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Estimating depth and source characterization of the North Korean Nuclear Tests (2006, 2009 and 2013) including the 2016 nuclear test using local and teleseismic networks

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Abstract

North Korea conducted underground nuclear explosions on October 9, 2006 (M 4.3), May 25, 2009 (M 4.7) and February 12, 2013 (M 5.1). We elicited to estimate source depths for the North Korean nuclear tests selecting pronounced coherent spectral nulls using pP+P, pPn + Pn and sPn+Pn including Rayleigh wave spectra for the 2006, 2009 and 2013 nuclear tests. The burial depths of the 2006, 2009 and 2013 nuclear tests were estimated at 2.21, 2.10 and 2.10 km respectively. It was also found that the mechanism of the 2006 test generated roughly a reverse faulting accompanying mostly Rayleigh waves, whereas the 2009 and 2013 tests were an oblique-reverse faulting generating SH and Love waves as well as Rayleigh waves. The generation of SH and Love waves for the 2009 and 2013 nuclear tests was attributed to not only release of tectonic stress but also other factors such as relaxation of cavity fractures, source configuration and source mechanism. We infer that the 2009 and 2013 tests must have well contained nuclear debris through long winding drifts not to have released radioisotopes to the atmosphere.

North Korea conducted its fourth underground nuclear test on 6 January 2016 (M 5.1). However it has been difficult to state the accurate source depth of the North Korean nuclear explosions. Here we show the source depth for the 2016 nuclear test selecting the average coherent spectral nulls from the spectra of pP+P, pPn+Pn and sPn+Pn using global seismic arrays as well as the local seismic array of Korea Seismological Research Station (KSRS). Minimizing the raypath effects and maximizing a signal-to-noise ratio from stacking and superposing every channel in the array, we estimated the burial depth of the 2016 nuclear test at 2.08 km. We anticipate our findings to be useful in study of the North Korean nuclear explosions.

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