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MOMENT TENSOR INVERSION OF THE NORTH KOREAN EXPLOSION ON FEBRUARY 12, 2013

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On February 12, 2013, North Korea conducted an underground nuclear test in the north-eastern mountainous granite rock of the country. The test was located by USGS at 41.308 N and 129.096 E and its yield was estimated to be 12 kt. The Lg magnitude mb(Lg) was 4.9 (5.1 USGS), the explosion being stronger than that in 2009 with mb(Lg) of 4.5 (4.5 USGS) or in 2006 with mb(Lg) of 3.9 (4.2 USGS). Since the radiated seismic waves were recorded at most of stations over the world, the explosion became one of the best ever recorded nuclear explosions in history, suitable to be exploited in various structural and source studies. Here we focus on determining the seismic moment tensor and the source-time function in order to study detailed physical and tectonic conditions at the source and to verify an explosive character of the source.

The highest quality recordings of the explosion are provided by stations of the neighboring countries with epicentral distance less than 1500 km: stations of the New China Digital Seismic Network, Japanese NIED Hi-Net and F-Net Seismograph Networks and South Korea National Seismic Network. In the high-frequency records, the Pn and Pg waves dominate, while the Sn and Sg waves are of significantly smaller amplitudes than for earthquakes. Both P and S phases form complex wave groups typical for wavefields excited by shallow sources, being characterized by strong coda waves generated at structural heterogeneities near the Earth's surface.

The explosion generated also surface waves visible well at low-frequency records (Fig. 1). Because of their large wavelength and insensitivity to small-scale heterogeneities their structure is rather simple. The surface waves consist of both Rayleigh and Love waves. The presence of Rayleigh waves in the wavefield is expected but the presence of Love waves is rather curious because theory prevents excitation of Love waves by radially symmetric sources. The amplitude of Love waves is even comparable to that of Rayleigh waves at some stations. The excitation of Love waves has been reported also for other nuclear explosions (Aki and Tsai, 1971; Helle and Rygg, 1984; Wallace et al., 1983; Murphy et al., 2013) and it can be studied by measuring ratio of maximum amplitudes of surface waves at transverse and radial components at stations located at various azimuths to the explosion site. Inverting moment tensor from waveforms and from T/R ratios of surface waves we show that the explosion displays partly non-isotropic radiation which has been reported also for the 2006 and 2009 North Korean nuclear explosions, and we discuss its possible physical origin.

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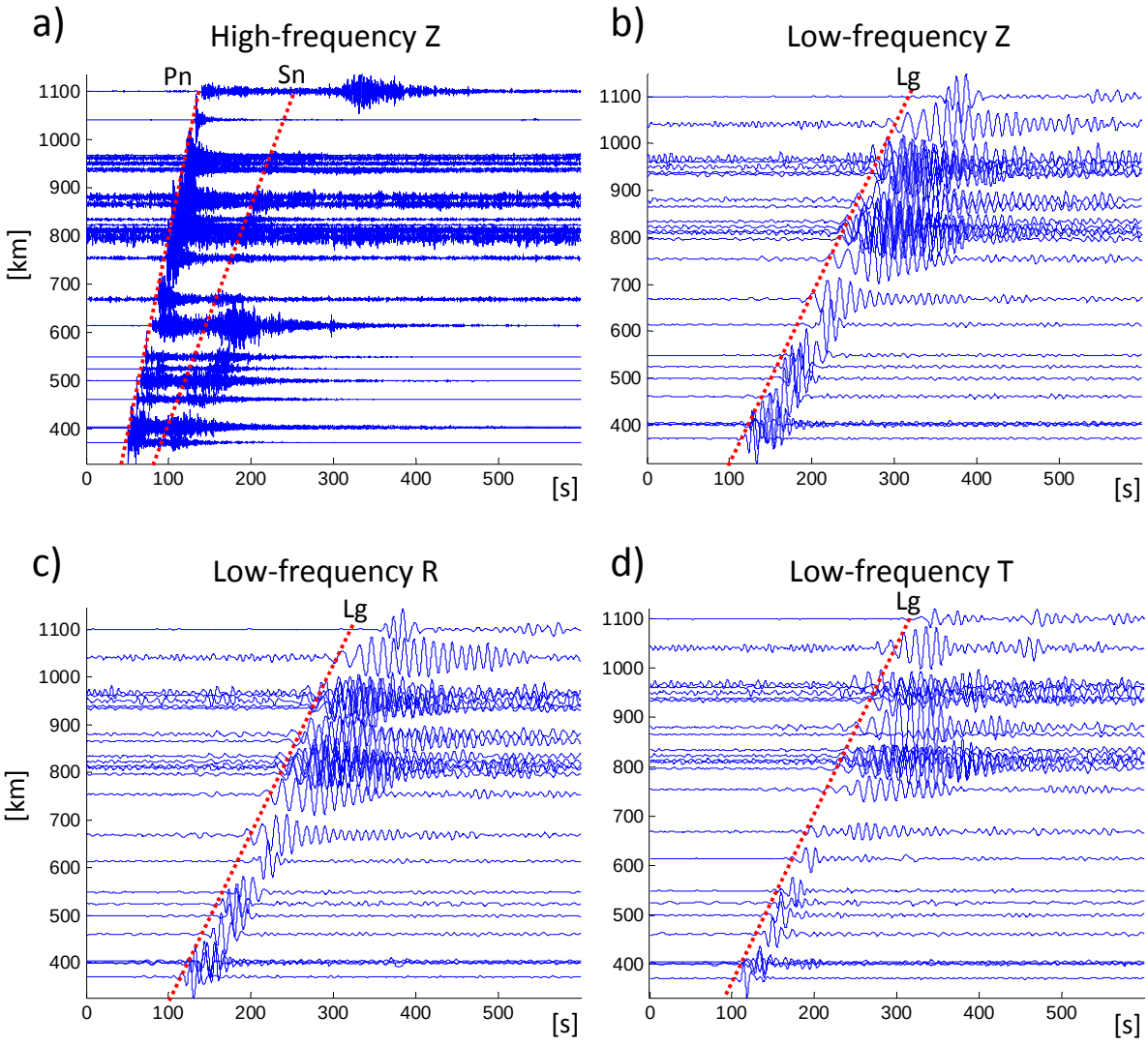

Figure 1. Velocity records at stations with epicentral distance less than 1100 km. High-frequency vertical records are displayed in the frequency band 0.7 Hz – 5.0 Hz (a), low-frequency vertical (b), radial (c) and transverse (d) records are displayed in the frequency band 0.04 Hz – 0.10 Hz. Notice a significant amplitude of surface Love waves at the transverse component (d) which is inconsistent with radiation of a radially symmetric source.