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

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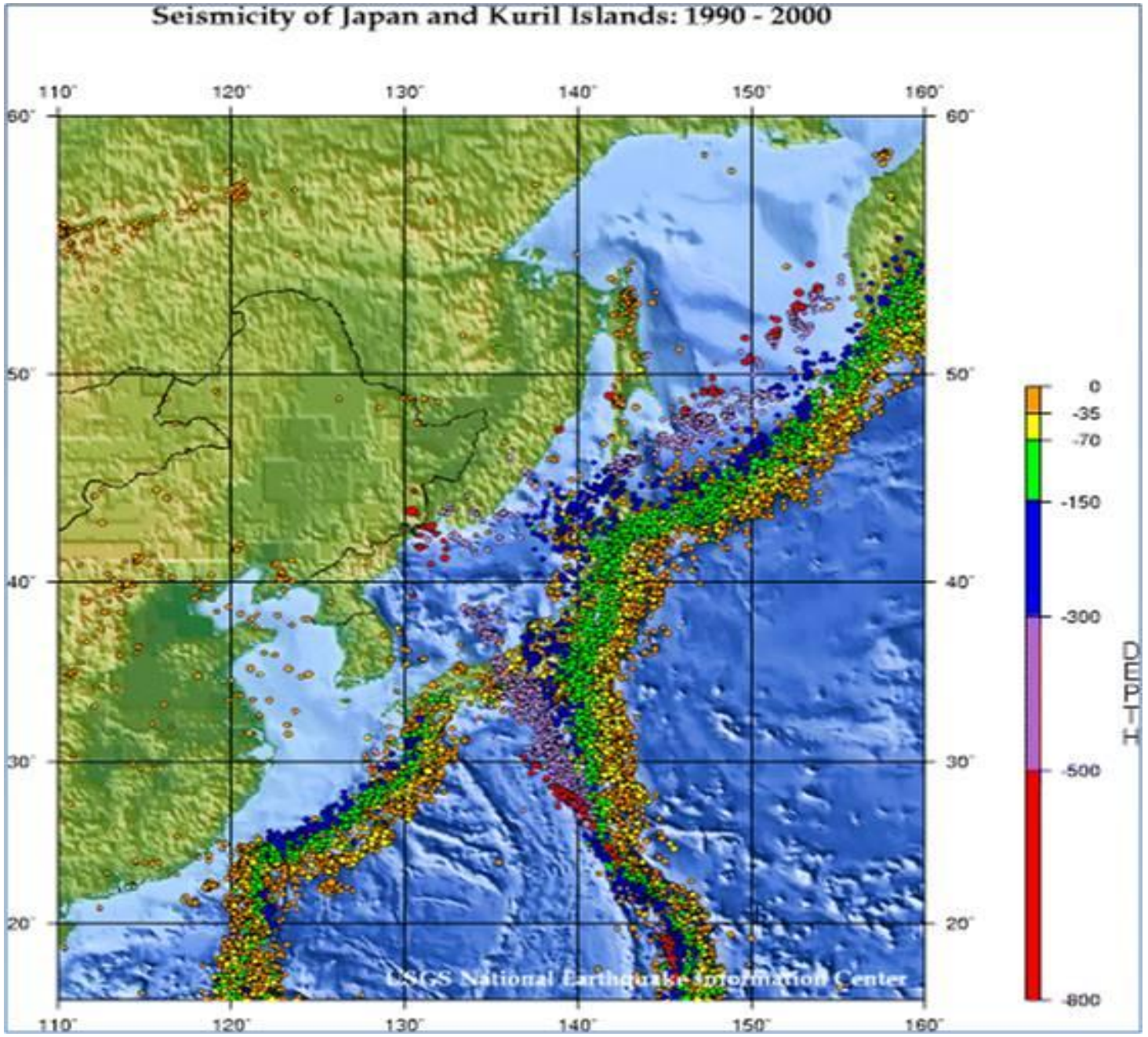
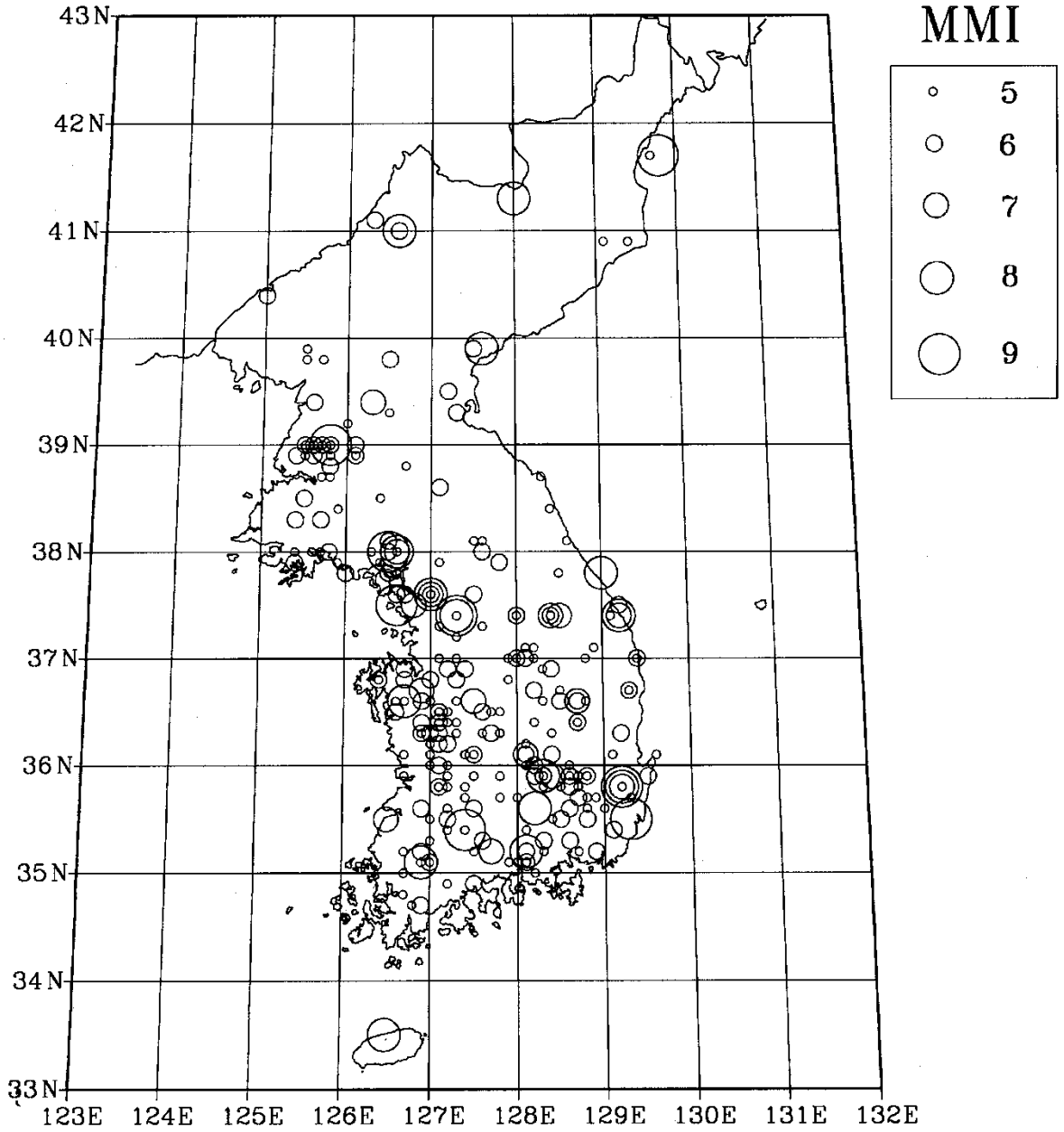

Seismicity of Japan and Kuril Islands: 1990 - 2000
110°
120°
130°
140°
150°
160°
60°
50°
40°
30°
20°
0
-35
-70
-150
-300
-500
-800
DEPTH
USGS National Earthquake Information Center

Historical earthquake

A.D. 2~1904

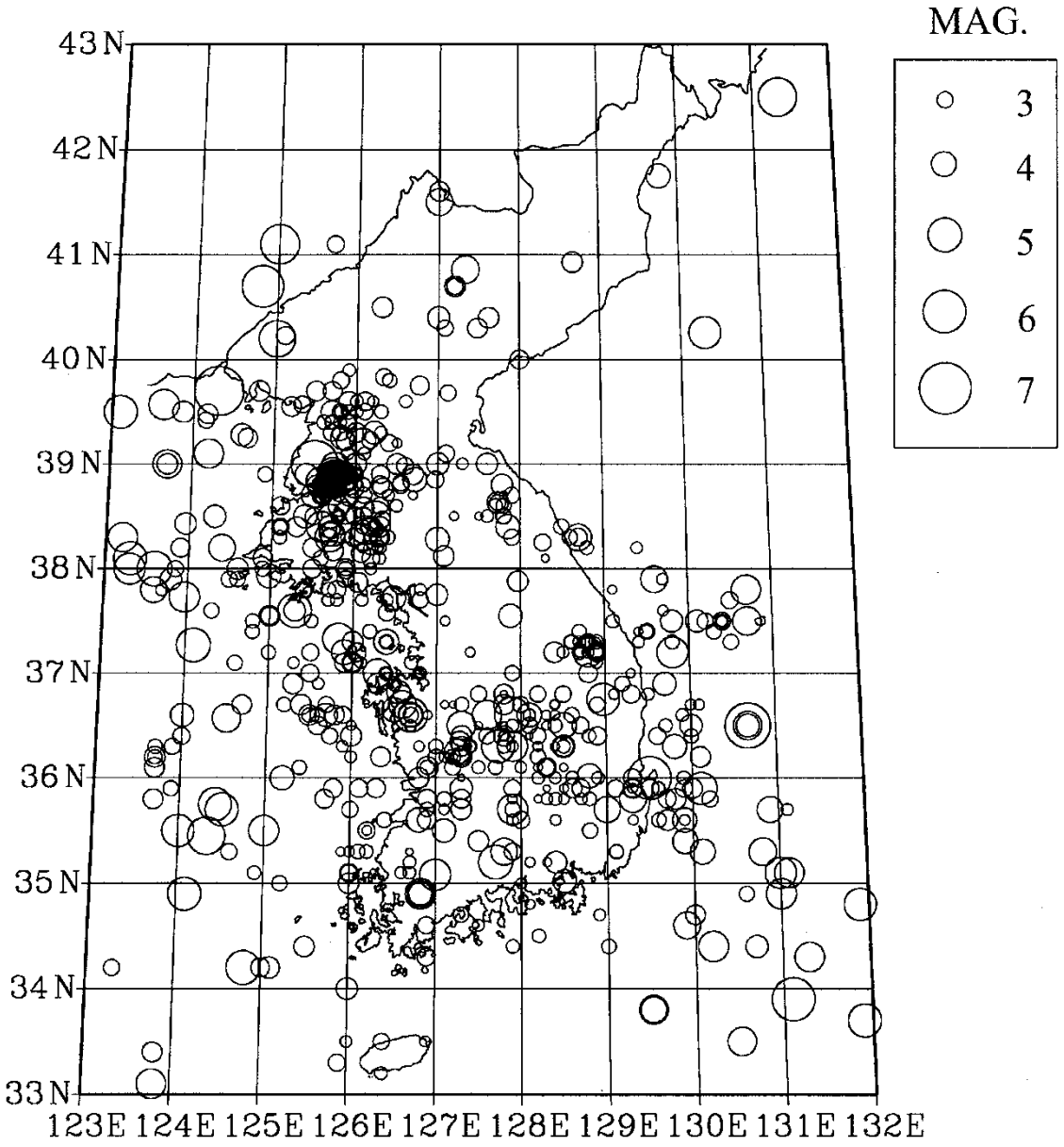
- Intraplate region with moderate seismicity
- About 2,000 earthquakes during about 2,000 years
- About 50 earthquakes with fatalities and damages



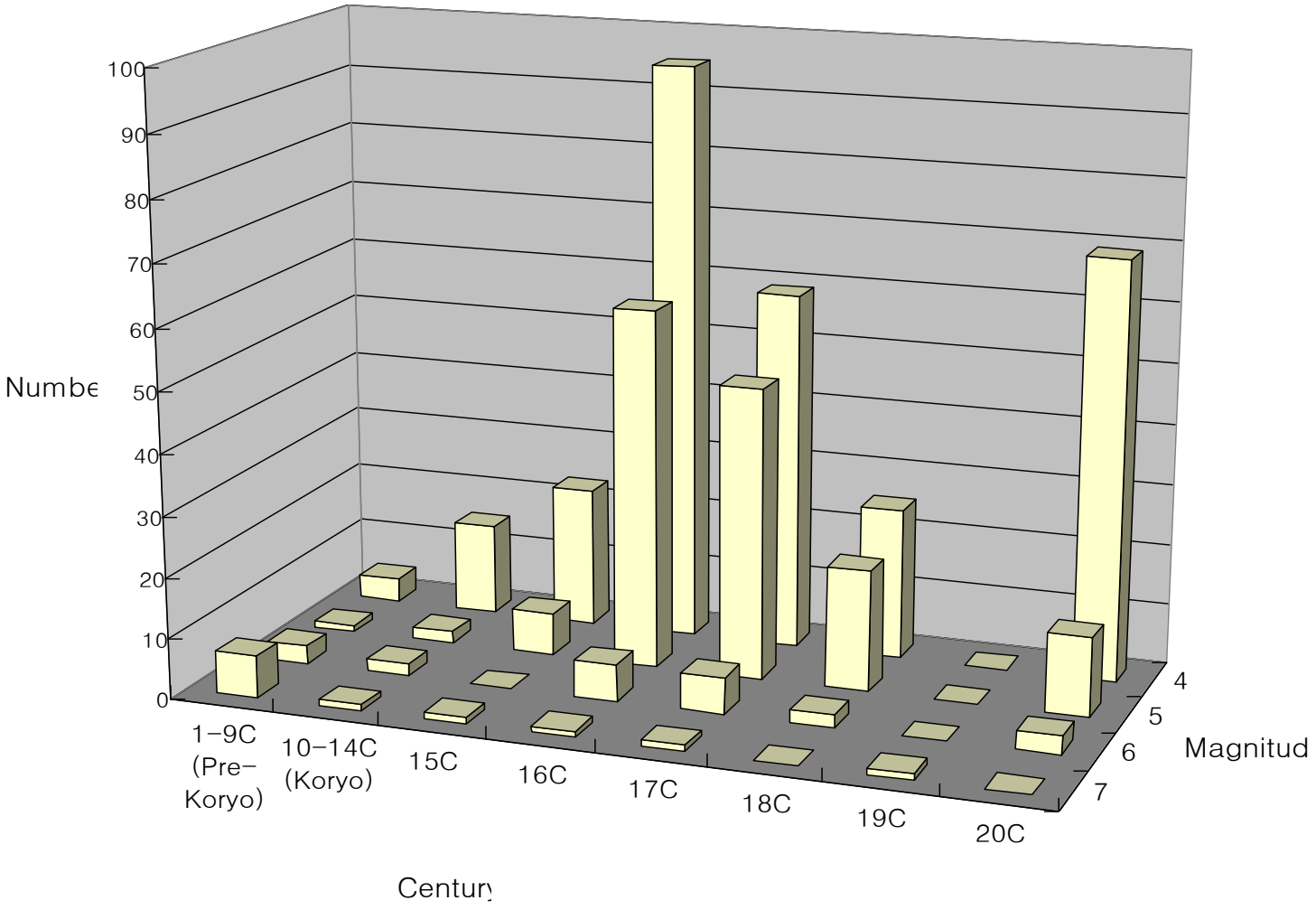
Instrumentally-recorded earthquake

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

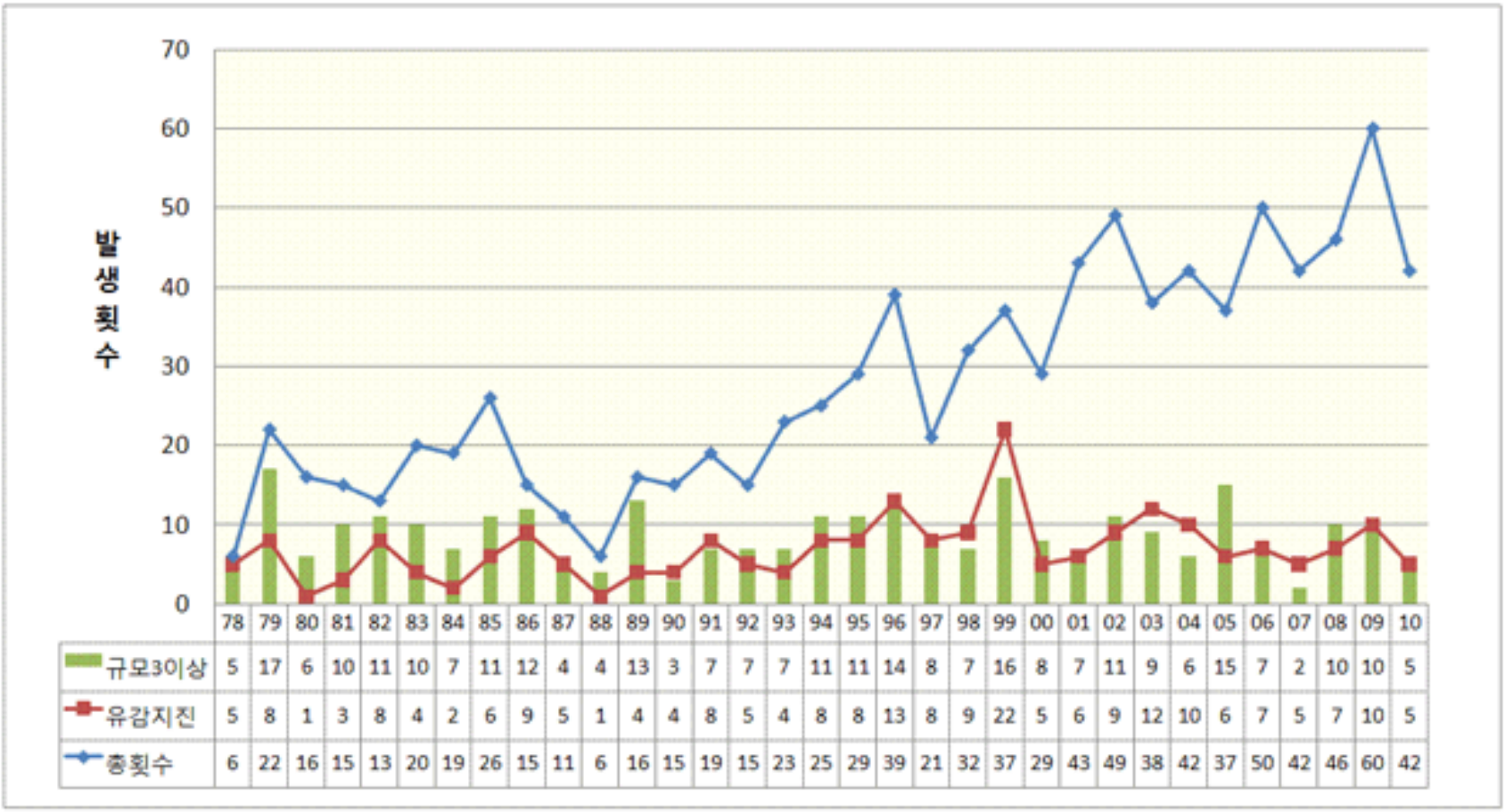


Temporal variation of seismicity in Korea



The seismic activity in the 16th and 17th centuries was very high.

Seismic Activity since 1978

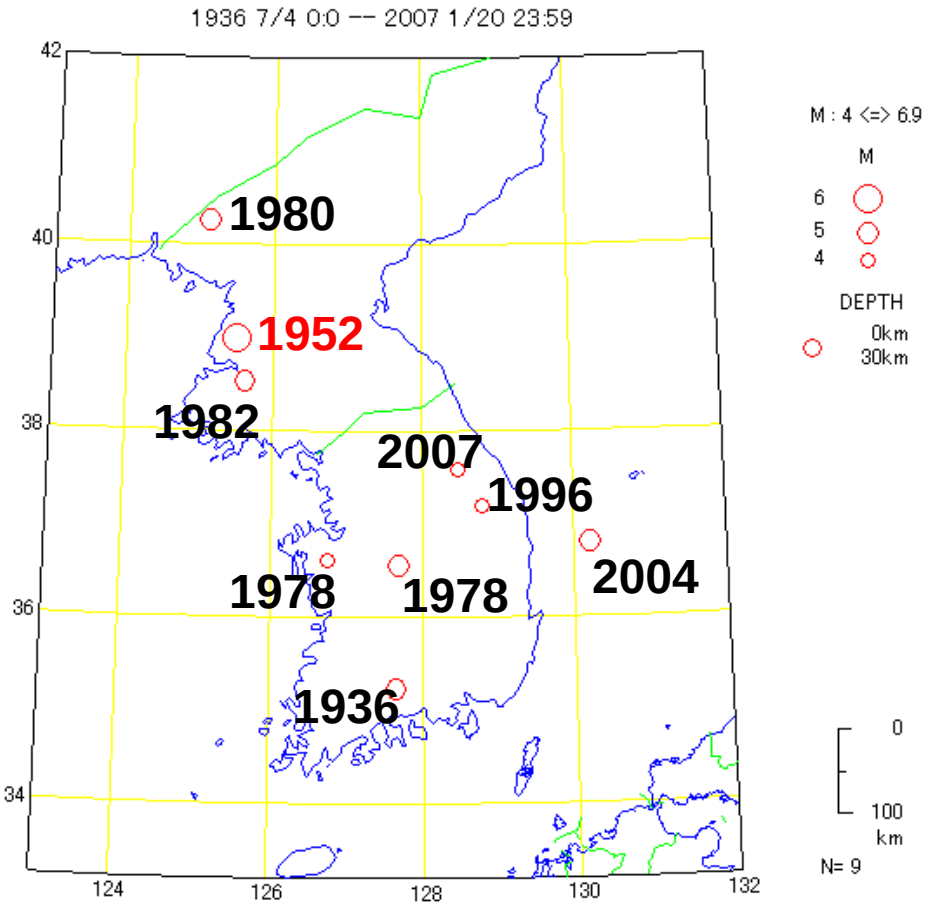


	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
규모3이상	5	17	6	10	11	10	7	11	12	4	4	13	3	7	7	7	11	11	14	8	7	16	8	7	11	9	6	15	7	2	10	10	5
유감지진	5	8	1	3	8	4	2	6	9	5	1	4	4	8	5	4	8	8	13	8	9	22	5	6	9	12	10	6	7	5	7	10	5
총횟수	6	22	16	15	13	20	19	26	15	11	6	16	15	19	15	23	25	29	39	21	32	37	29	43	49	38	42	37	50	42	46	60	42

- 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.

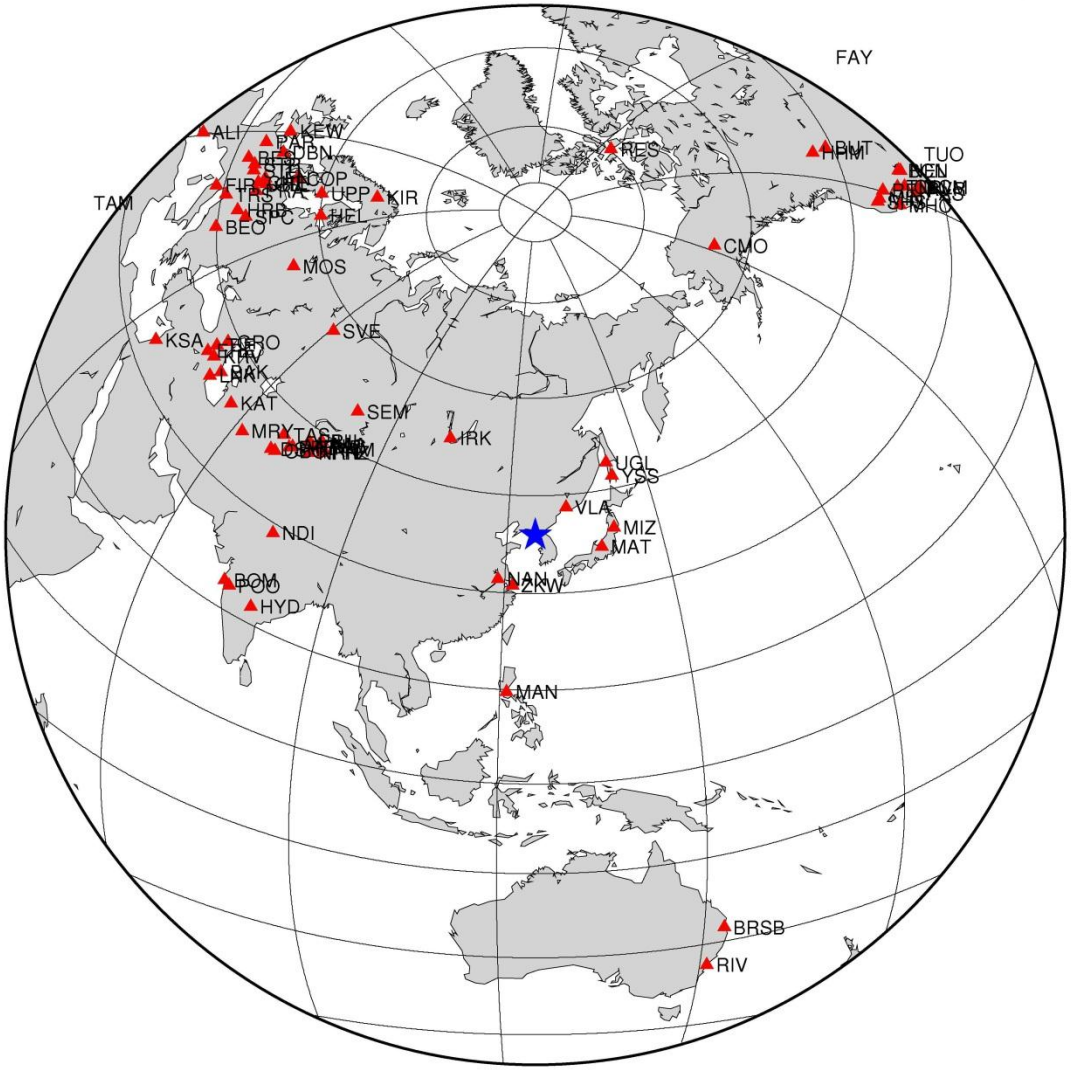
I. The 19 March 1952 earthquake near Pyeongyang, North Korea

- 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
  - 中国国家地震局科技情報中心 (1987): Ms=6.5
  - Yuche Li(2001): M=6.5
  - Ishikawa et al.(2008): Md=6.5



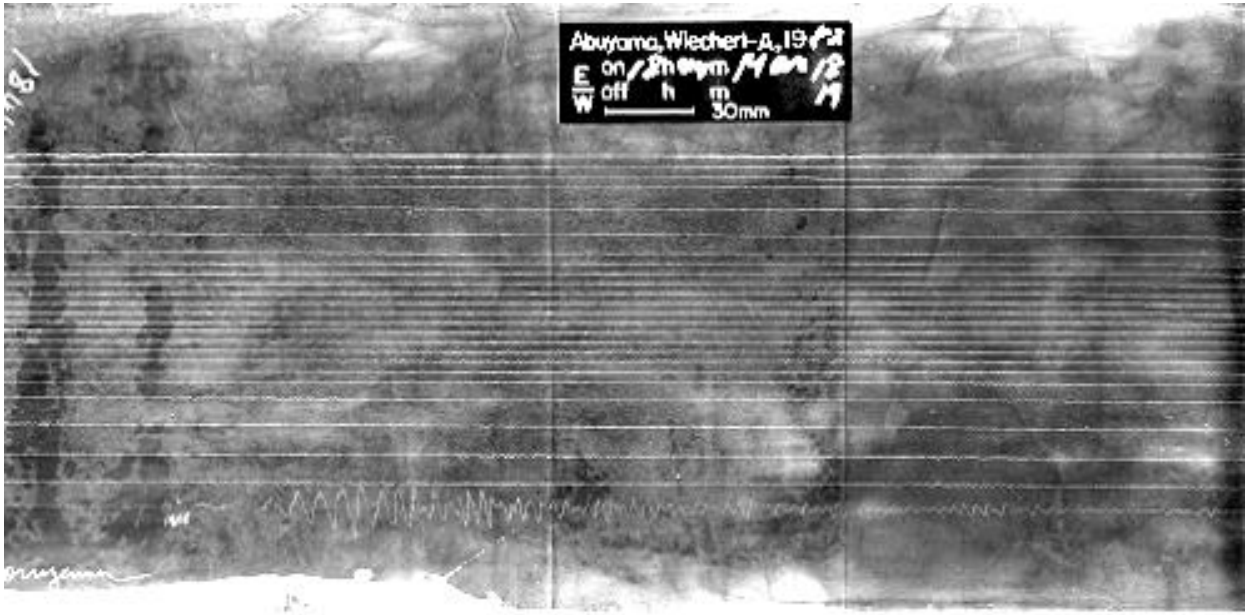
(Ishikawa et al., 2008)

II. Collection of data related to the 1952 earthquake

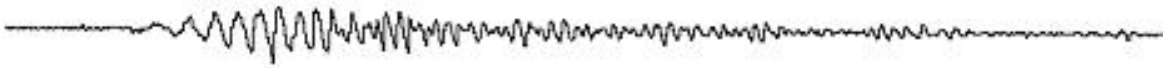


- Searching for global observations of the 1952 earthquake from ISC Bulletin
- Figuring out whether each station has the seismograms of the event or not
- Collecting information on the type of seismograph and paper, and recording parameters during the earthquake

III. Obtainment of analog seismograms and digital conversion



Example of the analog seismograms



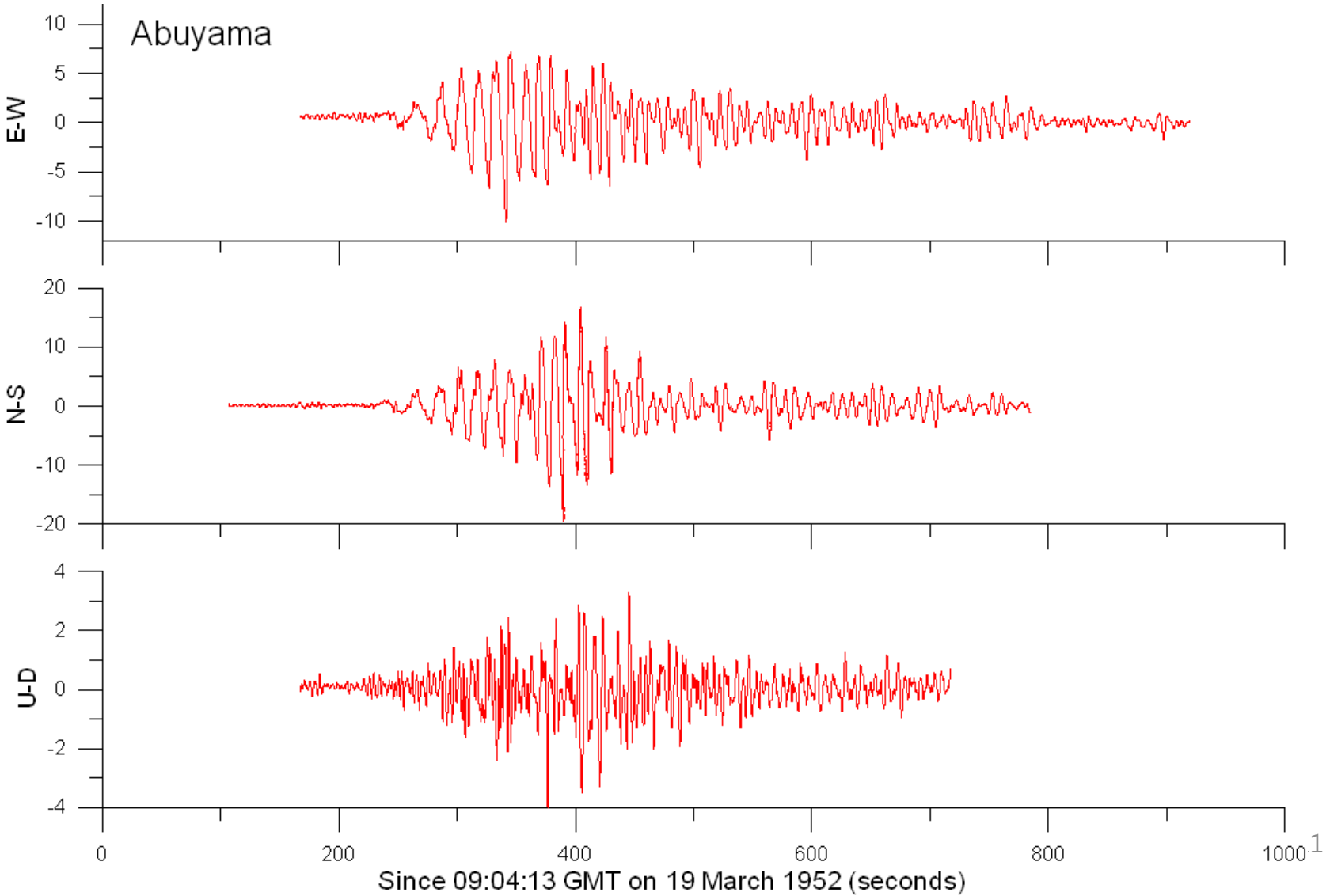
Digitization

- 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

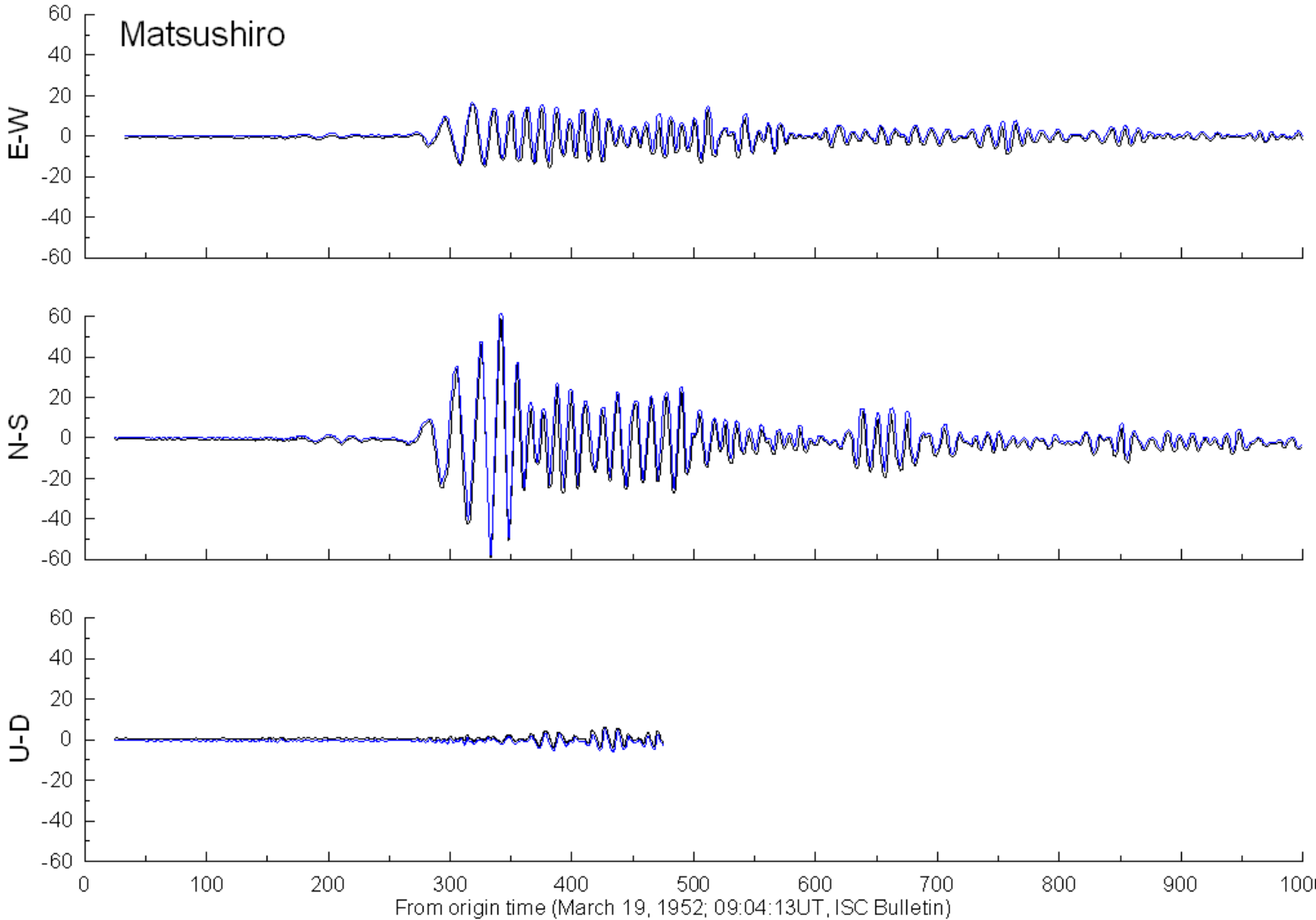
Analog-to-digital conversion

- 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

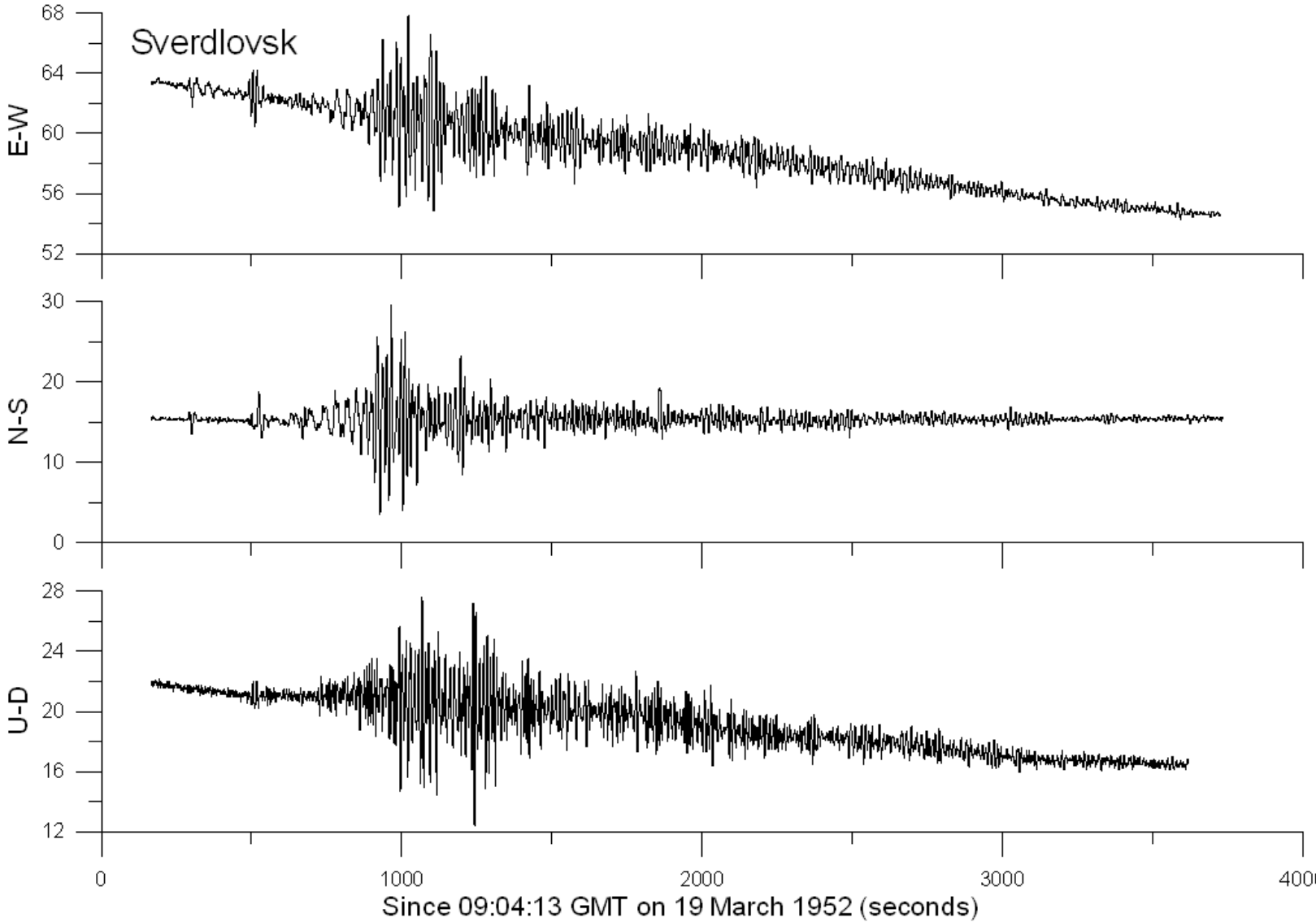
Abuyama


Abuyama
E-W
10
5
0
-5
-10
N-S
20
10
0
-10
-20
U-D
4
2
0
-2
-4
0
200
400
600
800
1000
Since 09:04:13 GMT on 19 March 1952 (seconds)

Matsushiro

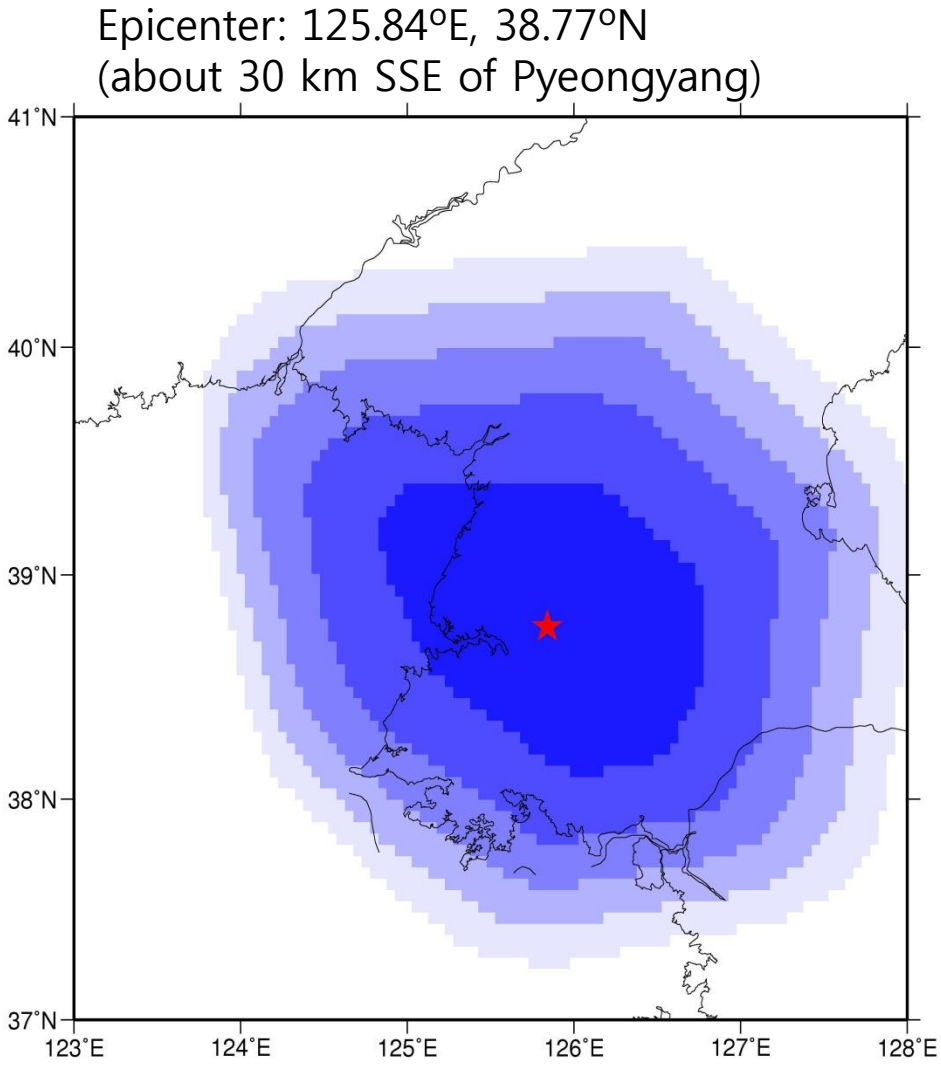

Matsushiro
E-W
N-S
U-D
60
40
20
0
-20
-40
-60
0
100
200
300
400
500
600
700
800
900
1000
From origin time (March 19, 1952; 09:04:13UT, ISC Bulletin)

Sverdlovsk


Sverdlovsk
E-W
68
64
60
56
52
N-S
30
20
10
0
U-D
28
24
20
16
12
0
1000
2000
3000
4000
Since 09:04:13 GMT on 19 March 1952 (seconds)

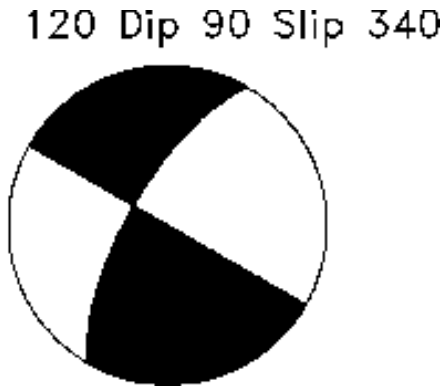
IV. Source parameters of the 1952 earthquake

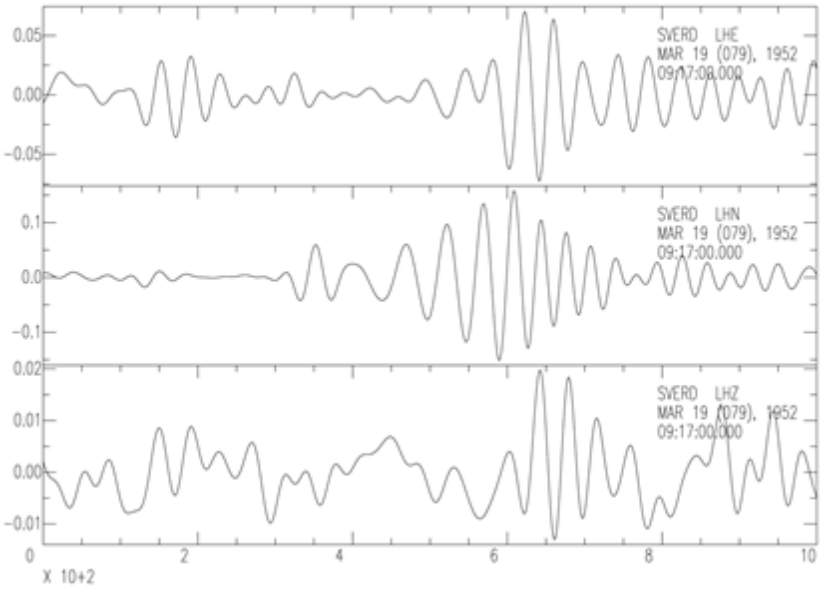
- Arrival times
  - ISC Bulletin
  - Travel-time report from Japanese seismograph stations
- Determination of epicenter using grid-search method based on travel-time data
- Determination of origin time from Wadati diagram using travel-time data: 1952/03/19-18:04:15(local time)

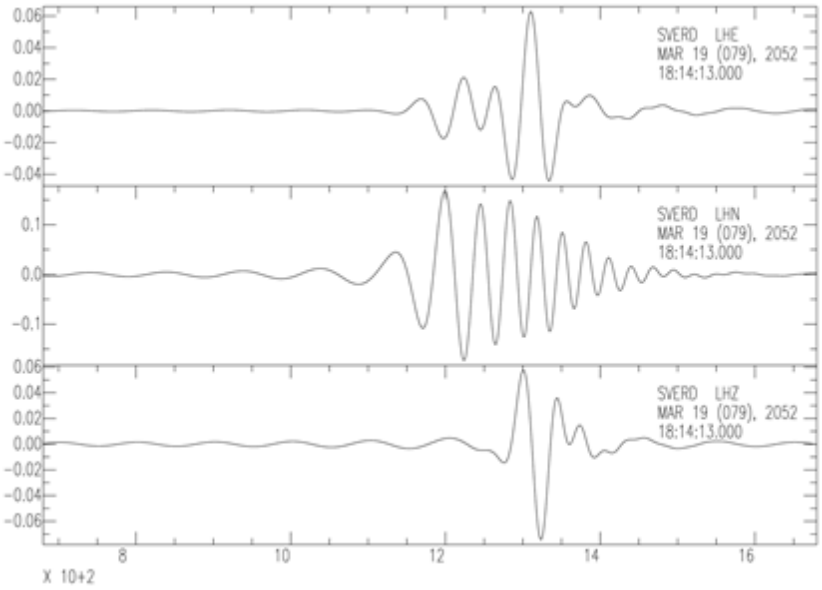


V. Waveform Modelling

- 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
  - 2.45×10^{25} dyne-cm (Mw = 6.17)
- Fault-plane solutions
  - Strike 120°, dip 90°, rake 340°
  - Strike 210°, dip 70°, rake -180°
  - NE-SW and NW-SE strike-slip fault

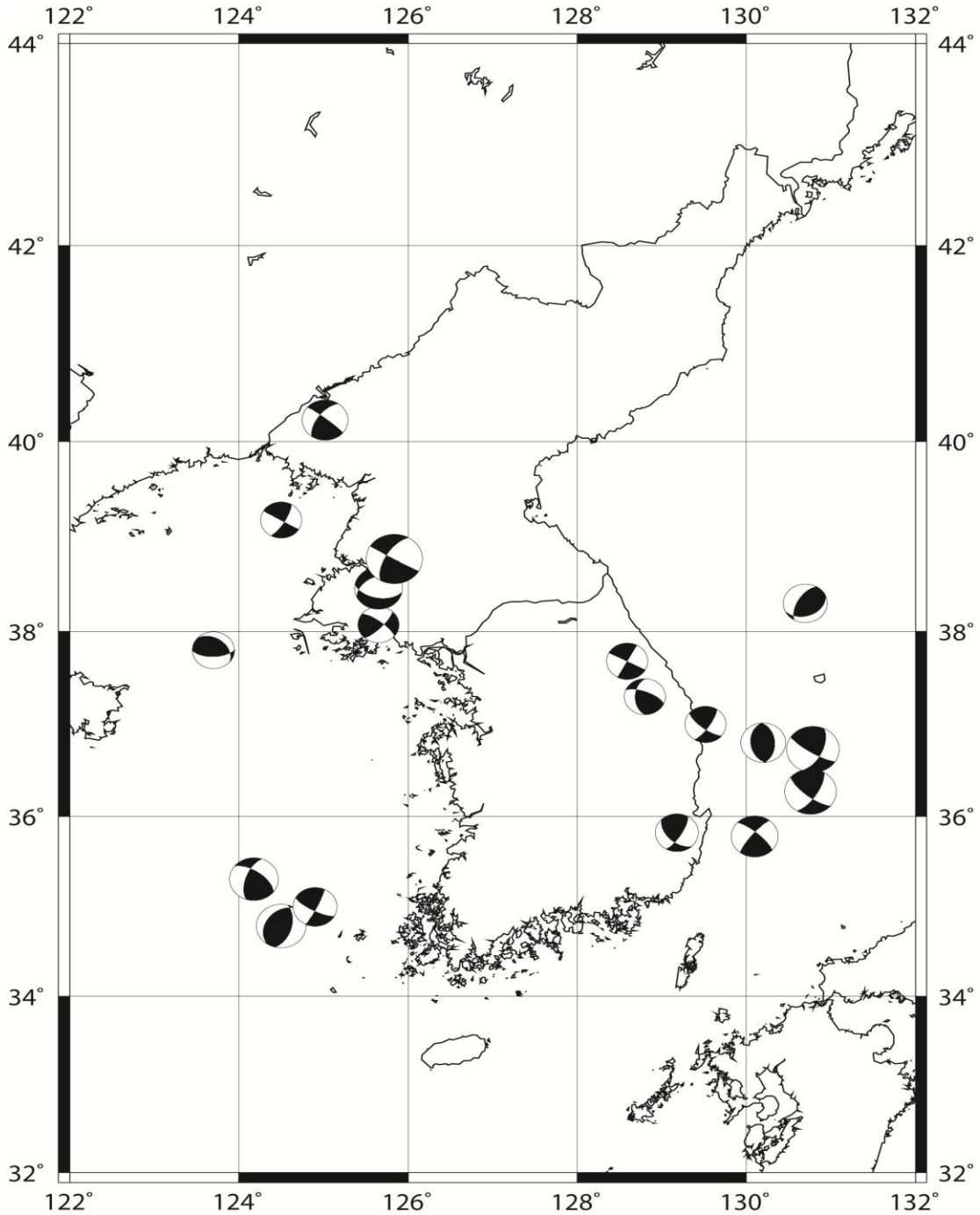


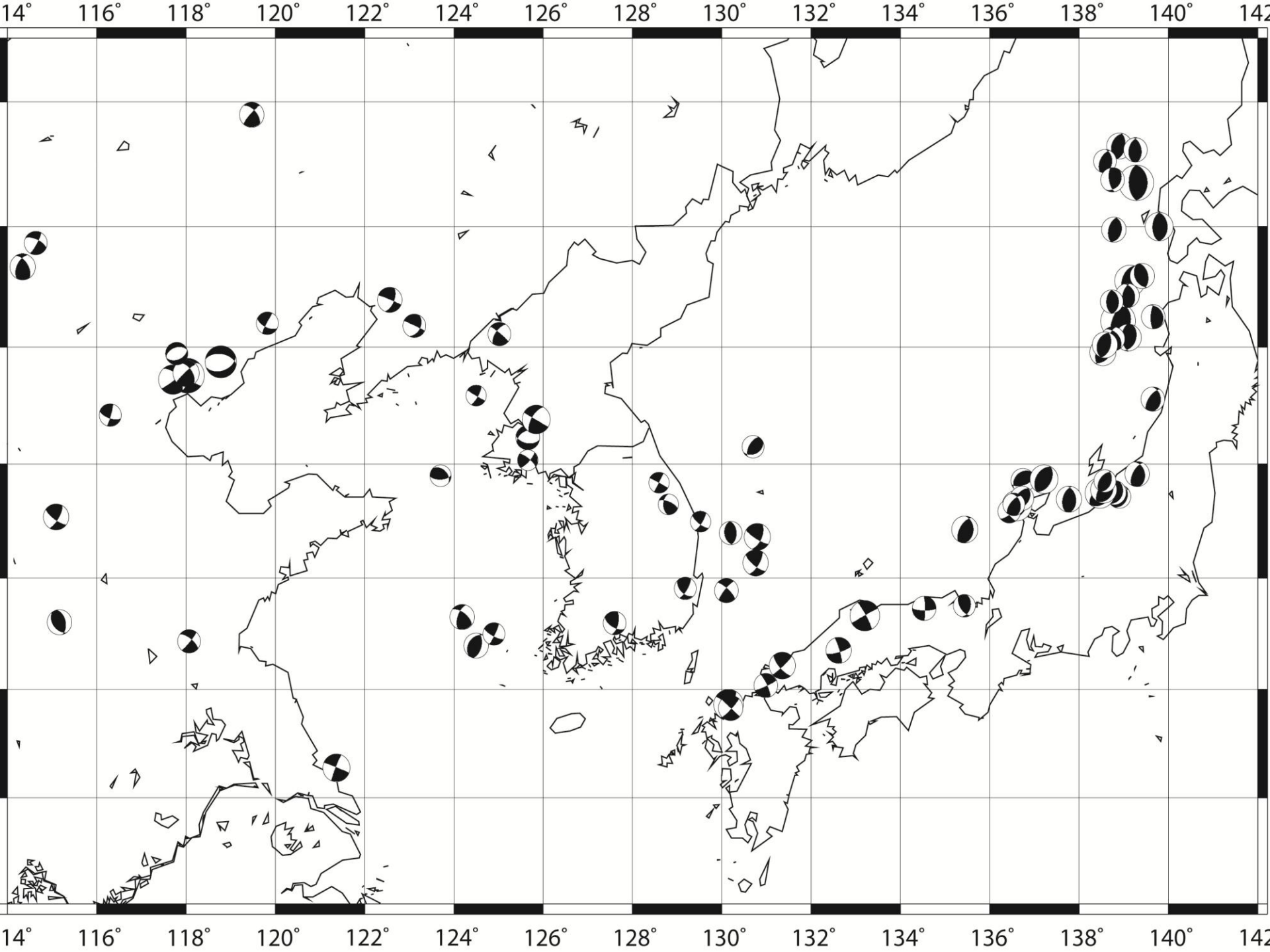




VI. Summary on the source parameters of the 1952 earthquake

- 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


122°
124°
126°
128°
130°
132°
44°
42°
40°
38°
36°
34°
32°


14°
116°
118°
120°
122°
124°
126°
128°
130°
132°
134°
136°
138°
140°
142