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Regional and teleseismic shear-wave radiation feature of underground nuclear explosions and its implications for shear-wave excitation mechanisms

T.-K. Hong

Yonsei University, Department of Earth System Sciences, Seoul, Republic Of Korea (tkhong@yonsei.ac.kr, 82-2-2123-8169)

Understanding the shear-wave excitation mechanism is a key issue for effective seismic monitoring of underground nuclear explosions (UNEs). We often observe strong shear waves from UNEs, which causes difficulty in prompt discrimination of nuclear explosions from natural earthquakes. Various mechanisms have been proposed to explain the shear-wave excitation from the UNEs. Consensus on dominant mechanism of shear-wave excitation has not been made. To constrain the shear-wave excitation mechanism, we examine the consistency in shear-wave radiation pattern using a source-array slowness-wavenumber (F-K) analysis, which allows us to check the time-invariant feature in the shear waves. We examine regional and teleseismic waveforms for the UNEs of the Balapan test site and Nevada test site along with the Indian and North Korean UNEs. We observe consistent radiation pattern in both regional and teleseismic shear waves. The observed radiation pattern suggests that the shear waves were not excited azimuthally-isotropic. Shear waves observed in teleseismic distances are far weak compared to those in regional distances, which implies that shear waves are excited stronger at high takeoff angles. Also, spectra of shear waves display significantly low overshoot feature that is different from those of P phases. The time-invariant anisotropic radiation pattern, strong excitation in high takeoff angle and low overshoot feature allow us to constrain the shear-wave excitation mechanism.