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Three-dimensional P- and S-wave velocity structure models and seismicity associated with arc-continent collision in Taiwan

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The Taiwan Island is located in the site of ongoing arc-continent collision zone between the Philippine Sea Plate (PSP) and the Eurasian Plate (EUP). Around the Taiwan Island, there are two active subduction systems, the subducting PSP beneath the EUP along the Ryukyu trench in northeastern Taiwan and the subducting EUP beneath the PSP along the Manila trench in southern Taiwan. The active and young tectonics and the associated high seismicity in Taiwan provide us with a unique natural laboratory to explore and understand the processes in the region related to the arc-continent collision. Numerous geophysical and geological studies are conducted in and around Taiwan to develop various models to explain the tectonic processes in the Taiwan region. However, their details have been known enough especially under the Central Range. In this study, we determined representative 3-D seismic velocity models for the crust and upper mantle by tomographic inversion and relocated seismicity beneath Taiwan. And the tectonic process, especially under the Central Range, inferred from these tomographic images.

In Taiwan, the Central Weather Bureau (CWB) operates an island-wide routine seismic network. However in the mountain area, there are fewer stations and interstation spacing is sparse. To know the details of seismic structure including seismicity, three temporary seismic networks were conducted in central and southern Taiwan; a temporary aftershock observation after 1999 Chi-Chi Taiwan earthquake, an array observation across central Taiwan in 2001, and new array observation across southern Taiwan in 2005. The earthquake data in this study are selected from reported CWB catalog for each term of temporary seismic observations.

The method used both for seismic tomography and relocation work in this study is the double-difference tomography method [Zhang and Thurber, 2003]. The initial hypocenters are the same as hypocenters reported by CWB. ALL selected earthquakes were relocated with the 3-D seismic structure in this study.

Most remarkable feature in the results of seismic tomography is the lateral repeated variation of P-wave high- and low-velocity. This alternate P-wave high- and low-velocity bodies repeats at least three times from west to east. All of imaged structures both high- and low-velocity bodies have trends of eastward dipping. The westernmost body is a high-velocity one from the western side of Taiwan to the mountain range, while easternmost one is low-velocity one under eastern part of Taiwan. And relocated seismicity under the mountain range concentrated and limited along the parts of the bottoms of high-velocity bodies.

This lateral alternation of high-velocity body and low-velocity body probably could not resolve in past studies because of sparse station distribution. Our study have reliable high-resolution to be able to discuss this alternate structure model because of dense array of temporary network. The easternmost block with low velocity in imaged models can be interpreted as a part of thrust sheets of upper/mid crustal Eurasian continental margin material interpreted in McIntosh et al. [2005]. We can divide these anomalous velocity bodies beneath Taiwan into three blocks, which were consists of high velocity body under low velocity body. We suggest new orogenic model in Taiwan by tomographic results separated into three upper continental crust bocks, named Upper Crustal Stacking Model. This Upper Crustal Stacking Model mainly made parts of upper crust detached from EUP, which were stacked, exhumated, and compressed, between the Northern Luzon Arc and westernmost EUP. In this model, a collision-related shortening length between the EUP and the Luzon arc is 120 km. If the collision in study area was started at 2.5 Ma, its shortening rate was about 5 cm/yr. This rate is consistent with velocity field estimated from GPS observation [Yu et al., 1997].