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Identification of Small Seismic Events Around the Underground Nuclear Test Site in the Democratic People's Republic of Korea

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Introduction

Since the last underground nuclear test (UNT) in September 2017 at the Punggye-ri test site in the Democratic People's Republic of Korea (DPRK), small seismic events have been detected. Between 2017 and 2025, the Korean Meteorological Administration (KMA) reported 96 events (M_L 2-3.3) (Figure 1). The seismic activity had been uneven in time, and about 1/3 of the reported events occurred in 2023.

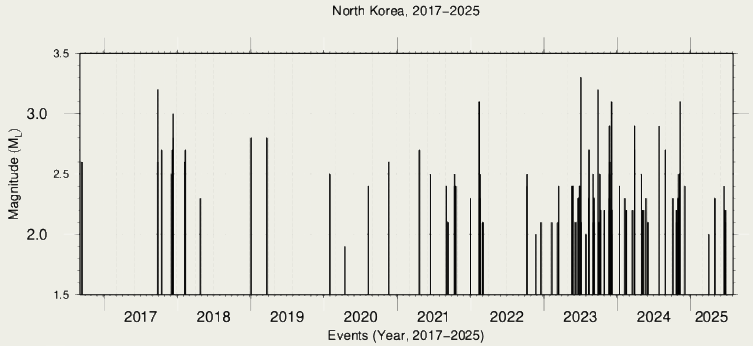


Fig. 1. Temporal distribution of small events around the test site in DPRK.

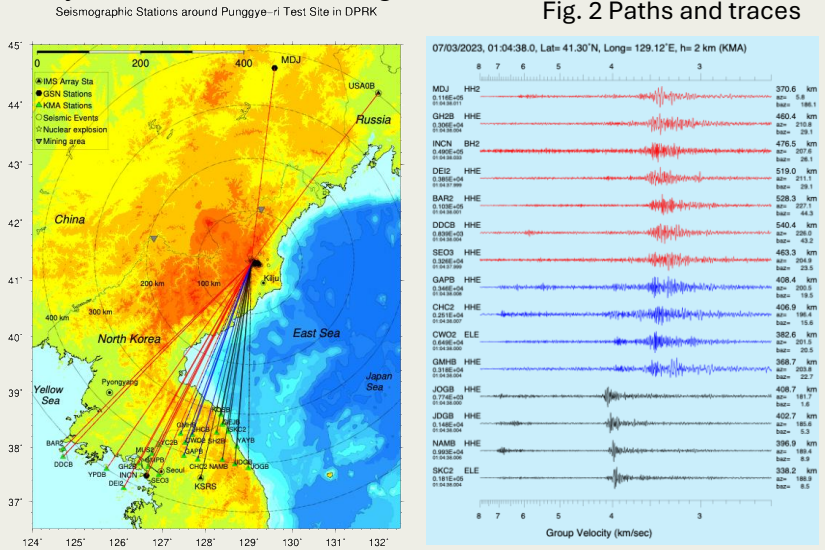
Over 90 reported seismic events are analysed using seismic waveforms recorded at stations at least 300 km from the source region. There are two IMS primary arrays (KSRS and USRK; Fig. 2), two GSN stations (MDJ and INCN), and numerous stations of the KMA network in the southern Korean Peninsula.

Data and Method

For utilizing the regional *Lg* waves, we encounter diverse propagation paths as depicted in Figure 2. The stations in southern Korea with azimuths greater than 210º show Lg waves in a stable crustal structure (red paths and traces), while stations with azimuths between 200º and 210º exhibit a slight deterioration of their properties (blue traces and paths). In contrast, stations in azimuth less than 190º show no clear *Lg* arrivals, mainly due to paths crossing oceanic crust.

The reported events are distributed within a 10 km radius of the test site. Based on the 2018 studies (e.g., Schaff et al, 2018; Dodge, 2018), among others. These events may have occurred in a tighter cluster.

Fig. 2 Paths and traces



Results

Following earlier studies, we relocated these events using the double-difference relocation method, employing regional *Lg* waves, because available data are limited. IMS, GSN, and other regional seismic network stations are at least 300 km away from the source area (see Figure 2).

We relocated these events by measuring precise differential travel times of the *Lg* waves at common stations from closely located event pairs. The cross-correlation technique is used for *Lg* waves in the 0.5–5 Hz passband.

Relocated events are aligned tightly together at a few km east of the previous UNTs in the area. Earlier events in 2017-2018 are analysed by Kim et al. (2018), who suggested that these are likely earthquakes. The focal mechanisms of the two most significant events indicate that a reverse faulting mechanism along a north-northeast striking nodal plane.

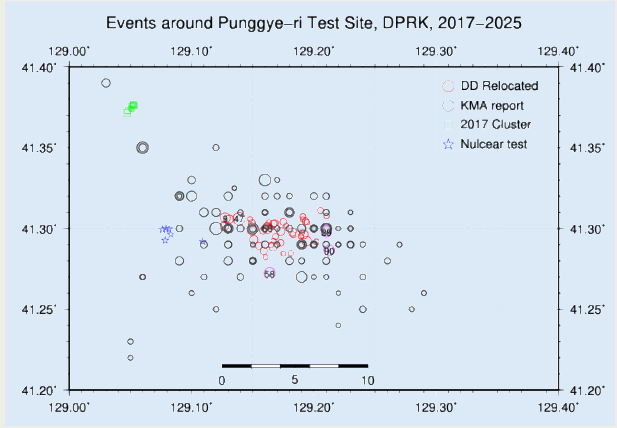


Fig. 3. 96 events reported are plotted by black circles. Red circles are relocated events.

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