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An interpretation of the active deformation of southern Taiwan based on numerical simulation and GPS studies

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Abstract

The fold-and-thrust belt of Taiwan results from oblique convergence between the Eurasia and the Philippine Sea plate, and its front structures are strongly influenced by the presence of large horsts and basins in the foreland. Using a 2-D numerical modelling (finite-element and distinct-element methods), we evaluate the influences on the active deformation of southern Taiwan of: (1) the foreland structural highs; (2) the major fault zones in the belt; and (3) the presence of a subduction zone to the south. To constrain our models, we take into account for the first time the present-day velocity field of southern Taiwan estimated based on new geodetic data obtained through the Global Positioning System (GPS). Particular attention is paid to the role of geological discontinuities, through an evaluation of the presence and role of mechanical decoupling along major faults, which plays an important role in the distribution of the regional and local velocity and stress patterns. This particular analysis of the behaviour and influence of weak shear zones in Taiwan is carried out by using, for the first time, the distinct-element method. Additional 3-D distinct-element modelling allows better consideration of oblique shearing, such as for the Longitudinal Valley Fault of eastern Taiwan. We conclude that the active velocity field and tectonic stress pattern in southwestern Taiwan strongly depend on: (1) the presence and shape of the Peikang High; (2) the presence of the major active regional discontinuities (the Longitudinal Valley Fault and the major thrusts of western Taiwan); and (3) the neighbouring weakness zone of the accretionary prism of the northern Manila subduction zone, and cannot be explained by any of these factors taken solely.

Keywords: numerical models; global positioning system; deformation; Taiwan

1. Introduction

The Taiwan mountain belt is an active curved collision belt and thrust wedge which developed as the result of the late Cenozoic oblique convergence between the Philippine Sea plate and the Eurasian plate (Suppe, 1984; Barrier, 1985; Angelier, 1986; Ho, 1986; Tsai, 1986; Teng, 1990; Lu and Hsü, 1992). This collision zone connects the south-vergent Ryukyu subduction zone, where the Philippine Sea plate is subducting beneath the Eurasian plate, and the west-vergent Manila subduction zone, where the Philippine Sea plate is overriding the crust of the South China Sea (Fig. 1). The fold-and-thrust belt of Taiwan advanced northwestward, while the orogen growth was propagating southwestward along the passive continent margin of the Eurasian plate (Suppe, 1984).

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