A study of Taiwan region velocity structures, focal mechanisms, and earthquakes relocation

Abstract

A large collection of 41,141 S-P times from the untapped records of the Taiwan Strong Motion Instrumentation Program (TSMIP) network is combined with the P- and S-wave arrival times from the Taiwan Central Weather Bureau Seismic Network (CWBSN) to image the Vp and Vp/Vs structures beneath Taiwan. The records from the 680 TSMIP stations throughout Taiwan in the past 15 years enhance the path coverage and the resolution in the tomography inversions tremendously. Our result for the Vp structure largely confirms previous studies, but brings better constraint on the Vp/Vs structure. The colliding Luzon volcanic arc is characterized by a belt of high Vp and high Vp/Vs with high seismicity that includes the offshore islands of Lutao and Lanyu, and the Coastal Ranges in eastern Taiwan, at the depth between about 13 and 25 km. This high Vp/Vs belt can be traced to the subduction zone in the region between Hualian and Ilan in the deeper portion. The shallow portions of the southwestern coastal plain and the Pingtung region are also characterized by a belt of high Vp/Vs with lower seismicity. Most of the events occurred at the base of the high Vp/Vs zones. We suggest that material strength in those regions may be too low to accumulate stress, which may indicate water-saturated young sediments. Finally, the Central Range region is characterized by a low Vp/Vs belt.

We determined the focal mechanism solutions for earthquakes with magnitude $M_L \geq 4.0$ occurred in the Taiwan region between 1991 and 2005. First-motion polarities of P waves recorded at over 700 seismic stations in Taiwan were used. Because of the large number of events and stations involved, we implemented the genetic algorithm in a non-linear global search for the focal mechanism solutions. The algorithm was tuned and validated through synthetic tests. We finally determined the focal mechanisms of 1,635 events with good qualities among 4188 earthquakes. Focal mechanism solutions for a majority of the earthquakes display a dominant pattern of thrust-fault type reflecting the compressive stress field due to the plate collision. Normal-fault events are occurred at intermediate depths in subduction zones, which is likely resulted from the bending of the subducting slabs. Strike-slip faults are also found within the Eurasia Plate around the Peikang Basement High and in collision zones near Ilan where the geometry of the colliding plates is complex. Our study provides a database of focal mechanisms for studying seismogenic structures and plate tectonics. This database can also be used by structural seismologists to compute synthetics for waveform tomography studies.

We have carried out a comprehensive relocation of a total of 267,210 earthquakes in Taiwan occurred during the past 15 years. We based our relocation process on the earthquake catalog of the CWBSN and made improvements in three aspects. First, we incorporated a large dataset of the S-P times from 680 TSMIP stations distributed throughout the island of Taiwan to improve the coverage to earthquakes on the Taiwan island. Secondly, we added 18 Japan Meteorological Agency (JMA) stations in the southern Ryukyu Island chain to enhance the station coverage for eastern offshore events, especially around the subduction zone northeast of Taiwan. Thirdly, we adopted the three-dimensional Vp and Vp/Vs models in predicting the travel times of P and S waves. The effectiveness of these improvements in earthquake relocation can be seen in three aspects: the reduction in the residuals of P-wave arrival times and S-P times; a better attenuation relationship between the peak-ground acceleration vs. the epicentral distance; and the geologically meaningful patterns of station corrections to P-wave arrival times and S-P times.