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SOURCE CONDITIONS OF MID-PERIOD STRONG MOTION OBSERVED IN THE WESTERN EDGE OF KANTO PLAIN

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Abstract

Seismic events greater than M_j 6.0 occurred from 1996 to Mar. 2016 in Japan are examined to investigate the source conditions of mid-period (1.6-sec) strong motion observed in a local area which is located in the western edge of Kanto Plain, Japan. It is found that eight events, including the 2011 Tohoku-Pacific Ocean Earthquake, generated the mid-period strong motions in the area. Seven out of the eight events have the focal epicenters in the off Pacific coast of Tohoku region. Source parameters and focal mechanisms show that large-magnitude events with low-angle and shallow-thrust fault ocurred in the northeast direction of Kanto Plain generate mid-period strong motions in the western edge of Kanto Plain.

Keywords: The 2011 Tohoku-Pacific Ocean earthquake, Mid-period strong motion, Focal mechanism

1. Introduction

The M_j 9.0 Tohoku-Pacific Ocean earthquake of 11 March 2011 generated strong and long period ground motion throughout the eastern part of Japan and strongly oscillated high rise buildings in Tokyo including a 17-story Meisei Uni. building in the western part of Kanto Plain [1]. Fig. 1 shows velocity response spectra of the seismograms observed at the free-field strong-motion stations shown in Fig. 2 during the 2011 Tohoku-Pacific Ocean event. Marked 1.6-sec peaks are found at the TKY004 and Meisei Uni. suggesting that the 1.6-sec ground motion was locally generated and enlarged the response of the building which has a natural period of about 2 sec. The former invetigation [1] showed that 1.6-sec ground motions are sometimes generated in the area. The mid-period ground motion including 1 to 2-sec period is a transient range between short and long period range, and thus less be clarified its generation mechanism although the period is equivalent to the natural period of many high rise buildings. Some local geologic effects, source and propagation conditions could generate the mid-period strong motion. In this study the author investigated source conditions which generated the mid-period ground motion.

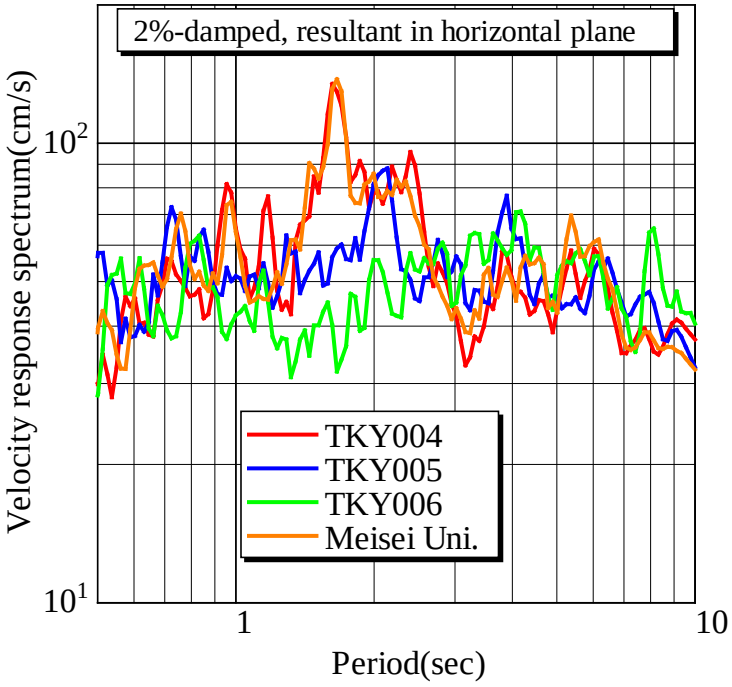

Fig. 1 – 2%-damped velocity response spectra obtained at K-NET stations of TKY004, TKY005, TKY006 and Meisei Uni.

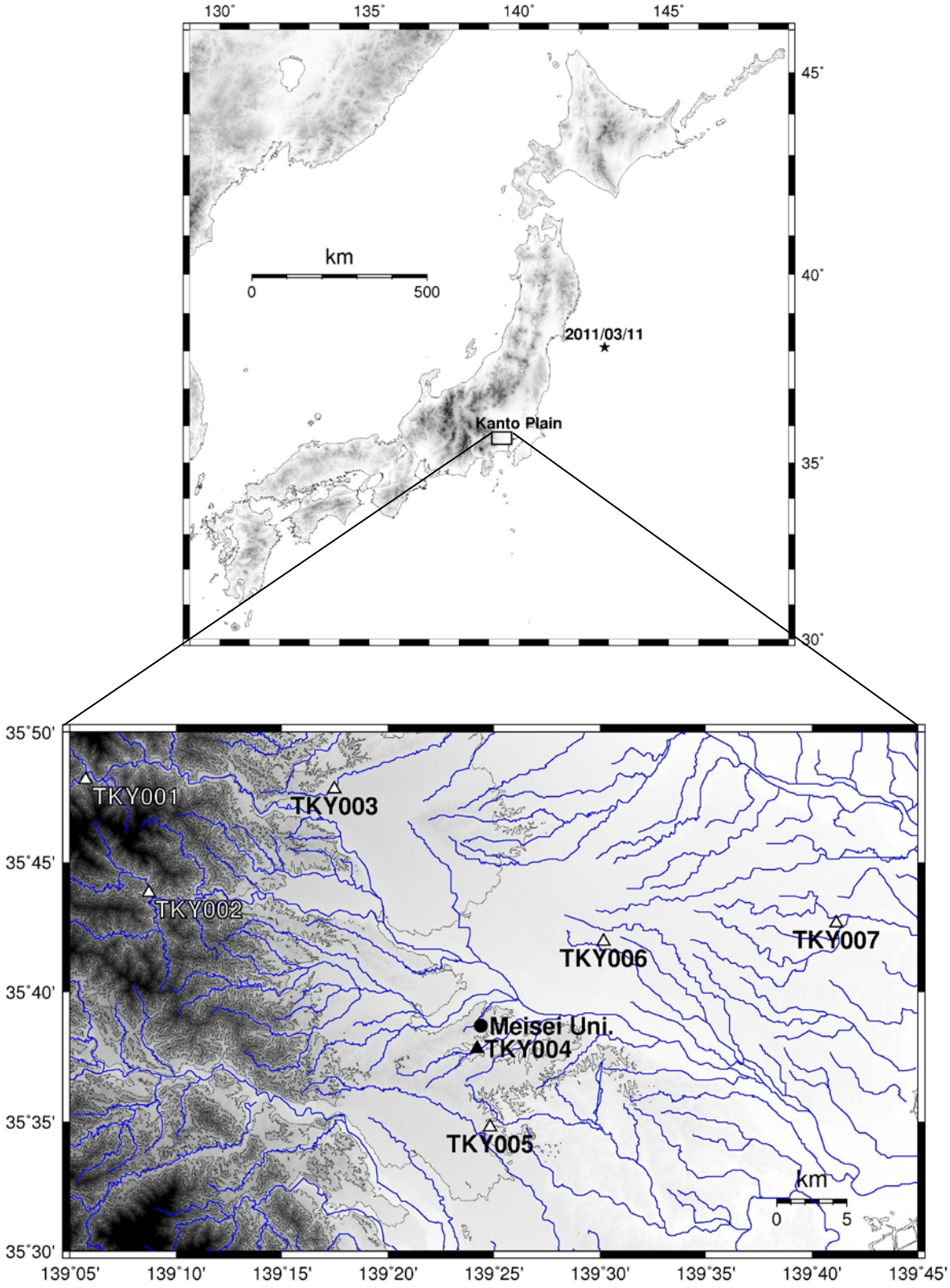

Fig. 2 – Map of western part of Kanto Plain.

2. Seismic events which generated mid-period ground motion

Fig. 3 shows the hypocenters of the events greater than M_j 6.0 during which strong motions were observed and focal mechanisms were obtained at the K-NET station of TKY004 from 1996 to March 2016 [2, 3]. The solid triangle is the location of TKY004. Circles and crosses respectively show the hypocenters of the events during which the 1.6-sec ground motions were and were not observed at TKY004. Table 1 shows the seismic parameters of the events during which 1.6-sec ground motions were observed at TKY004. It is found that 8 events generated the local 1.6-sec ground motions at TKY004. Except for the event No.5 (the 2007 Noto Peninsula event), the hypocenters are located in off Miyagi and off Fukushima regions within the longitude of 141°-143° and the latitude of 37°-39°.

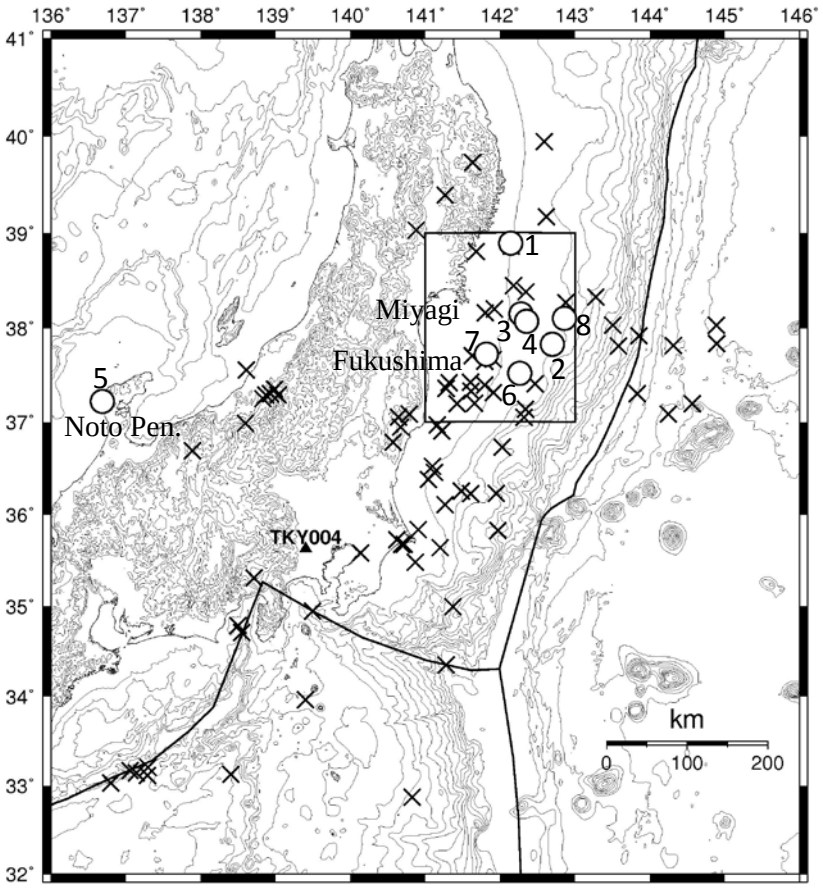

Fig. 3 – Hypocenters of the events during which strong motions were observed at TKY004.

Table 1 – Seismic parameters and focal mechanisms for the events during which mid-period ground motions were observed at TKY004

No.	Origin time(JST)	Latitude	Longitude	Depth (km)	M_j	Strike	Dip	Rake	M_o(Nm)	M_w
1	2002/11/03 12:37	38.8935°	142.1422°	45.8	6.1	184°	15°	74°	3.87×10^{18}	6.4
2	2003/10/31 10:06	37.8292°	142.6995°	33.4	6.8	196°	26°	80°	1.42×10^{19}	6.7
3	2005/08/16 11:46	38.1507°	142.2795°	41.6	7.2	194°	22°	76°	5.43×10^{19}	7.1
4	2005/12/02 22:13	38.0727°	142.3535°	40.3	6.6	205°	19°	93°	5.39×10^{18}	6.5
5	2007/03/25 09:41	37.2207°	136.6860°	10.7	6.9	173°	48°	34°	1.36×10^{19}	6.7
6	2008/07/19 11:39	37.5208°	142.2645°	31.6	6.9	234°	20°	119°	2.39×10^{19}	6.9
7	2010/03/14 17:08	37.7242°	141.8180°	39.8	6.7	199°	21°	89°	6.83×10^{18}	6.5
8	2011/03/11 14:46	38.1035°	142.8610°	23.7	9.0	200°	27°	88°	1.07×10^{22}	8.7

3. Seismic parameters

The last chapter demonstrates that the primary condition to generate the mid-period ground motion at TKY004 is the location of the hypocenter; i.e. except for the 2007 Noto Pen. Event, the hypocenters were located in the area of 141°-143° in longitude and of 37°-39° in latitude. In this chapter, seismic parameters of the events, the hypocenters of which are located within the area, are investigated.

Fig. 4 shows a plot of seismic moment M_o against the moment magnitude M_w. Circles and crosses respectively indicate the events during which the 1.6-sec ground motions were and were not observed at TKY004. It is found that the seismic moments smaller than 3.0×10^{18}Nm did not generate the 1.6-sec ground motions. The corresponding threshold in moment magnitude is 6.3.

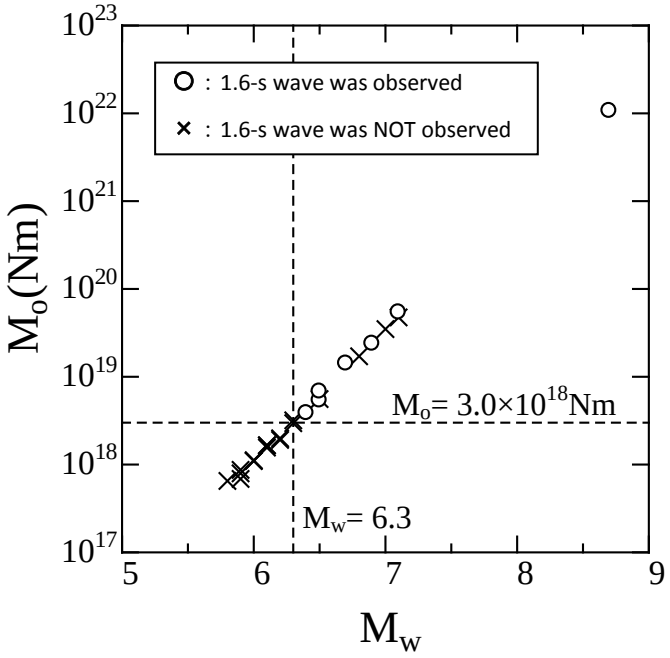

Fig. 4 – Plot of seismic moment M_o vs. the moment magnitude M_w.

Fig. 5 shows the focal mechanisms of the events with seismic moment greater than 3.0×10^{18}Nm ocurred in the longitude of 141°-143° and the latitude of 37°-39°. The radius of the beach ball is proportional to the moment magnitude and the tension quadrants are shaded in black for the events during which the 1.6-sec ground motions were observed at TKY004. Because the Pacific plate subducts beneath the North American plate in this area the source mechanisms are reverse-fault type. The tension axes of the black shaded beach balls direct coordinately demonstrating that the mid-period ground motions at TKY004 were generated under some limited conditions of focal mechanism.

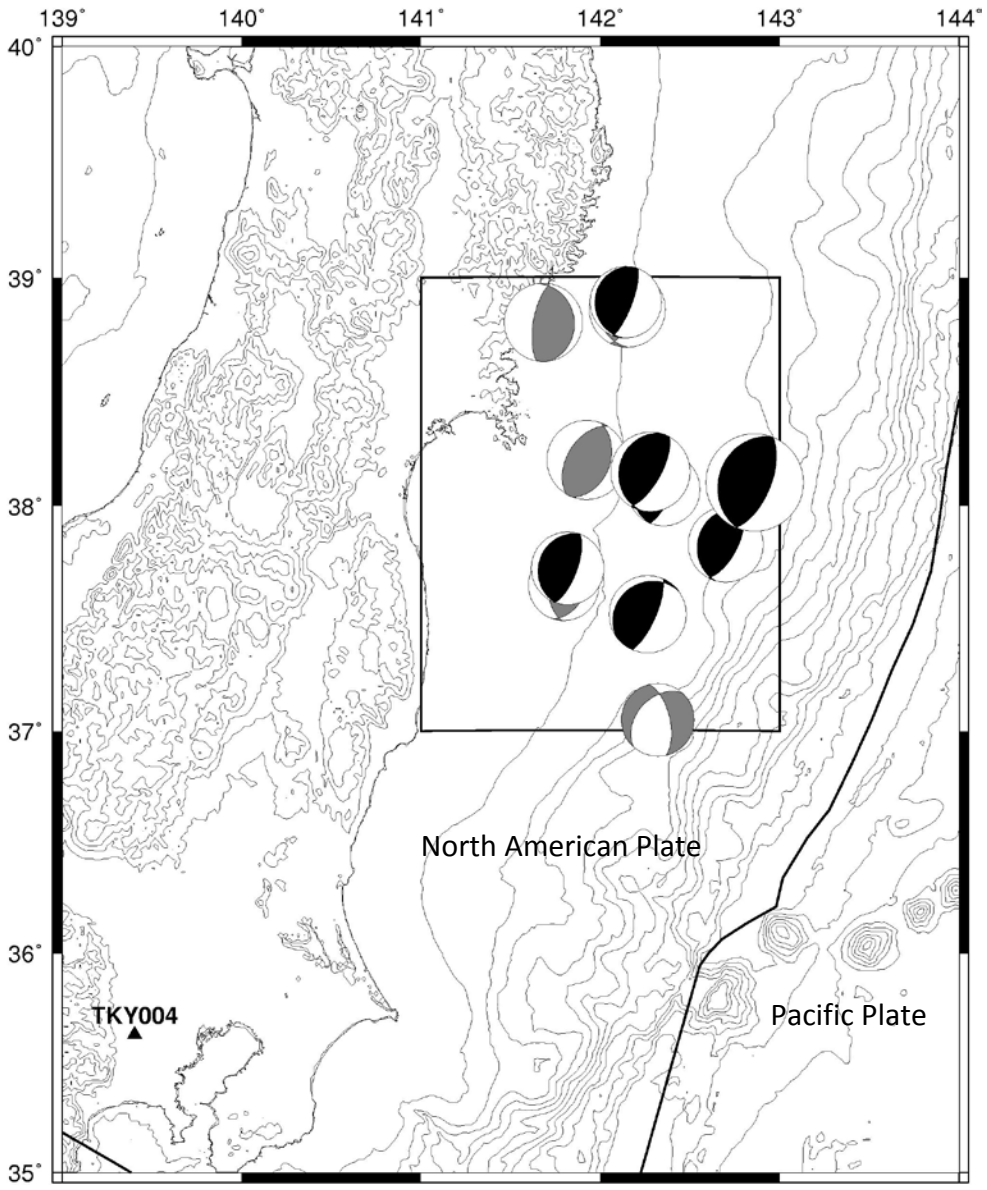

Fig. 5 – Focal mechanisms of the events with Mo > 3.0×10^{18}Nm ocurred in the longitude of 141°-143° and the latitude of 37°-39°.

Fig. 6 shows a plot of strike angle against focal depth of the events with seismic moment greater than 3.0×10^{18}Nm ocurred in the longitude of 141°-143° and the latitude of 37°-39° while Fig.7 shows a plot of rake angle against dip angle of the events. Circles and crosses respectively indicate the events during which the 1.6-sec ground motions were and were not observed at TKY004. From Fig. 6 it is found that circles are between 180° to 240° in strike angle and shallower than 50km in focal depth while from Fig.7 it is found that circles are between 70° to 120° in rake angle and lower than 30° in dip angle, indicating that shallow reverse-fault with low dip-angle are key conditions to generate the 1.6-sec ground motions at TKY004.

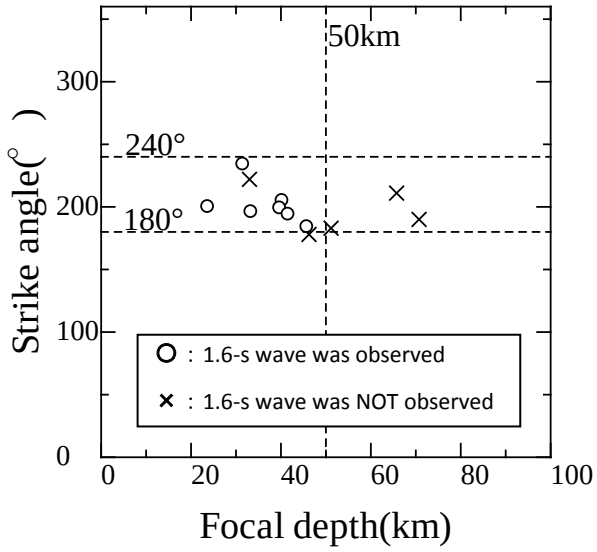

Fig. 6 – Plot of strike angle vs. focal depth.

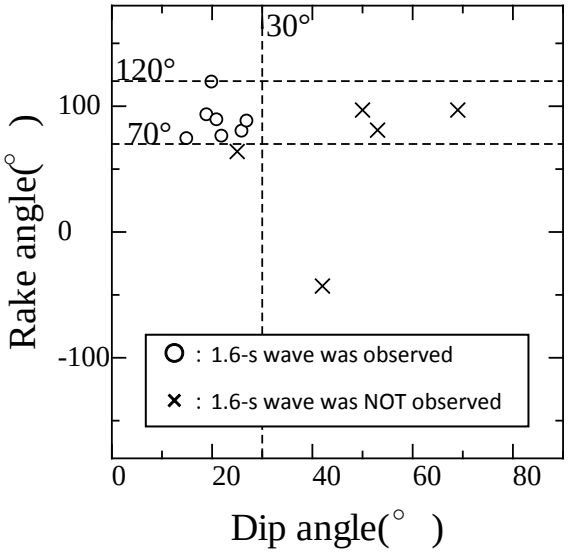

Fig. 7 – Plot of rake angle vs. dip angle.

4. Conclusions

In this study the author investigates the conditions to generate mid-period ground motion at TKY004 located in the western edge of Kanto Plain. The conditions are as follows:

1. The hypocenter is in the longitude of 141°-143° and the latitude of 37°-39° (Northeast of TKY004).
2. The seismic moment is grater than 3.0×10^{18}Nm and the moment magnitude is greater than 6.3(Big event).
3. Strike angle is between 180°-240° (Pacific and North American plate boundary).
4. Focal depth is shallower than 50km (Shallow earthquake).
5. Rake angle is between 70°-120° (Reverse fault).
6. Dip angle is less than 30° (Low dip-angle fault).

Thus in addition to the local geologic condition, a large magnitude with low-angle and shallow-thrust fault ocurred in the northeast of the TKY004 is the source conditions to generate mid-period ground motion in the western edge of Kanto Plain.

5. Acknowledgements

The seismic records investigated in the paper are obtained from K-NET. The seismic parameters and focal mechanism are obtained from NIED. GMT was used to depict maps. The author wishes to thank to all concerned.

6. References

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