Geophys. J. Int. (2009) **179,** 678–686 doi: 10.1111/j.1365-246X.2009.04307.x

The 2005 Ilan earthquake doublet and seismic crisis in northeastern Taiwan: evidence for dyke intrusion associated with on-land propagation of the Okinawa Trough

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Accepted 2009 June 23. Received 2009 June 17; in original form 2008 December 30

SUMMARY

Northern Taiwan underwent mountain building in the early stage of the Taiwan orogeny but is currently subjected to post-collisional crustal extension. It may be related to gravitational collapse or to the rifting of the Okinawa Trough, which lies offshore northeastern Taiwan. The Ilan Plain, northeastern Taiwan, which is bounded by the normal fault systems and filled up with thick Pliocene–Pleistocene sedimentary sequences, formed under such an extension environment. Over there on 2005 March 5 two earthquakes with about the same magnitude ($M_L = 5.9$) occurred within 68 s and produced intense aftershocks activity according to the records of Central Weather Bureau Seismic Network of Taiwan. We relocated the earthquake sequence by the three-dimension earthquake location algorithm with the newly published 3-D *Vp* and *Vp*/*Vs* velocity model, and determined the first-polarity focal mechanisms of the earthquake doublet. One major cluster of aftershocks which trends E–W and dips steeply to the south can be identified and picked up as a potential fault plane. The focal mechanisms of the two main shocks are both classified as normal type by first-polarity but strike-slip by centroid moment tensor inversion; however two methods both yield consistent E–W strike. Static coseismic deformation was additionally determined from Global Positioning System (GPS) daily solutions at a set of continuous GPS stations and from strong-motion seismographs. These data show NW–SE extension at high angle to the fault plane, which cannot be explained from a simple strike-slip double-couple mechanism. On the other hand, the small vertical displacements and steep fault plane cannot be explained from a simple normal event as well. We present from elastic dislocation modelling that the geodetic data are best explained by significant component of tensile source with centimetre-scale of opening on a 15-km-long fault extending from 1 to 13 km depth. We therefore interpret the crisis as the result of dyke intrusion at the very tip of the Okinawa Trough, which is reasonably driven by backarc spreading.

Key words: Seismicity and tectonics; Backarc basin processes; Dynamics: seismotectonics; Neotectonics; Kinematics of crustal and mantle deformation; Crustal structure.

1 INTRODUCTION

Taiwan is located at an active plate boundary where an arc-continent collision has been acting between the Eurasian Plate and the northward subducting Philippine Sea Plate since late Miocene (Ho 1986, 1988; Teng 1990; Yu *et al.* 1997, Fig. 1a). On the basis of the orogenic evolution of the southward-migrating collision, the northern Taiwan has undergone the mountain building in the early stage, but is subjected to post-collision crustal extension since the Pleistocene (Suppe 1984; Lee & Wang 1988; Teng 1996). To the east of the northeastern Taiwan the NE–SW trending Okinawa Trough behind the Ryukyu Arc is an actively rifting backarc basin, which is believed being accelerated by the southward migration of the collision in Taiwan. According to the topography, westernmost tip of the trough has pierced into northeastern Taiwan (Suppe 1984; Letouzey & Kimura 1986; Yeh *et al.* 1989; Liu 1995; Sibuet *et al.* 1998, Fig. 1b). The Quaternary volcanism in the northern Taiwan may also triggered by such a recent tectonic evolution