A seismic gap in Vrancea (Romania) -Where and when will the next *M*7 intermediate-depth earthquake occur?

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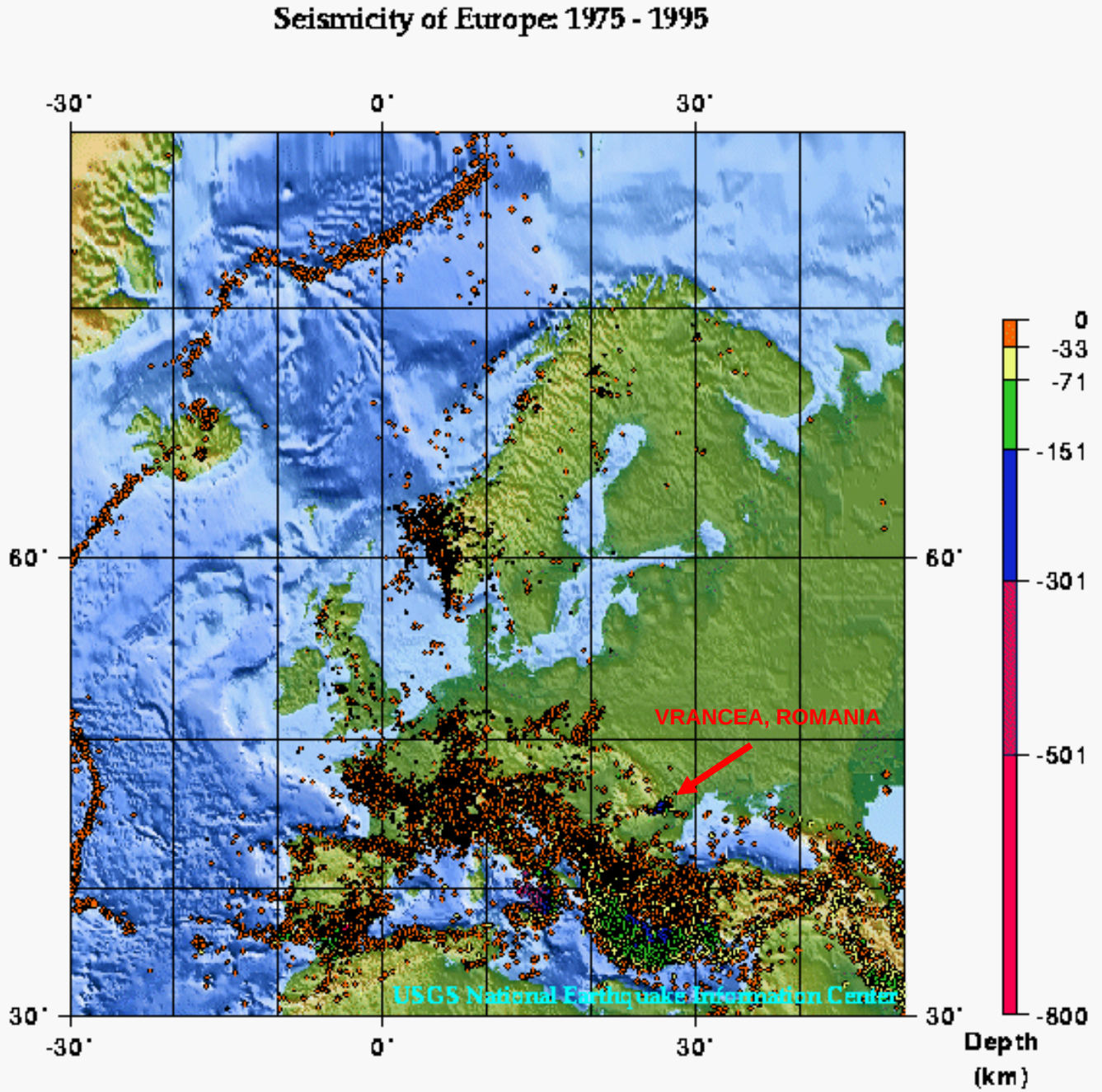
2006.11.10 UJNR at Tokushima


Seismicity of Europe: 1975 - 1995
-30°
0°
30°
60°
30°
VRANCEA, ROMANIA
USGS National Earthquake Information Center
0
-33
-71
-151
-301
-501
-800
Depth
(km)

USGS

Earthquake Prediction in Romania

Purcaru (1974, 1979)
Enescu et al. (1974)

Three seismic active time in each century

P1: 0-10
P2: 30-40
P3: 70-90

1977 (Mw7.5) Eq was predicted.

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The next one will be in 2000-2010.

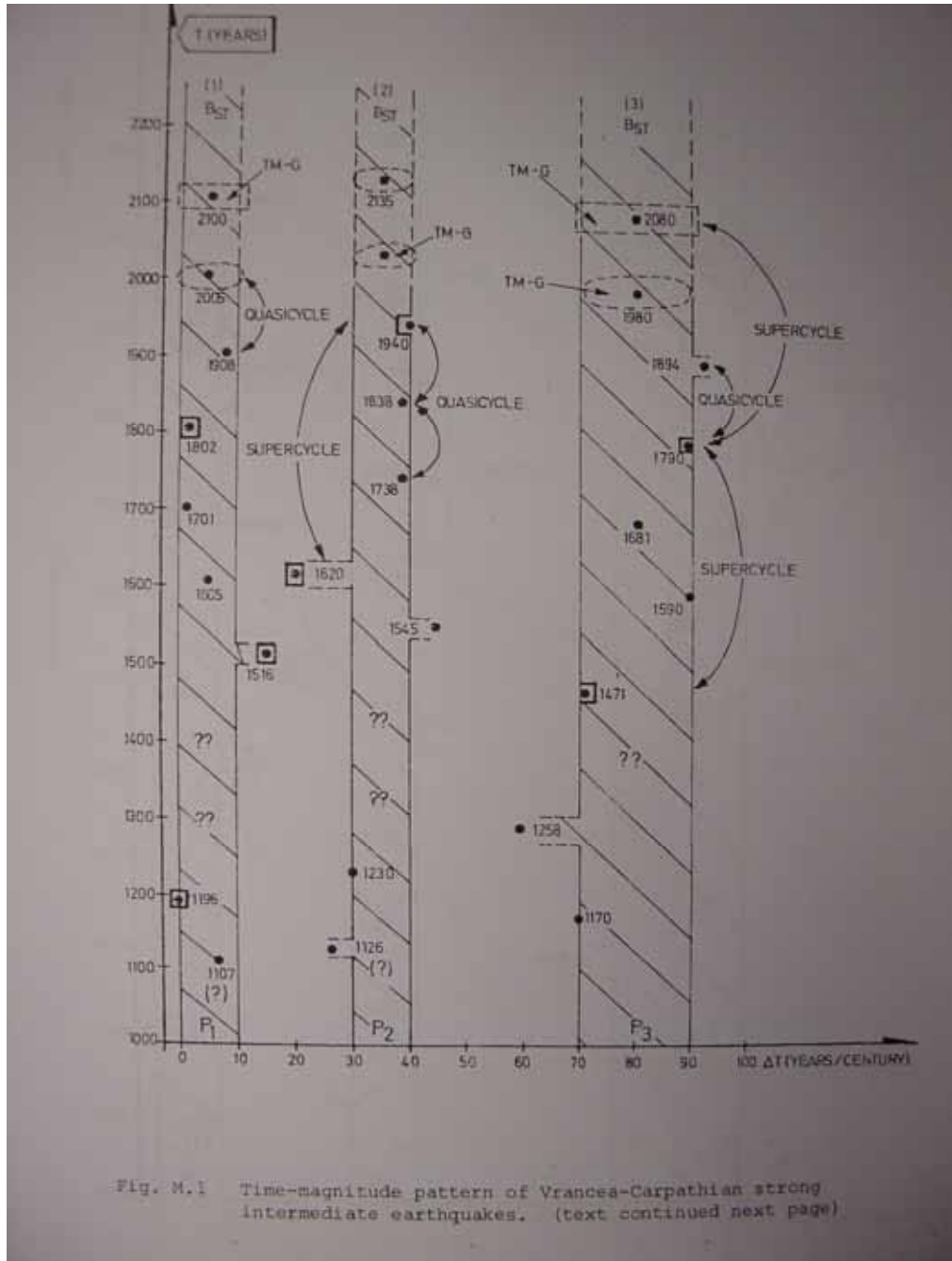


Fig. M.1 Time-magnitude pattern of Vrancea-Carpathian strong intermediate earthquakes. (text continued next page)

Purpose

- Accurate relocation of intermediate depth earthquakes in Romania

  ↓

- Obtain relative location of past large earthquakes and recent small ones.

  →1940 (Mw7.7), 1977 (Mw7.5), 1986 (Mw7.2), 1990 (Mw6.9) Earthquakes

  ↓

- Prediction of Next Big One

  →**Epicenter, Depth, M, Year**

Relocation of Earthquakes

- Data
  - Dataset 1: ISS/ISC: Mainshocks of Large Earthquakes and Their Aftershocks
    - 1934 - 1995 ($M \geq 6.0$)
    - Large Earthquakes ($Mw \geq 6.9$) and Their Aftershocks
  - Dataset 2: NIEP: 1996.1 – 2003.11

- Method
  - Modified Joint Hypocenter Determination (MJHD) Method by Hurukawa & Imoto (1992)

Modified Joint Hypocenter Determination (MJHD) Method

$$\sum_{i=1}^{n}(S_i - a_1 * D'_i) * D_i = 0$$

$$\sum_{i=1}^{n}(S_i - a_2 * \cos\theta_i) * \cos\theta_i = 0$$

$$\sum_{i=1}^{n}(S_i - a_3 * \sin\theta_i) * \sin\theta_i = 0$$

S_i: Station Correction
D_i: Epicentral Distance
Θ_i: Azimuth
n: No. of Stations
$D' = D/AVE(D) - 1$
$AVE(D)$:Average Epicentral Distance

$a_i \neq 0$ →Shift Location of Hypocenters

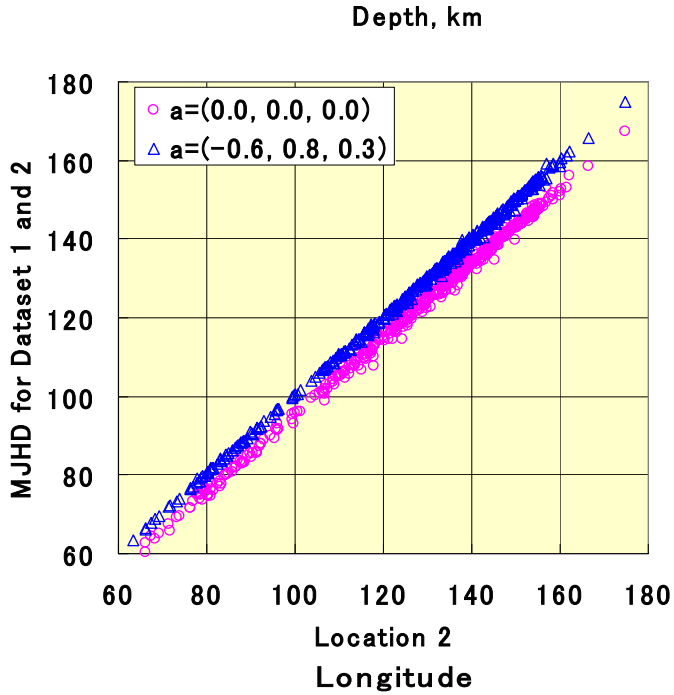
↓

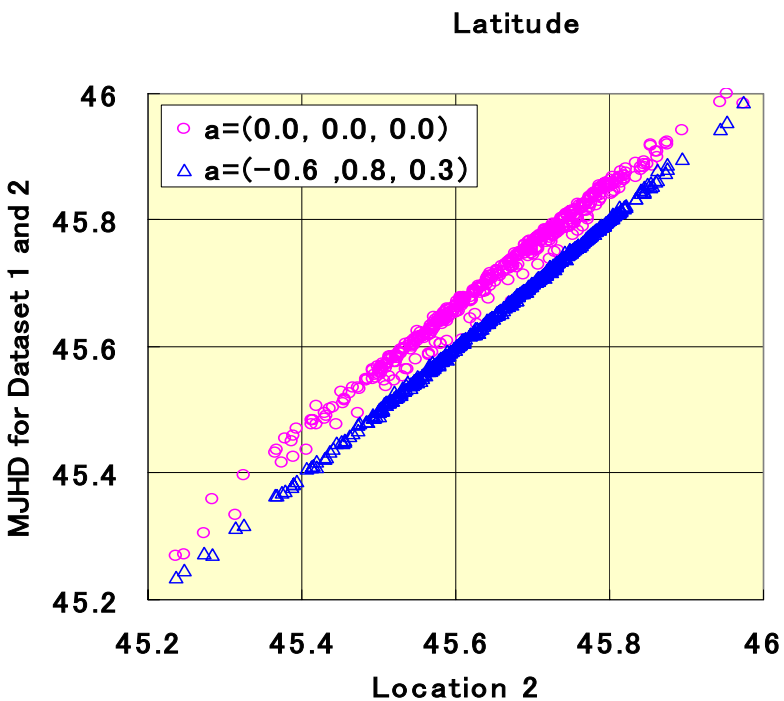
Changing a_i,
Relocated Location = NIEP Location

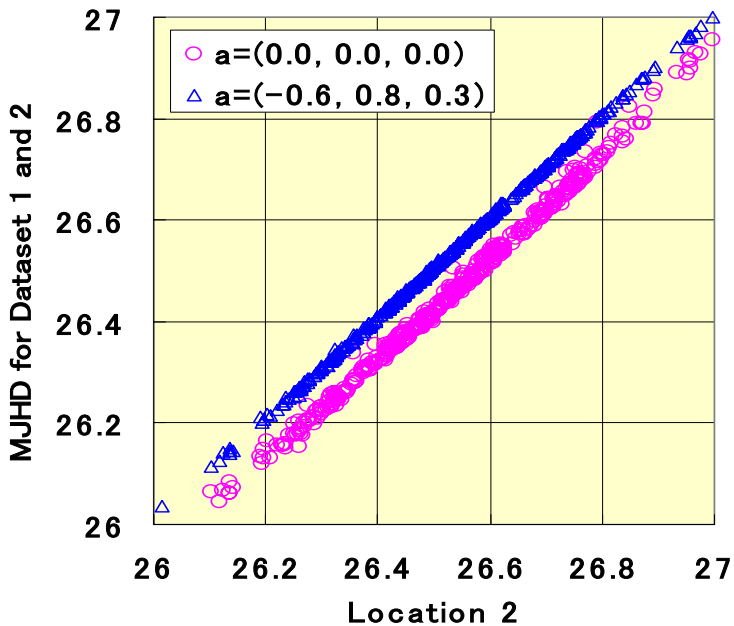
↓

Absolute Location of Older Earthquakes

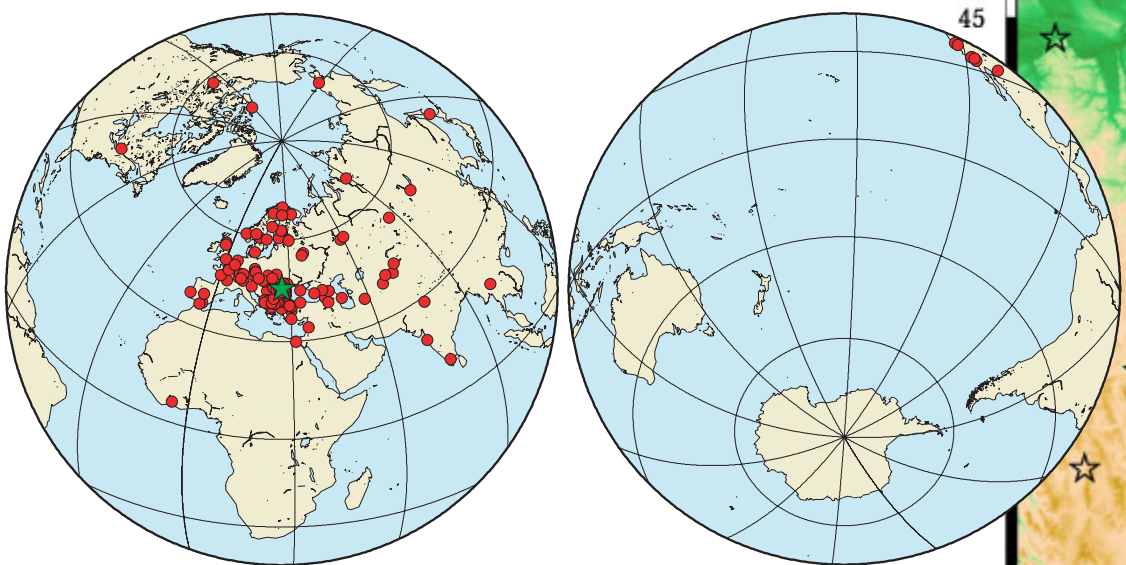
Comparison of latitude, longitude and focal depth of events of 1996-2003 for both parameter sets.





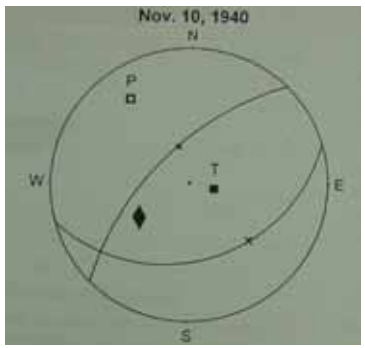


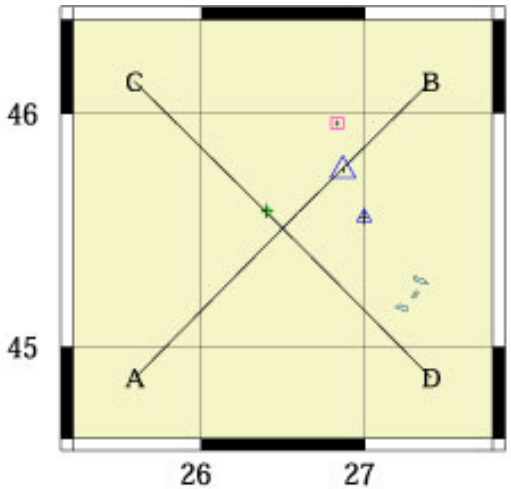
Epicentral Area and Stations

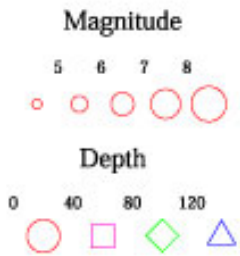


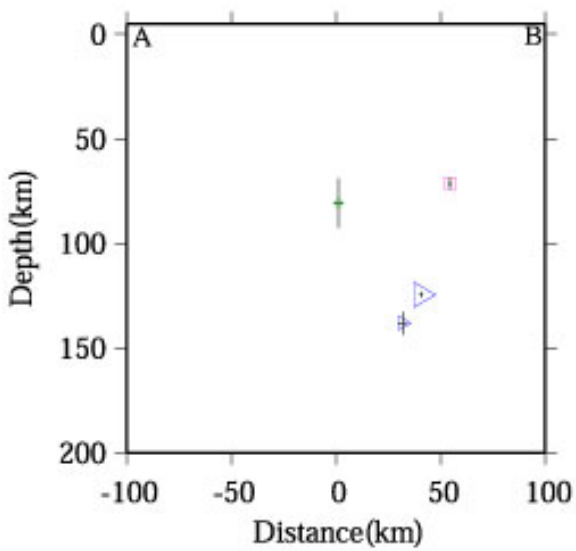
1940.10.22 (Mw 7.7)

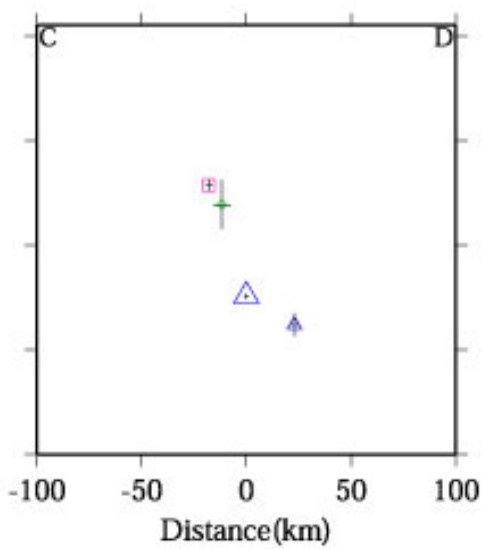
Nov. 10-23, 1940





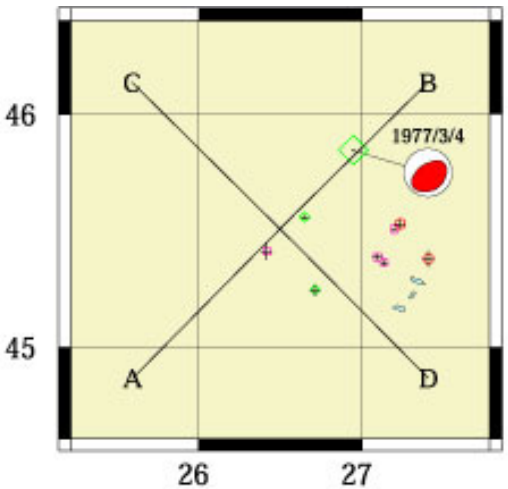


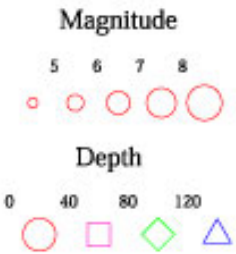


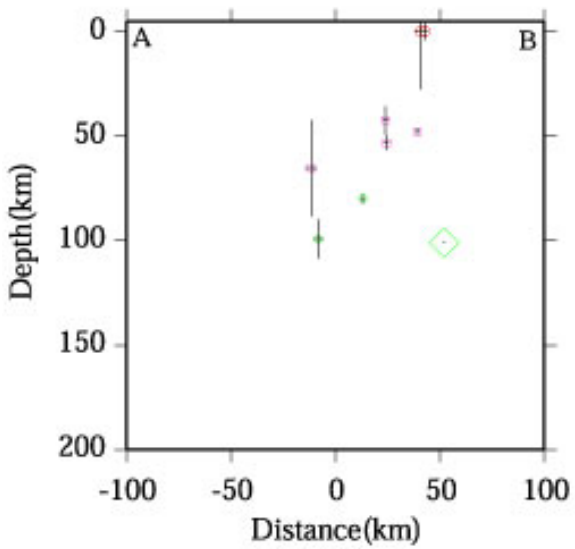


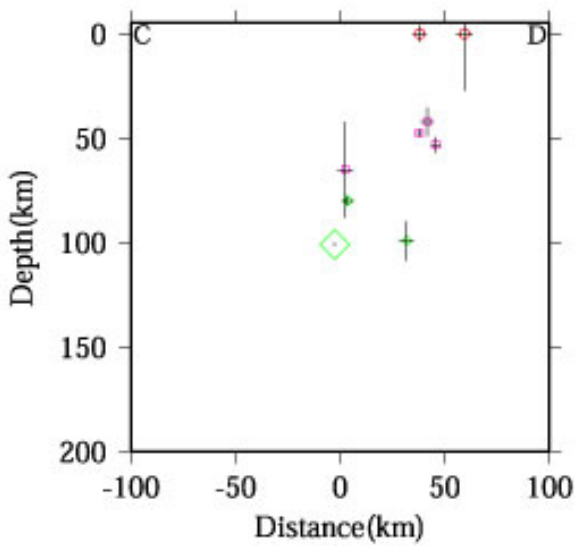
1977.3.4 (Mw 7.5)

March 4 – April 30, 1977



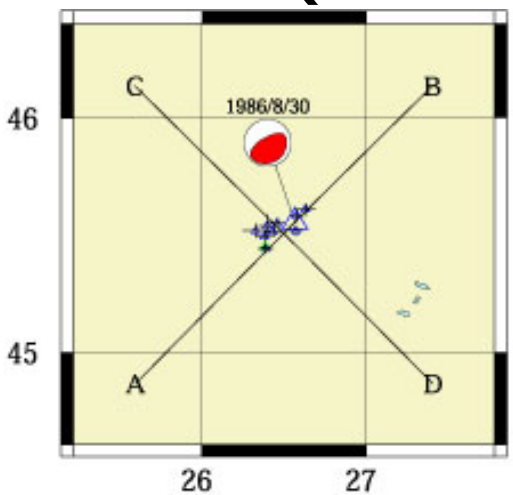


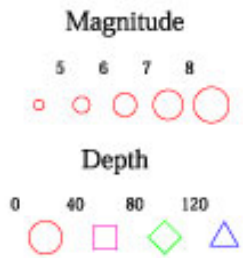


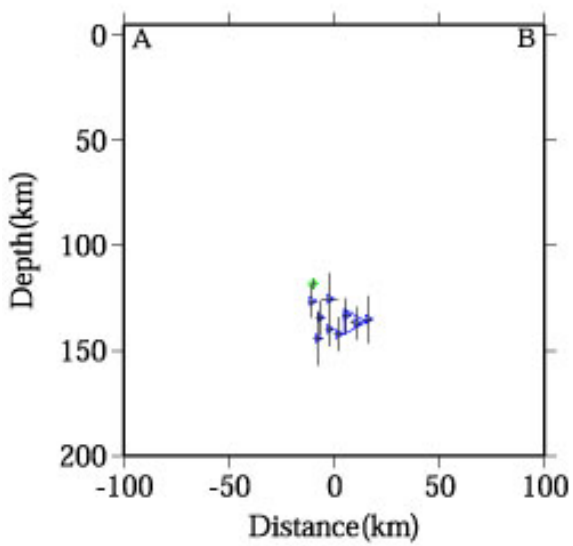


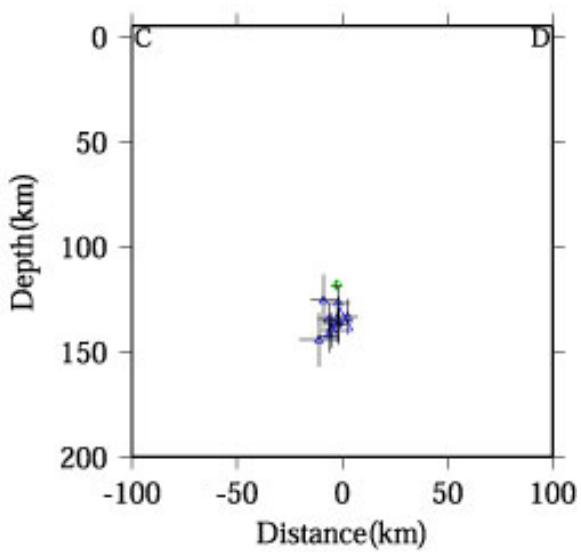
1986.8.30 (Mw 7.2)

Aug. 30-31, 1986



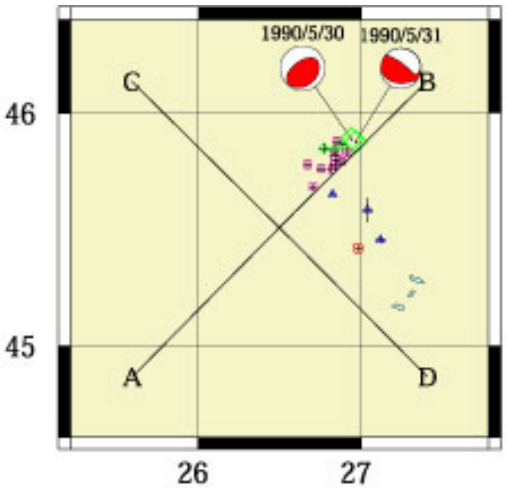


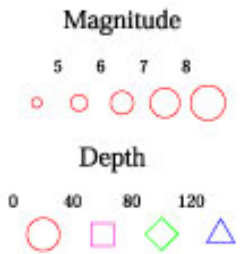


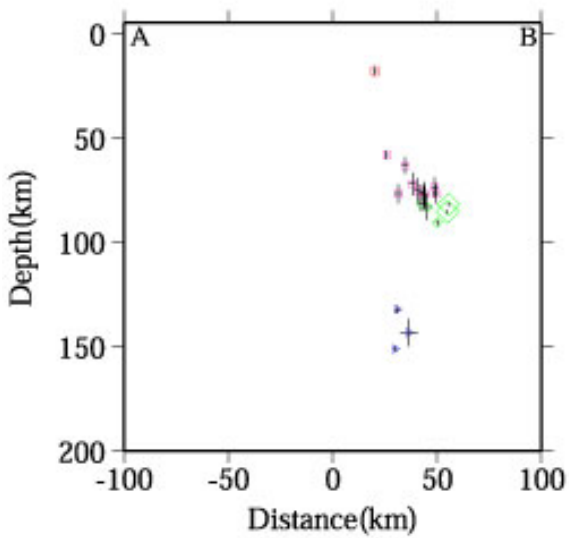


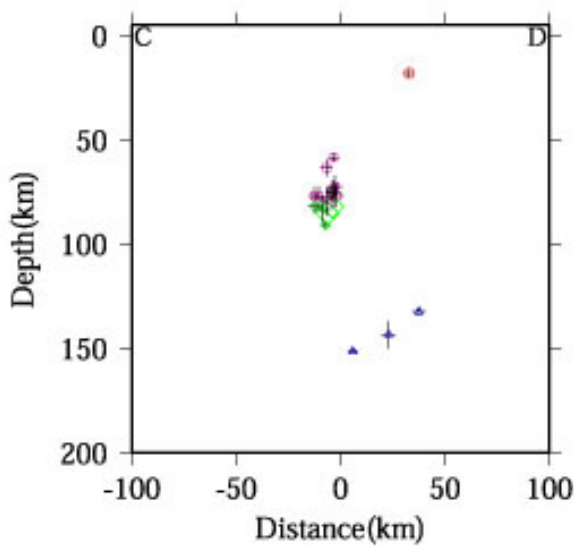
1990.5.30 (Mw 6.9)

May 30-31, 1990

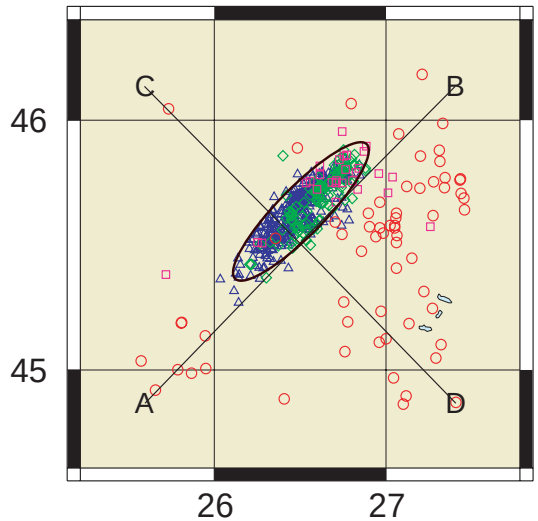


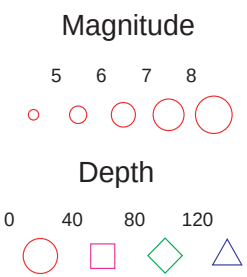


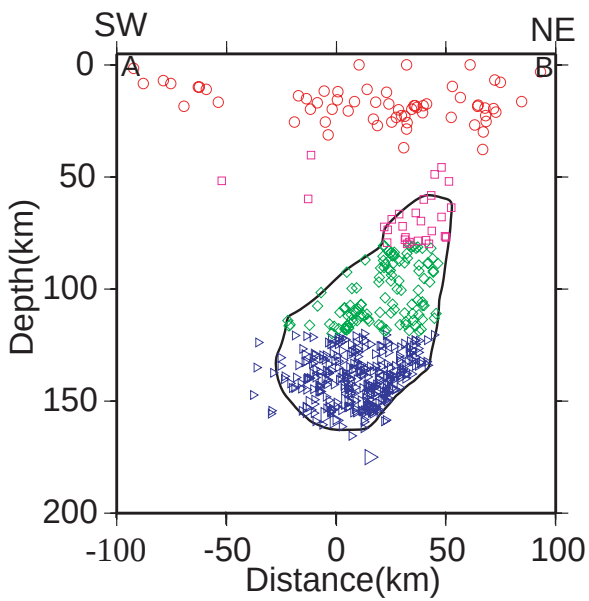


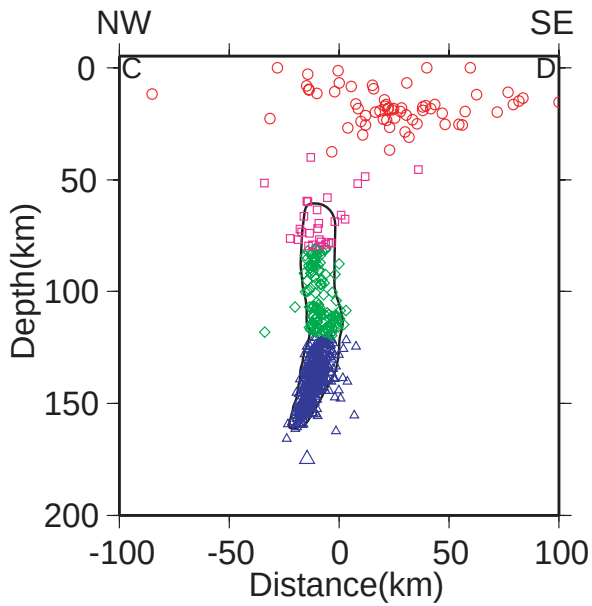


Relocation: Jan. 1996 - Nov. 2003

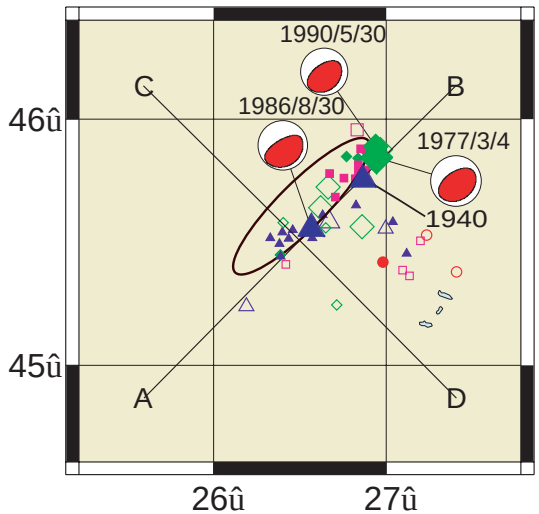


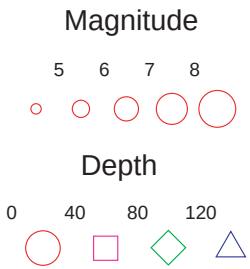


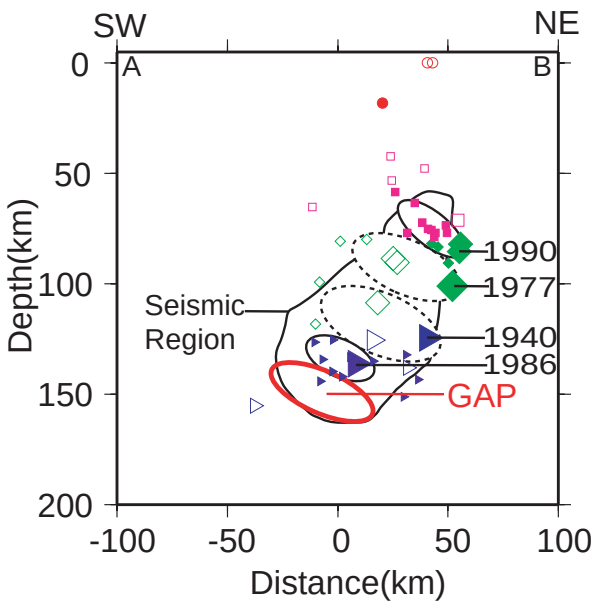


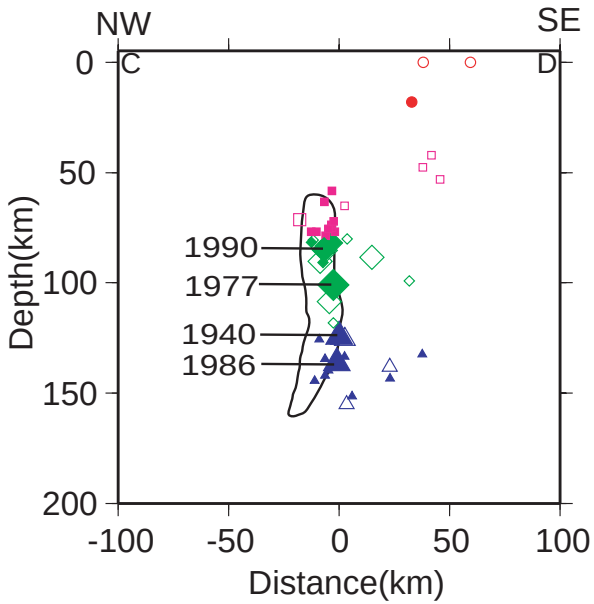


Relocation: M≥6 earthquakes during 1934 to 1990.









List of relocated hypocenters of earthquakes with $M \geq 6.0$

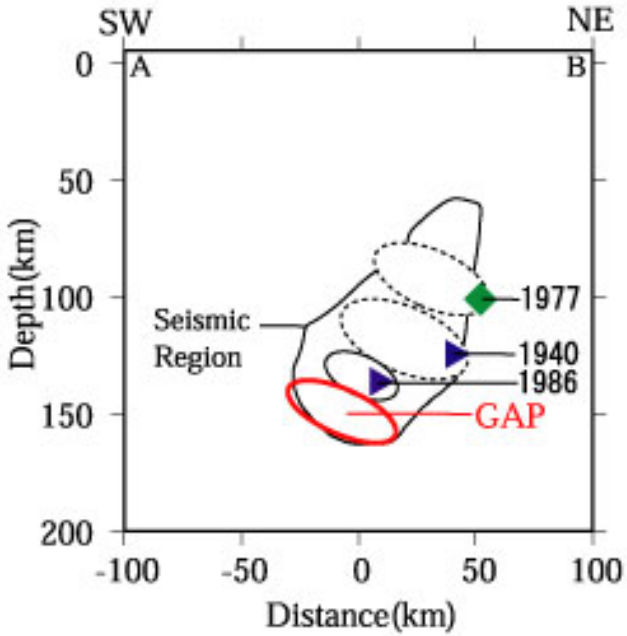
Date	Time	Lon.	Lat.	D	M	
1934/03/29	20:06	26.62	45.64	109	6.2	1)
1940/10/22	06:37	26.67	45.59	126	6.5	1)
1940/11/10	01:39	26.87	45.76	124	7.7	2)
1945/09/07	15:48	26.66	45.73	90	6.5	1)
1945/12/09	06:08	26.86	45.57	89	6.0	1)
1977/03/04	19:21	26.94	45.85	101	7.5	3)
1986/08/30	21:28	26.57	45.56	136	7.2	3)
1990/05/30	10:40	26.94	45.89	85	6.9	3)
1990/05/31	00:17	26.97	45.88	82	6.3	3)

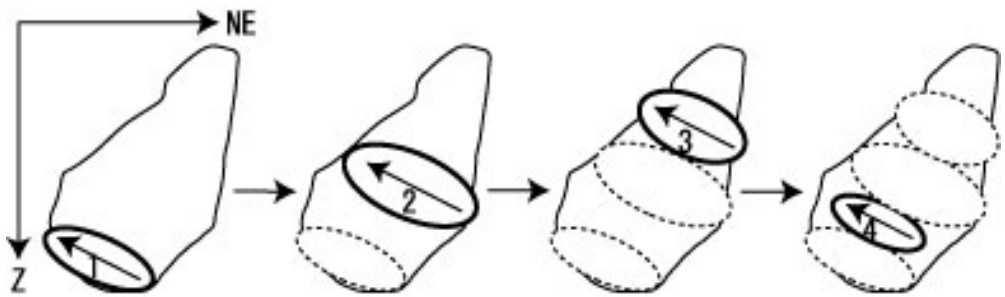
[1] Ms by International Seismological Summary (ISS),

[2] Mw by *Oncescu et al*. (1999) (Note that Ms by ISS is 7.4.),

[3] Mw by Harvard University (*Dziwonski et al.* [1981] and later updates).

M7 Earthquakes in 20 Century & Seismic Gap





1908(M7.1) 1940(Mw7.7) 1977(Mw7.5) 1986(Mw7.2)

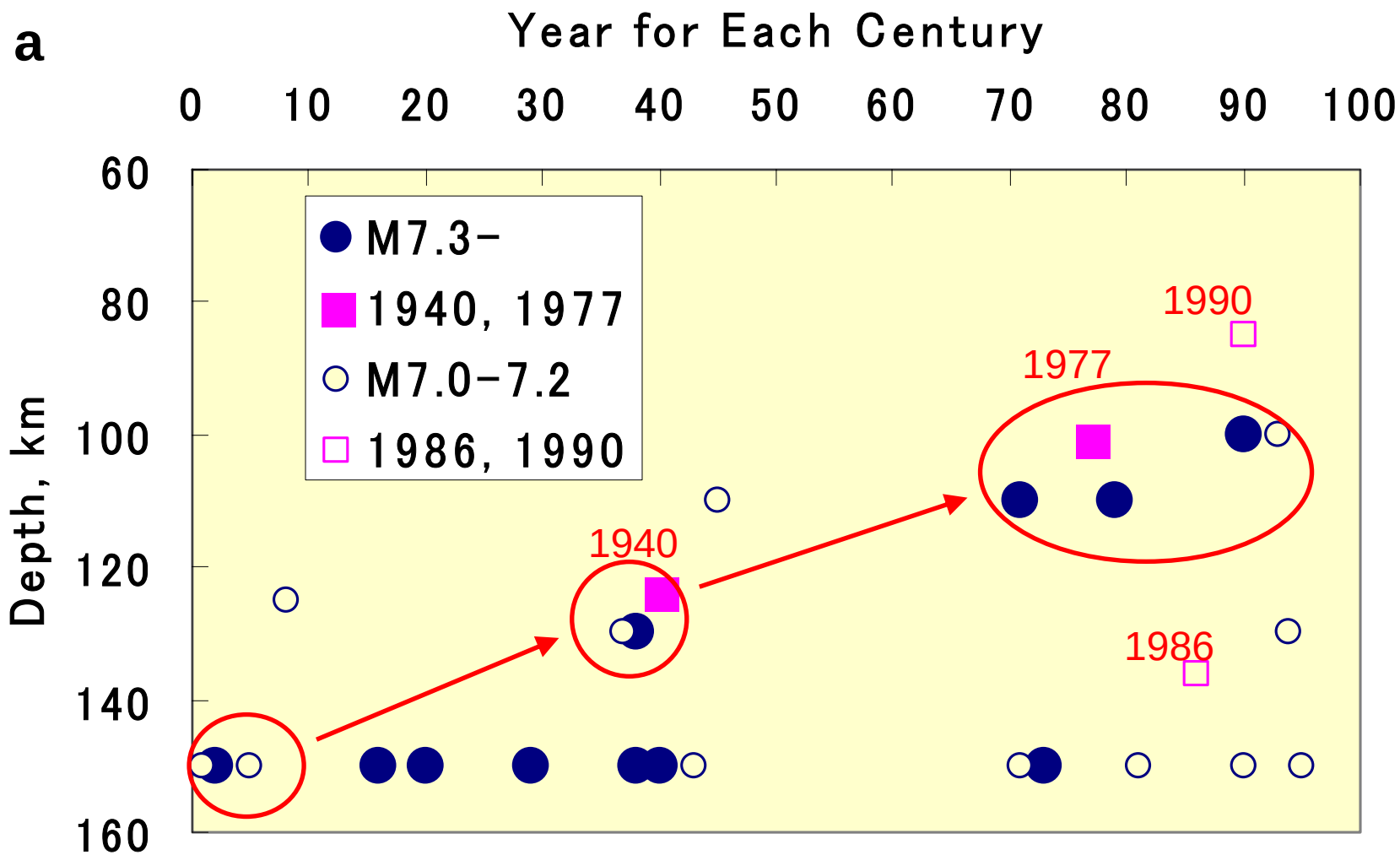
2007+-6

Image of Next Earthquake

- Epicenter: 45.6+-0.1^{o} N, 26.6 +-0.1^{o} E
- Epicentral Area: 50km in NE-SW Direction and 20 km width
- Rupture: Uni-Lateral Toward SW
- Depth Range: 140 – 160 km
- Magnitude: M=7.3+-0.4
- Time: 2007+-6

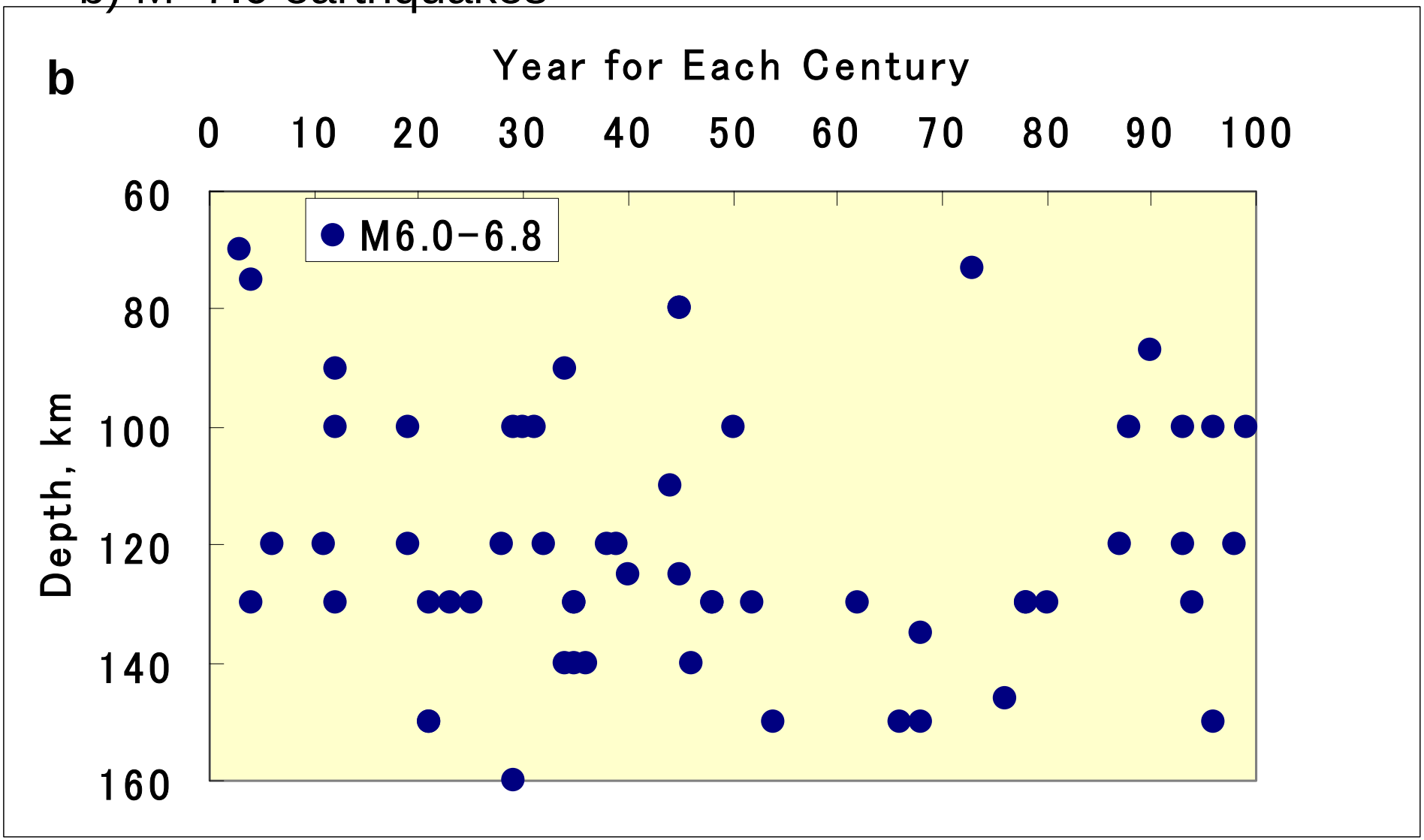
Relationship between focal depth and year for each century during 1471-2005.

a) M≥7.0 earthquakes

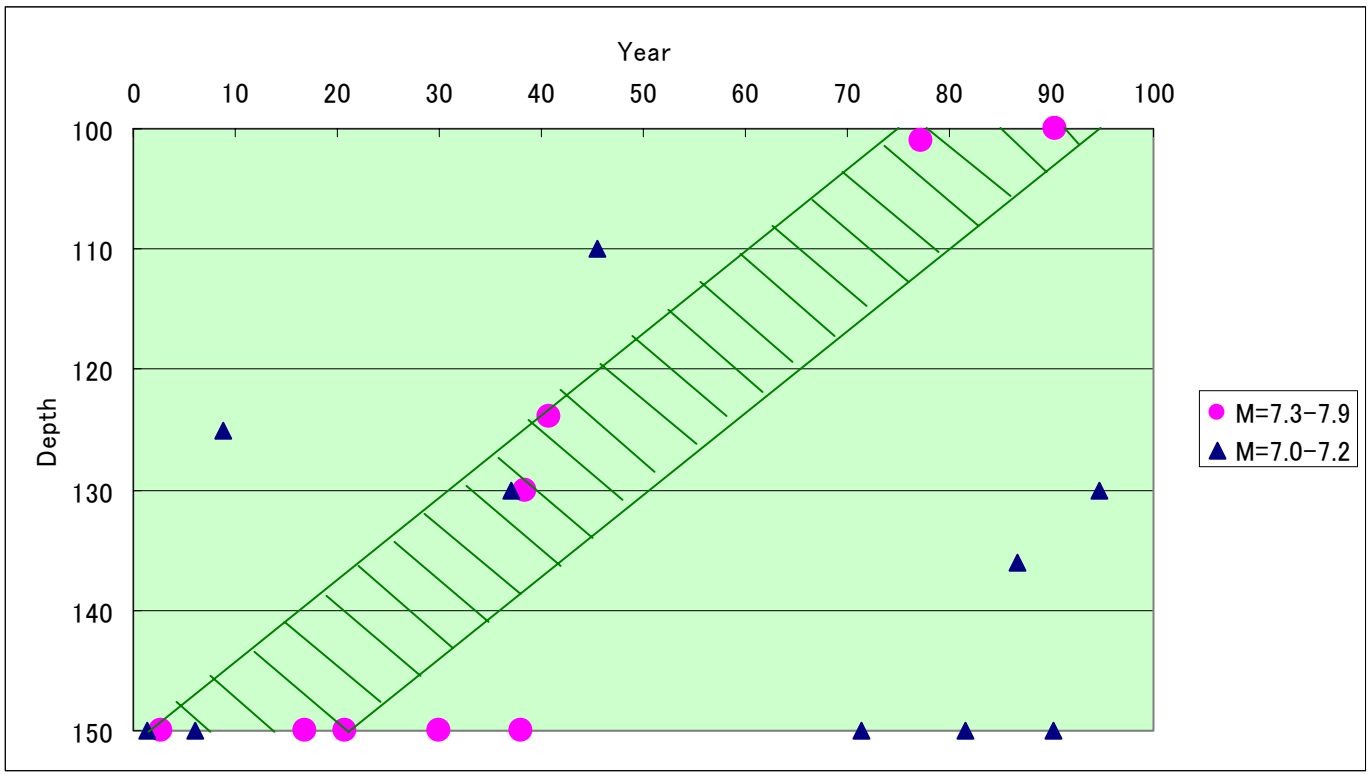


Relationship between focal depth and year for each century during 1471-2005.

b) M<7.0 earthquakes



Depth Migration Model



AIC indicates that this is a better model than a Poisson model.

Conclusion

- Past large earthquakes were relocated with recent small earthquakes by the MJHD method to know reliable absolute location.
- The epicentral area is 85 km NE-SW and 20n km width.
- A seismic region extends 60 – 160 km at depth.
- Their rupture started at NE edge of each large event.
- Depths of past large earthquakes in 1940 (Mw7.7), 1977 (Mw7.5), 1986 (Mw7.2), 1990 (Mw6.9) are 124, 101, 136, 85 km, respectively.
- The proposed seismic gap at depth of 110-130 km corresponds to the source area of the 1940 earthquake.
- The real seismic gap exists at depth of 140 – 160 km.
- An image of the next big one was proposed.