The Waveform Characteristics and Classification of Intermediate-depth Earthquakes in Ryukyu Subduction Zone

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Using intraslab earthquakes shallower than 150 km in the southernmost Ryukyu subduction zone, previous studies in Taiwan found the wave guide effect that typically shows a low-frequency (<2Hz) first P arrival followed by sustained high-frequency (3–10 Hz) wave trains. Recently occurred deeper events at depth 150-300 km allow us to better quantify the properties of those seismic waves traveling in the subduction zone. In this study, we aim to systematically scan through the local broadband waveforms of the intermediate depth earthquakes with M>5 between 1997 and 2016. Event are classified based on the waveform characteristics and their frequency contents.

To detect events with similar properties, we applied sliding-window cross-correlation (SCC) using three components of P waveform data simultaneously for a set of stations. The time window used here was 10 s and traces were bandpass filtered in the frequency range 0.5–10 Hz. After the degree of similarity are calculated, events containing comparable waveforms can be sorted into families. The events within a family would have been triggered because they came from the same source region and their paths to a particular receiver should produce similar waveforms. Our results show that most earthquakes are low in waveform similarity, implying no “repeating” behavior for those intermediate intraslab events. However, some events (cc>0.6 threshold) present enough charterers that can be grouped as a family.

One important property is the frequency content of the arrivals that may be related to the speed of structure traveled. We have developed a work scheme to determine the delayed time of higher-frequency energy. On family of events show beautiful dispersion with arrival time smoothly increasing with frequency between 0.5 and 6 Hz. Another type of dispersive waveforms appear as two distinct arrivals: low frequency and then high-frequency energy, separated by around 1 s. The time delay seems to be independent of focal depth. The latter case has been reported in the previous study for shallower event and it was interpreted as effect from low-velocity layer or heterogeneity of the subducted slab. On the other hand, the continuous dispersion is a new feature observed by our study, which may infer a thinner layer and/or longer propagation for some kind of reflecting waves to develop such interference.

In addition, we will classify the waveforms according to the frequency content and decay of coda. The variations in P coda properties can be associated with the way in which the seismic energy gets ducted into the stochastic waveguide associated with the lithosphere. With sufficient amount
of data, it is possible to further identify the earthquakes with unusual source properties or structure anomaly along specific propagation paths. We expect the classification results can provide a reference for future numerical simulation analysis.

Keywords: Ryukyu subduction zone, SCC, guide wave, waveform classification, intermediate-depth earthquakes