



Spectral modulation effect in teleseismic P-waves from DPRK nuclear tests recorded at different azimuths

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Two underground nuclear explosions conducted by North Korea in 2009 and 2013 were recorded by the Israel Seismic Network. Pronounced coherent minima (spectral nulls) at 1.2-1.3 Hz were revealed in the spectra of teleseismic P-waves. For a ground-truth explosion with a shallow source depth (relatively to an earthquake), this phenomenon can be interpreted in terms of the interference between the down-going P-wave and the pP phase reflected from the Earth's surface. A similar effect was observed at ISN stations for the Pakistan nuclear explosion at a different frequency 1.7 Hz indicating a source and not site-effect.

Similar spectral minima with about the same frequency were observed in teleseismic P-waves of all three North Korea explosions (including the 2006 test) recorded at network stations and arrays in Kazakhstan (KURK), Norway (NORESS, ARCESS), Australia (Alice Springs, Warramunga) and Canada (Yellowknife), covering a broad azimuthal range. Data of the 2013 test at Warramunga array showed harmonic spectral modulation with several minima, evidencing a clear interference effect. These observations support the above-mentioned interpretation.

Based on the null frequency dependency on the near-surface acoustic velocity and the source depth, the depth of the North Korea tests was estimated as ~ 2 km (different from the value ~ 1 km reported by USGS for the third test). This unusual depth estimation needs an additional validation based on more stations and verification by other methods.