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Crustal structure of the southernmost Ryukyu subduction zone: OBS, MCS and gravity modelling

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SUMMARY

In 1995, a combined ocean-bottom-seismometric (OBS) and multichannel seismic (MCS) survey with strong air-gun shots was carried out in the southernmost Ryukyu subduction zone. A crustal velocity structure constructed from the layer-stripping Monte Carlo inversion of three OBS/MCS profiles and the associated density models inverted from gravity data in the SW end of the Ryukyu arc-trench system are presented. Parallel to the arc in the southernmost Ryukyu subduction system, the OBS/MCS profiles show sedimentary layers of the Hoping, Nanao and East-Nanao forearc basins from west to east, warping of the arc basement and buckling of the subducted slab beneath the Hoping basement rise. The arc-parallel variation of the crustal structure may result from increasing lateral compression westward due to oblique subduction of the Philippine Sea plate and collision with the Luzon arc near the northwestern edge of the forearc region. Northward subduction and arc-parallel compression of the slab also have generated thrust faulting along the subduction interface and strike-slip faulting within the subducted slab, respectively. On 2002 March 31, an earthquake with a moment magnitude of 6.84 was induced by buckling of the subducted slab and strongly affected cities within an epicentral distance of 100 km. The velocity-interface models, the density models and the focal mechanisms presented in this paper therefore suggest that earthquakes induced by slab buckling or arc-parallel compression have been stronger but less frequent than those generated by northward subduction in the Ryukyu seismogenic zone off Taiwan.

Key words: forearc system, Monte Carlo inversion, seismicity, subduction, travel-time inversion.

INTRODUCTION

Investigation of crustal structure in subduction zones is important to understand the correlation between seismogenic structure and seismicity and to evaluate the earthquake hazard for nearby areas. For example, the tsunamigenic potential is high in a subduction zone with a small accretionary prism and thin layers of subducted sediment (Polet & Kanamori 2000), while the activity of shallow earthquakes in a subduction zone depends on the thickness of the overriding plate, the subduction angle and the temperature at the forearc. Hyndman *et al.* (1997) proposed the up-dip and down-dip limits of seismogenic structures to be, respectively, the thrust contact with the overriding crust at 100–150°C and that with the forearc Moho at 350°C isotherms along the subduction interface. In general, the area shallower than the up-dip limit is the stable sliding friction regime of unconsolidated sediments, while a zone beyond the down-dip limit may consist of compacted and dehydrated sediments (Polet & Kanamori 2000). Through investigation of the seismicity and crustal structures in subduction zones, the up-dip limit of a seismogenic zone has been correlated with the deepest base of the accretionary prism (Kodaira *et al.* 2000; Tsuru *et al.* 2000).

Although the hypocentre distribution, focal mechanisms and seismic tomography have been widely used to delineate seismogenic structures, their resolution, accuracy and structural constraints are limited. These limitations are more serious for imaging crustal structures offshore, where seismic stations are sparse. On the other hand, with precise station relocation, an ocean bottom seismometric (OBS) can be deployed almost everywhere in an ocean and can receive both earthquake and control-sourced signals. Many OBS surveys have been conducted for imaging subduction systems in the circum-Pacific belt since the seismicity in this region represents more than 68 per cent of that in the global subduction zones according to the Council of the National Seismic System (CNSS).

In this paper, we first introduce the tectonic setting and seismicity in the Ryukyu subduction zone (Fig. 1), then analyze velocity models imaged by OBS surveys in the southernmost Ryukyu arc (the inset in Fig. 1), and finally present OBS velocity models and their correlation with the seismicity in the southernmost Ryukyu subduction zone. OBS imaging of the overlying and subducted plates, the subduction boundary, the subduction angle and the arc-parallel variation of the crustal structure presented in this paper enable us to determine both the dip limit and the lateral extent of the southernmost