從大地測量看台灣西南部衝頂背斜發育導致的快速變形率

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摘要

本研究在 2002 至 2010 年間採用了 106 個 GPS 移動站的觀測和 310 個基準點的精密水準測量來了解當今泥岩地區的地殼變形，並估計台灣西南部小岡山斷層（HKSF）和旗山斷層（CHNF）的地震發生潛力。旗山斷層以東的水平速度為～66 mm/yr 朝 N270°，並逐漸向西遞減至～15 mm/yr 朝 N259°；小岡山斷層和旗山斷層之間的水平速度梯度約為～15 mm/yr，小岡山斷層以西和旗山斷層以東的沉降速率約為～5-10 mm/yr，在這兩個斷層之間的最大抬升速率為 18 mm/yr。二維斷層運動學的模擬結果難以全面性地滿足變形觀測。加上，與野外泥岩中垂直剪切帶的關係也指示其變形模式可能受到殘留在陸上仍持續在垂直抬升的泥貫入體所控制。由於地質現象和大地垂直速度場的一致性、岩區的弱岩性、以及過去百年內無災害性地震發生，暗示泥岩區的小岡山斷層正發生潛移現象；然而，旗山斷層或與它有關的滑脫面可能仍具有地震發生潛力。

關鍵字: GPS、精密水準測量、二維斷層運動學模型、泥貫入體

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Rapid deformation rates due to development of diapiric anticline in southwestern Taiwan from geodetic observations

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ABSTRACT

We adopted 106 campaign-mode GPS observations and 310 precise leveling measurements between 2002 and 2010 to understand the present-day crustal deformation in mudstone area and to estimate the earthquake potential of the Hsiaokangshan (HKSF) and the Chishan faults (CHNF) in southwest Taiwan. Horizontal velocities east of the CHNF are ~66 mm/yr, 270° and gradually decrease westward to ~15 mm/yr, N259°. A horizontal velocity gradient of ~15 mm/yr is shown between the HKSF and CHNF. Subsidence rates west of the HKSF and east of the CHNF are ~5–10 mm/yr, while the uplift is observed between these two faults in the highest elevation with the maximum rate of ~18 mm/yr. The observed deformation patterns are difficult to be fully modeled by 2D kinematic fault model. Field relationships within the vertical shear zones of the mudstone therefore indicate that the deformation pattern may be also controlled by a relic onshore mud diapir that is still experiencing vertical uplift. Consistency between the geological and geodetic vertical velocities, weak rock strength, and no destructive earthquakes over the last 100 years imply that faults (HKSF) within the mudstone area are creeping. However, the CHNF or the associated décollement may still have earthquake potential.

1. Introduction

The stress accumulated due to the high surface shortening rate measured by geodetic surveys due to the friction on reverse fault planes is proposed to be released by earthquakes in the compressive environment [e.g., Kostrov, 1974; Savage and Simpson, 1997]. In this condition, an anticlinal landform grows due to the formation of thrust-related anticline [e.g., Lacombe et al., 1997, 2004]. However, the anticlinal landform is also the apparent topographic feature of the mud diapir because of ascending of the buried sediments due to buoyancy contrast in materials [Kopf, 2002]. The mud diapir, an upward migrating mass of buoyant, clay-rich sediment but not piercing all of its overburden rock, is usually related to regional compressive stresses, too [Hedberg, 1974; Jenyon, 1986; Magara, 1978; Shih, 1967; Sumner and Westbrook, 2001; Kopf, 2002; Franek et al., 2014]. In other words, the upward migration of mud diapir will reduce the estimated seismic hazard. Therefore how to distinguish the mechanisms of the thrust-related anticline and mud diapir in the high shortening region is an important issue to evaluate the earthquake potential.

Southwest Taiwan (the Kaoping region) (inset of Fig. 1a) contains the second largest city in Taiwan, Kaohsiung metropolitan area, at the western Kaoping region with more than 2.7 million people and two national freeways and one high speed railroad pass through this area (Fig. 1a). This region is an excellent experimental field to answer the foresaid question because of the high contraction rate of ~1.0 μstrain/yr and right-lateral shearing inferred from previous sparse GPS horizontal velocities [Bos et al., 2003; Chang et al., 2003; Ching et al., 2007b, 2011b; Hsu et al., 2009], suggesting that there is a potential for a large seismic event. However, the historical earthquake records indicate that no significant earthquakes have occurred within the last century [Cheng and Yeh, 1989]. Therefore does it mean a large earthquake being coming in SW Taiwan in the near future because seldom earthquakes occurred in this area, such that the *M* 8.8 Maule earthquake occurs at a seismic gap in a subduction zone [e.g., Moreno et al., 2010]?

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