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Active deformation front delineated by drainage pattern analysis and vertical movement rates, southwestern Coastal Plain of Taiwan

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Abstract

Orogenesis in Taiwan results from an arc-continent collision between the Eurasian plate and the Philippine Sea plate. The southwestern part of Taiwan absorbs active shortening as evidenced by rapid crustal deformation and frequent earthquakes. Southwestern Taiwan may be subdivided into three tectonic–geomorphic domains, including the plain (PL), the tilted tableland (TT), and the low hills (LH), based on geomorphology, drainage pattern and stratigraphic records. The PL domain is the westernmost and is characterized by meandering rivers with relatively low surface slope and river gradient, but high river sinuosity. The TT domain has slightly tilted terraces with river meanders and many tributaries are developed on its surface. Anomalous river sinuosity occurs as a result of active tectonics. The LH domain has higher elevation and deformed geomorphic surfaces associated with a dissected landscape. This domain also has high stream gradients with low sinuosity which may indicate active deformation. We define crustal deformation, using Holocene deposits and radiocarbon dating in addition to geomorphic analysis that suggests a blind thrust may exist between the PL and TT domains. This blind thrust may indicate the position of the active deformation front of the orogenic belt of southwest Taiwan.

Keywords: Deformation front; Blind thrust; Drainage pattern; Digital Elevation Model (DEM)

1. Introduction

Taiwan is located in the junction between the Eurasian plate and the Philippine Sea plates. This oblique arc-continent collision is propagating from north to south (Suppe, 1981, 1984; Teng, 1990; Teng et al., 2000), and this governs the development of Taiwan orogen and defines four geological terranes. From west to east, these terranes, respectively, include the Coastal Plain, Foothills Belt, Backbone Range and the Coastal Range. Rapid uplift and frequent earthquakes in Taiwan indicate that this plate collision is ongoing. The location of the deformation front of the Taiwanese orogen remains a key question for hazard assessment. Ho (1967) considered that the westernmost border of the Foothills is the deformation front of the fold-and-thrust belt. In contrast, Biq (1992) proposed that a major thrust fault may be situated along the westernmost part of Coastal Plain as a result of basement collision. Liu et al. (1998) argued that the deformation front might be easily recognized as the northern extension of the Manila Trench based on submarine topographic depression (Fig. 1a). However, it is unclear where the location of deformation front is on land in southern Taiwan due to extremely high rates of sedimentation from the mountain belt to the east. Recently, Deffontaines et al. (1997) suggested that the deformation front may be situated along the western margin of the Tainan tableland (TN) and extends northward (Fig. 1b), but this is uncertain because obvious topographic features are unknown in this region. Meanwhile, Sun et al. (1998) showed that, based on a shallow seismic reflection

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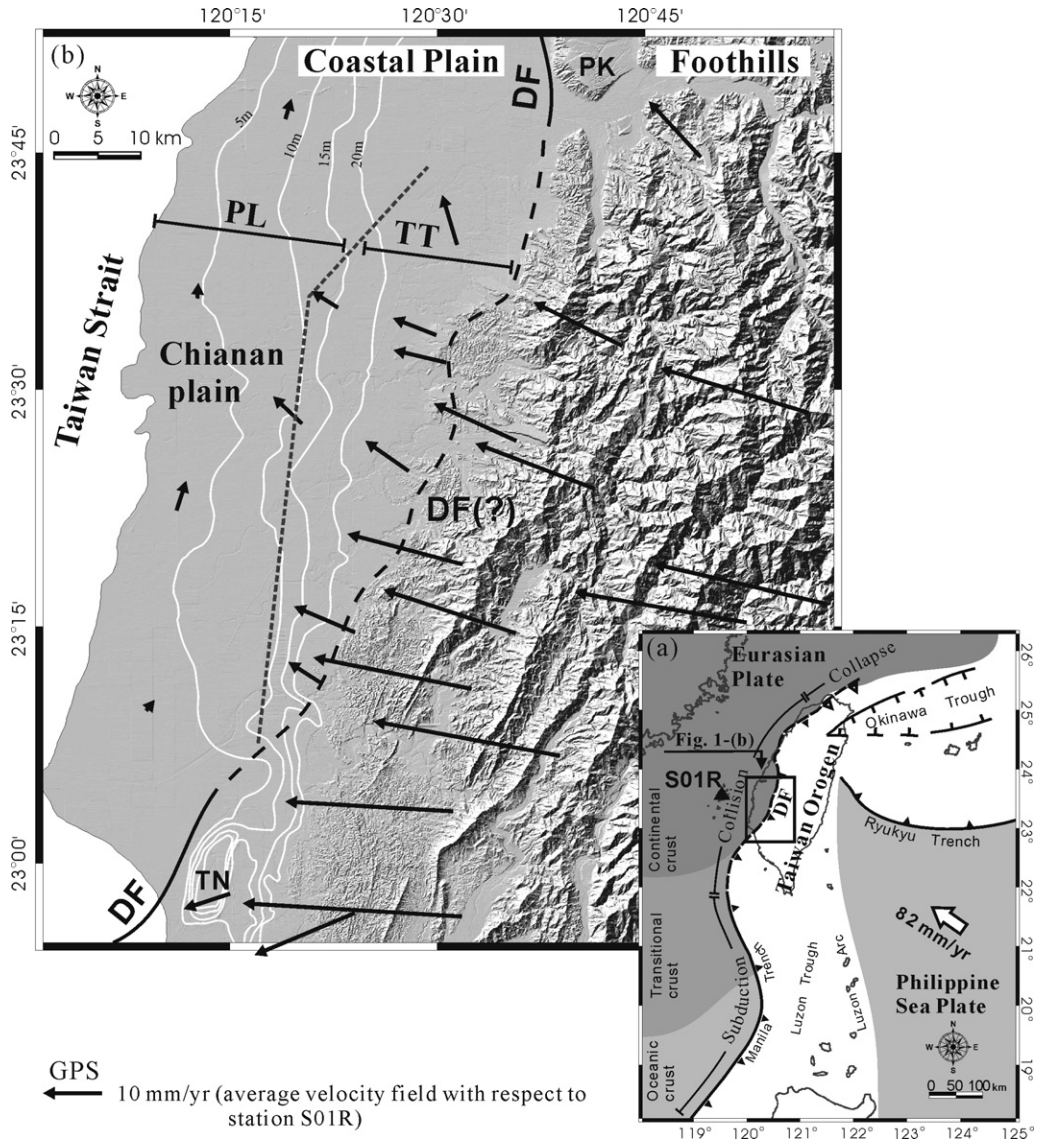

Fig. 1. (a) Tectonic framework around Taiwan. The deformation front is created by the arc-continental collision between the Eurasian plate and the Philippine Sea plates. Arrow indicates the direction of convergence (Modified from Teng et al., 2000). (b) Shaded topographic map of southwestern Taiwan obtained from 40-m Digital Elevation Modal. Deformation front (DF) can be identified along the western borders of the Tainan Tableland (TN) and Pakau (PK) Tablelands (solid line), but it is not clear in the section in between. Previous studies locate it along the hill front (thick-dash line) (Ho, 1967). The thin-gray dashed line in Coastal Plain divides, tentatively, Chianan plain into the plain domain (PL) and tilted tableland domain (TT). South part of the gray dashed line is suggested along the 10 m contour with a flat plain to the west and tilted surface to the east can be related to contraction recorded by GPS data (Yu et al., 1997). The bending of the gray dashed line is inferred from GPS data marking a change in direction from west to northwest movement.

study, deformed Holocene strata beneath exist the Chianan plain in the southern part of Coastal Plain. Geodetic data also show that crustal strain accumulated in the Chianan plain (Fig. 1b) (Yu et al., 1997; Hsu et al., 2003). Frequent historical earthquakes beneath the Coastal Plain also indicate that it is tectonically active (Cheng and Yeh, 1989). Thus, the eastern part of the Chianan plain is probably the westernmost leading edge of the Taiwan orogen. Since the Chianan plain may be considered to be tectonically active and it has a dense population, delineating location of active faults and folds is urgently needed.

We show that the deformation front of the Taiwan orogen may have migrated westward into Coastal Plain and west of the Foothills domain. However, our interpretation is controversial because Holocene deposits cover the entire area of central and southern Coastal Plain. In this paper, we analyze the drainage pattern and stratigraphic records of the Chianan plain. We would make looked for a steepening of river gradients to mark the westernmost point of uplift in the belt. Borehole data are used for calculating the rates of vertical crustal movement. Based on these data we locate a hinge line between uplift and subsidence.