Characteristics of T-wave envelopes observed by S-net

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S-net enables us to access continuous sea-floor network observation data. Different from observed data in the inland area, the strong signal of the T-wave appears following the P- and S-waves in the seismograms recorded by S-net stations. T-wave is the acoustic wave propagating in the ocean. The low-velocity layer called SOFAR channel efficiently delivers the T-wave to distant stations. Owing to this property, T-wave has been used to monitor nuclear tests and activities of submarine volcanoes [Okal, 2008]. The pulse width and the amplitude of the T-wave can be used as a proxy to distinguish the explosion source and the natural earthquake [Talandier & Okal, 2001]. The rise time of the T-wave and the amplitude ratio of the T-wave and the body wave is related to the focal depth [Yang & Forsyth, 2003; Dziak et al., 2005; Wech et al., 2018]. These features were derived from observations of the T-wave at distant stations. On the other hand, we now become able to investigate the detailed process of the conversion between seismic waves and T wave because we can analyze the T-wave generated by local earthquakes by using the S-net. In this study, we summarize the characteristics of envelopes of T-waves recorded by S-net stations.

We calculate envelopes of T-waves by summing squared three components velocity seismograms band-passed in the frequency range of 8-16 Hz. The duration of the envelope is characterized by $\tau_{1/3}$ or T_{rms} which do not depend on the onset, because the onset of the T-wave is gradual and sometimes buried in the S-wave coda. $\tau_{1/3}$ is the duration during which the amplitude is higher than the one-third of the peak. T_{rms} corresponds to the standard deviation of the envelope. The strength of the T-wave is defined by the TPEF (T-phase energy flux) [Okal et al., 2003].

The propagation velocity is about 1.5 km/s in general, but it is sometimes higher in deeper stations. The onset is not clear and the amplitude gradually increases to the peak. Different from the envelope of the seismic wave which shows the long coda compared to the rise time, the time scales of the increase and the decrease of the T-wave are almost the same. This indicates that the generation process is more dominant than the scattering effect in the propagation process. However, the scattering effect also exists, because the T_{rms} increases with the propagation distance. This result is different from the observation in the relatively flat bathymetry area [Yang & Forsyth, 2003]. $\tau_{1/3}$ in the shallow station is smaller than that in the deeper station, although it shows a large variation. Regarding the energy of the T-wave, TPEF is larger in the deeper stations. This is because the T-wave is reflected by the up-slope of the ocean trench and enough energy can’t reach the shallower stations. T-waves generated by the earthquakes near the triple junction mainly propagates along the trench. The TPEF shows a power-law decay with distance. The power law exponent varies from -1 to -6 depending on the source location. Outer rise earthquakes generate strong T-wave compared to inter- and intra-plate earthquakes. This is because the T-waves converted at the down-slope of the trench enter the SOFAR channel with lower incident angles and are efficiently trapped. The conversion point for the case of the intra-plate earthquake whose focal depth is about 100 km is located around the trench. The seismic wave traveling along the slab is converted to the acoustic wave at the trench. This conversion shows strong directivity.

As we mentioned above, T-wave recorded by the S-net stations is strongly affected by the bathymetry and the Earth structure. The modeling of the T-wave by considering both the elastic and the seawater media is necessary to correctly model the T-wave envelopes. By modeling the characteristics observed in this study, we can understand the details of the conversion process between the elastic and acoustic waves.

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