

Similarity of the regional PL waves in the crustal waveguide and the teleseismic W-phase in the upper-mantle waveguide

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We examine the development and propagation of the moderately long-period ($T=5-10$ s) PL wave at near-regional distances ($D=150-1,500$ km) using observations and numerical simulations of the 2004 Mid Niigata earthquake, Japan, ($M_w=6.6$; $h=8$ km). Dense observations from the K-NET and KiK-net strong motion networks show that the normally dispersed long-period PL wavetrain begins to develop at distances less than 100 km, and builds with wide-angle PmP reflections. Near the source near-field contributions from the source are important, but at larger distances the longer-period PL wave is gradually built up from constructive interferences of wide-angle PmP reflections in the crustal waveguide. Attenuation of PL wave occurs by conversion to SV waves at the free surface that then leak into the mantle. Nonetheless, PL can travel rather long distances (>500 km) across Japanese Islands. When low-velocity sediment occurs in the near-surface, the amplitude of the PL wave is strengthened, since enhanced PmP reflections and SmP reflections supply energy to the crustal waveguide, while P-to-SV conversion at free surface is reduced.

Similar PL-type waves propagation processes can occur in the waveguide formed by the entire upper-mantle in a much longer period band (100-1,000s period). This signal observed at teleseismic distances (1,000 –10,000 km) is well recognized as the “W-phase” (Kanamori, 1983). We demonstrated by observations and numerical simulations of the wave propagation for the 2011 Off Tohoku earthquake, Japan ($M_w=9.0$; $h=20$ km) that the W-phase is produced by multiple PP-type reflections from the upper-mantle, reinforced by the Earth’s sphericity. Thus, the propagation of the PL wave and the much longer-period W-phase have common features at different space and time scales; The PL wave travels in the crustal waveguide and the W-phase travels in the waveguide formed by the lower wavespeeds in the upper-mantle. The W-phase has been used extensively for the CMT source inversion for large ($M_w>7.5$) earthquakes, and recently, it is extended to apply for much smaller events. The continuity of behavior between PL and W indicates the possibility of further extension of W-phase style source inversion to much smaller events (i.e., to $M_w < 5-6$) exploiting dense observation networks at regional distances, with the use of regional structural models.

キーワード : PL-wave、 W-phase、 wave propagation

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