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Subducting oceanic high causes compressional faulting in southernmost Ryukyu forearc as revealed by hypocentral determinations of earthquakes and reflection/refraction seismic data

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Abstract

Absolute earthquake hypocenter locations have been determined in the area offshore eastern Taiwan, at the Southernmost Ryukyu subduction zone. Location process is run within a 3D velocity model by combining the Taiwanese and neighboring Japanese networks and using the 3D MAXI technique. The study focuses on the most active seismic cluster in the Taiwan region that occurs in the forearc domain offshore eastern Taiwan. Earthquakes distribute mainly along 2 active planes. The first one aligns along the subduction interface and the second one, shallower affects the overriding margin. Focal mechanisms within the shallow group indicate that nodal planes are either compatible with high-angle back-thrusts or low-angle thrusts. The active seismic deformation exclusively indicates reverse faulting revealing that the forearc basement undergoes trench-perpendicular strong compression. By integrating the seismological image into the regional context, we favor the hypothesis in which the dense seismicity occurring offshore marks the activity of *en-échelon* high-angle reverse faults accommodating the uplift of a broken piece of Ryukyu Arc basement, called Hoping Basement Rise. The uplift is inferred to be caused by the subduction of an oceanic relief, either exotic block, seamount or oceanic crust sliver. Our favored solution satisfies the narrowness of epicenter's cluster along the Hoping Canyon, and the observation of high-angle active faults on seismic lines crossing the area. Furthermore, this solution is compatible with the active uplift of the Hoping Rise demonstrated from morphological and sedimentological data. We do not exclude the branching of the high-angle reverse faults system onto a splay fault connected with the subduction interface but further investigations are needed to map precisely the 3D distribution of active faults that break the margin.

Keywords: Splay fault; Ryukyu subduction; Taiwan; Earthquake location

1. Introduction

Great earthquakes mostly generate on plate interface of subduction zones. Near Taiwan, the southernmost Ryukyu subduction zone exhibits, in the Ryukyu forearc domain, the densest seismic activity of the whole area. This area, located at a few tens of kilometers from Taiwanese and Japanese coasts, has generated historical earthquakes as the June 5th 1920, magnitude-8 event (Wang and Kuo, 1995) or more recently the Mw 7.1 earthquake, on February 31st 2002 (Fig. 1 and Table 1). In this offshore area, hypocentral determinations based on local seismological observation are usually poorly resolved. Consequently, the subduction thrust fault zone – the most destructive earthquakes and tsunamis generator – is badly imaged and seismic hazard inefficiently evaluated.

This paper reviews independent studies carried on the Nanao forearc region with the purpose of better understanding the high concentration of seismicity occurring there (Fig. 1C). We first present the morphological and tectonic structure of the southernmost Ryukyu forearc essentially based on marine reflection and refraction seismic data. In this framework, we then describe the hypocentral distribution of a refine earthquake dataset whose location has been reprocessed using appropriate heterogeneous velocity model (Font et al., 2003) and 3D location technique. We will briefly summarize the technique used to

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obtain the refine data set. More detail on the MAXI technique can be found in Font et al. (2004). Finally, this study reveals the geometry of active faults that present a potential seismogenic risk for neighboring coastal cities.

2. Geodynamic background

Taiwan is located at the boundary between the Philippine Sea plate (PSP) and the continental margin of the Eurasian plate (Fig. 1A). Near Taiwan, the PSP converges toward the Eurasian plate at a rate of 8–9 cm/year along N306°–N312° (Yu et al., 1997). North-East of Taiwan, the PSP subducts beneath the rifted Eurasian plate margin (i.e. the Ryukyu Arc located south of the opening South Okinawa Trough) along the Ryukyu Trench (Fig. 1B,C). East of Taiwan, the deformed Eurasian continental margin collides against the Luzon volcanic arc, originated from the Manila east-dipping subduction system (southwest of Taiwan). The Taiwan orogen is often regarded as the result of this active collision (e.g. Suppe, 1981; Ho, 1986).

Due to the Okinawa Trough extension (Sibuet et al., 1995, 1998), the westernmost Ryukyu Arc segment is presently moving southward, 1.4 cm/year faster than NE Taiwan (Fig. 1;

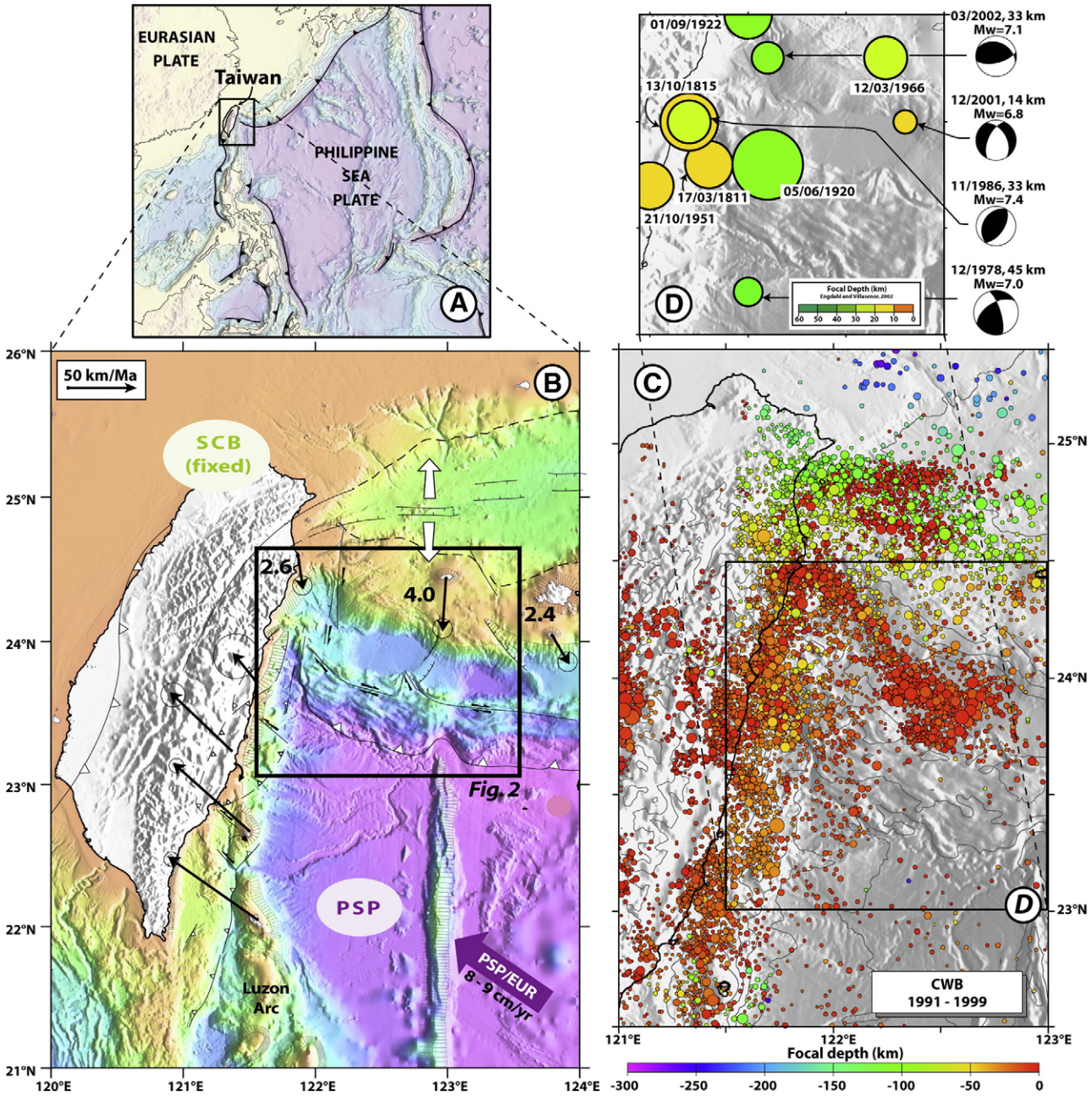

Fig. 1. A. Plate boundaries around Taiwan. B. Geodynamic context of Taiwan (modified after Lallemand and Liu, 1998). C. Seismicity map from 1991 to 1999 (hypocenter catalog from Central Weather Bureau). D. Instrumental seismicity of magnitude earthquake bigger than 7 (from Engdahl and Villasenor, 2002) and studied focal mechanism (see also Table 1).