The 1952 Near Pyongyang, North Korean Earthquake and it’s Tectonic Implication around the Region

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Historical earthquake

A.D. 2~1904

- Intraplate region with moderate seismicity
- About 2,000 earthquakes during about 2,000 years
- About 50 earthquakes with fatalities and damages
Instrumentally-recorded earthquake

A.D. 1905~2010

- Installation of a modern seismograph in Incheon during 1905
- About 20 earthquakes over magnitude 4.5 in the 20th century
- No significantly large, damaging earthquakes in the instrumental period
The seismic activity in the 16\textsuperscript{th} and 17\textsuperscript{th} centuries was very high.
Seismic Activity since 1978

- Since 1978, seismograph stations are continually increasing.
- Detection capability of micro earthquakes has been improved.
- However, there is no obvious evidence on variation of seismic activity.
I. The 19 March 1952 earthquake near Pyeongyang, North Korea

• Importance
  – Presumably the largest earthquake in the Korean Peninsula since 1905
  – Largely unknown earthquake information due to the Korean War
  – No seismograph station in the Korean Peninsula
  – Highly significant to seismic hazard in the Korean Peninsula

• Estimated magnitude
  – Rustanovich et al. (1963): $M=6.3$
  – Yuche Li (2001): $M=6.5$
  – Ishikawa et al. (2008): $Md=6.5$
II. Collection of data related to the 1952 earthquake

• Searching for global observations of the 1952 earthquake from ISC Bulletin
• Figuring out whether each station has the seismograms of the event or not
• Collecting information on the type of seismograph and paper, and recording parameters during the earthquake
III. Obtainment of analog seismograms and digital conversion

- Obtainment of the analog seismograms of the 1952 earthquake from the eight seismograph stations in the neighborhood countries
  - Japan: Abuyama, Matsushiro, Mizusawa seismograph stations
  - China: Zikawei, Nanking seismograph stations
  - Russia: Vladivostok, Sverdlovsk, Pulkovo seismograph stations
- Digital conversion to extract seismic traces from the images of analog seismograms
Analog-to-digital conversion

- Extraction of seismic traces from the image of analog seismograms: Teseo software (Pintore et al. 2005)
- Difficulties in digitizing the raw seismograms: low resolution, bad continuity of seismic trace
- Successful digitization of the analog seismograms from the Abuyama, Matsushiro, and Sverdlovsk seismograph stations among a total of the eight stations
- Correction of instrumental response and geometry
  - Instrumental responses of the three stations
  - Lack of information on the geometry of instruments: arm length supporting pen of the recording system, angle between pen and paper
  - Hard to correct the recording curvature of the analog seismograms
  - Implicit errors in the analysis of seismic source parameters through waveform modeling
Matsushiro

Waveform diagrams for Matsushiro:

- EW component
- NS component
- UD component

From origin time (March 19, 1952, 09:04:13 UT, ISC Bulletin)
IV. Source parameters of the 1952 earthquake

- Arrival times
  - ISC Bulletin
  - Travel-time report from Japanese seismograph stations
- Determination of epicenter using grid-search method based on travel-time data
- Determination of origin time from Wadati diagram using travel-time data: 1952/03/19-18:04:15 (local time)
V. Waveform Modelling

- Synthetic seismograms: Mineos (Masters et al. 2007)
- Depth: 10 km fixed
- Velocity structure: PREM model
- Lowpass filter < 10 s
- Waveform fitting on one-cycle swing including the largest peak
- Seismic moment
  - $2.45 \times 10^{25}$ dyne-cm ($M_w = 6.17$)
- Fault-plane solutions
  - Strike $120^\circ$, dip $90^\circ$, rake $340^\circ$
  - Strike $210^\circ$, dip $70^\circ$, rake $-180^\circ$
  - NE-SW and NW-SE strike-slip fault

Strike 120 Dip 90 Slip 340
VI. Summary on the source parameters of the 1952 earthquake

- Origin time: 1952/03/19, 18:04:15 (local time)
- Epicenter: 125.84°E, 38.77°N (near Pyeongyang)
- Magnitude: Mw 6.2
- Fault plane solutions (strike, dip, rake)
  - (120°, 90°, 340°)/(210°, 70°, -180°)
  - NE-SW and NW-SE strike-slip fault