 2010); it is useful for both pedologists who work on soil-forming processes (Birkeland, 1999) and geomorphologists who can use these datasets to interpret landform evolution (Tsai et al., 2006, 2007a; Huang et al., 2010). However, further applications are limited because of the lack of absolute ages or time constraints along soil sequences. These challenges in soil dating remain, even with the application of ^{10}Be techniques (Tsai et al., 2008; Siame et al., 2012). Soil mapping has been successfully used to interpret the local geology (Arkley, 1964; Birkeland, 1999; Holiday et al., 2002), suggesting that this technique can be applied in Taiwan. Such information would help in improving the existing knowledge about soil pedogenesis, as well as providing an understanding of the paleo-environments of the area. For instance, detailed topographic maps of the area were not published until the early 20th century. The complex river migrations on the modern alluvial fan were poorly documented before the publication of these maps. Consequently, determining the fluvial environment of the pre-historical era was difficult. Moreover, the boundary between the geological terrains of the Choshui alluvial fan and the Changhua coastal plain remains ambiguous, requiring a detailed description (Lin, 1957; Teng, 1983; CGS, 2000).

In this study, a geographic information system (GIS)-based soil database was developed on the basis of previous detailed surveys. Representative soil profiles are also presented for better illustration of their morphological characteristics. A genetic relationship between soil properties and geomorphic environments is suggested for each kind of soil distributed in the area, facilitating the interpretation of the paleo-environment on the pattern and the migration of the fluvial system in

Abbreviations: WPDI, weighted profile development index; GIS, geographic information system; CEC, cation exchange capacity; PDI, profile development index.

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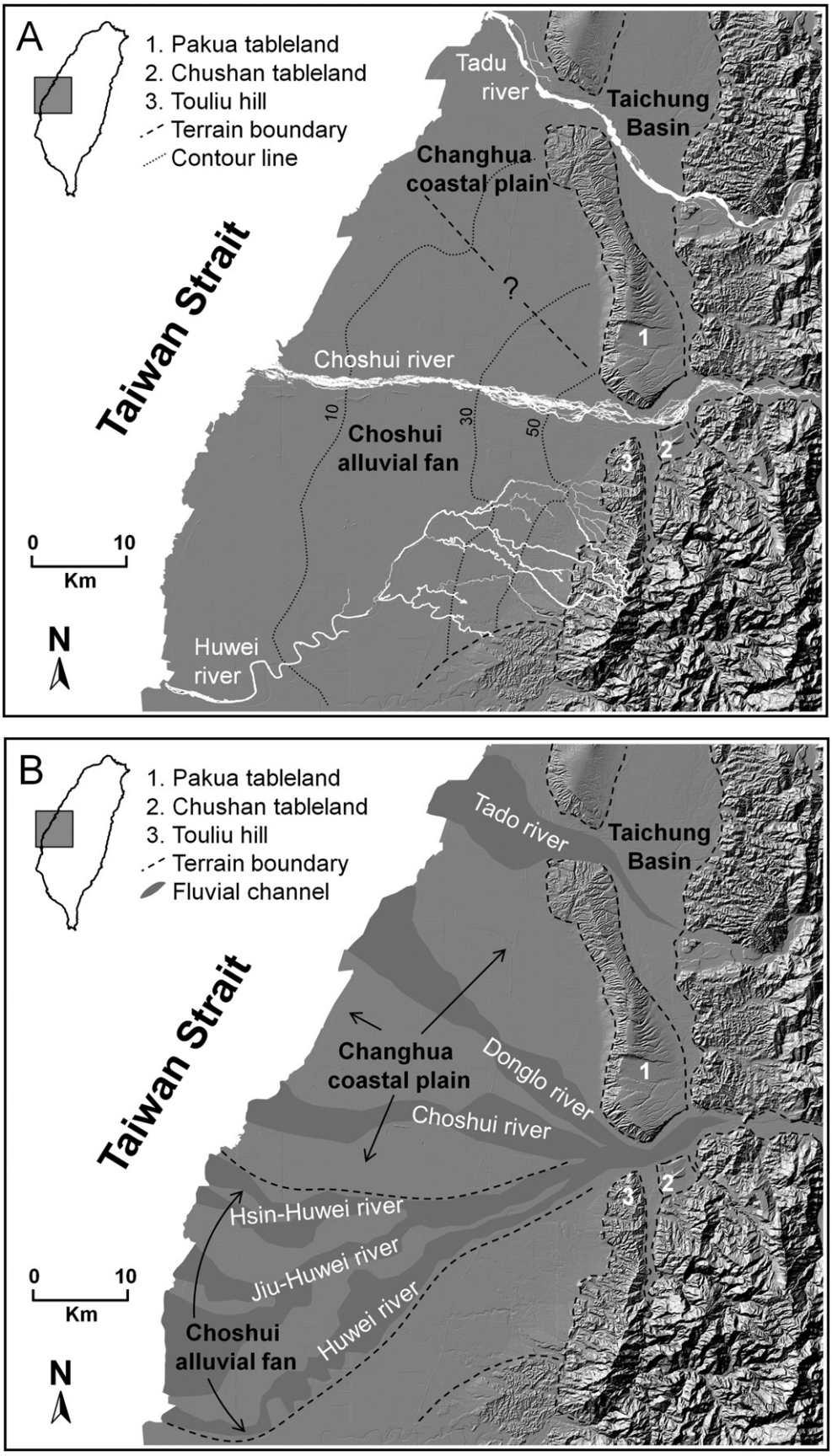

Fig. 1. The shaded relief map based on 40 × 40 m DEM data. (a) The study area includes the geologic terrains of coastal plain, alluvial fan, and anticline (in the landforms of tableland and hill). Three of the largest rivers in the area are shown. (b) The geologic terrains of the Changhua coastal plain and the Choshui alluvial fan interpreted from soil mapping.