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朝鲜核爆的Rayleigh波震级测量

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Measurement of Rayleigh-wave magnitudes for North Korean nuclear tests

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摘要

利用1995年至2009年中国东北及邻近地区11个宽频带台站记录到的77个地震事件、3个化学爆炸和2次朝鲜核爆的区域地震资料,标定该区域台网的Rayleigh波震级.通过对8~25 s 周期的垂直分量Rayleigh波形进行分析,获取基于最大振幅的面波震级.计算82个区域事件不同周期的台基响应,经过台基校正后取最大振幅的面波震级为事件震级.2006年和2009年两次朝鲜核爆的面波震级分别为2.93±0.19和3.62±0.21.将地震和核爆事件的面波震级M_s与体波震级m_b(Lg)进行比较,发现根据该区域台网的数据利用M_s-m_b识别方法无法鉴别朝鲜地区的核爆与地震.朝鲜核爆的面波震级相对较大,使M_s-m_b识别方法失效,其原因可能是源区介质的不均匀性、由核爆炸冲击引发的深部的拉伸破坏被抑制,或者是近爆源区存在张性的构造预应力.假定核爆可能的埋藏深度范围是0.01~1.0 km,用Rayleigh波震级估计朝鲜核爆的当量,对2006年和2009年核爆当量的估值范围分别为0.42~3.17 kt和2.06~15.53 kt.

关键词 Rayleigh波, 震级, 台基校正, 核爆

Abstract：

We collect regional seismic data recorded at broadband seismic stations from 77 earthquakes, 3 chemical explosions and 2 nuclear explosions between 1995 and 2009 in Northeast China and its vicinity. These data are used to calibrate the regional seismic network for measuring the Rayleigh-wave magnitude. Based on vertical-component Rayleigh wave records between 8 and 25 s, we obtain the maximum-amplitude surface-wave magnitudes. Using records from 82 events, we calculate the site corrections at different period for all stations. After removing the site response, we obtain the Rayleigh-wave magnitude for individual station-event pair. Finally the network average magnitude is obtained for each event. The Rayleigh-wave magnitudes are 2.93±0.19 and 3.62±0.21 for 2006 and 2009 North Korean nuclear explosions. The comparison between the Rayleigh-wave magnitude M_s and the body wave magnitude m_b(Lg) suggests that M_s-m_b method is invalid in discriminating the nuclear explosions from earthquake populations in Northeast China/North Korea region and within the regional distances. The two North Korean nuclear explosions excited strong Rayleigh waves, leading to the poor performance of M_s-m_b discrimination. The possible reasons include near-source heterogeneities, asymmetric source or existing tensile tectonic release. Given the depth of burial between 0.01 and 1.0 km and using the obtained Rayleigh-wave magnitudes, the yields of the 2006 and 2009 North Korean nuclear tests are estimated to be 0.42~3.17 kt and 2.06~15.53 kt, respectively.

Keywords Rayleigh-wave, Magnitude, Site correction, Nuclear explosion

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