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Department of Earth Sciences, National Taiwan Normal Univ.

Subducted Eurasian plate beneath Taiwan: Evidences from slab guided waves and strong motion data

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1. Introduction

Taiwan is located at the boundary between the Philippine Sea Plate (PSP) to the east and the Eurasian Plate (EP) to the west, with a convergence rate of ~80 mm/yr in the northwest direction. This plate boundary is complex since it contains two subduction zones of reverse polarities. The PSP subducted underneath the EP in northern Taiwan, whereas in southern Taiwan the EP subducted underneath PSP. The interaction between these two plates is still unclear, especially the geometry and shape of EP beneath Taiwan. In this study we want to understand the spatial extent of the EP underneath Taiwan using a special seismic characteristic, guided waves.

Seismic events near subduction zones radiate complex wave field. When intermediate (deeper than 70 km) events occur in subduction zones, seismic waves travel through the plate to the surface stations and produce the special waveforms, In particular, low-frequency arrivals followed by large-amplitude, high-frequency with long coda (Fig. 1) [e.g., Martin and Rietbrock, 2006; Furumura and Kennett, 2005]. These intermediate events cause surprisingly large intensity in the forearc station. They were not felt near the epicenter but far-away region, corresponding to larger amplitude and higher frequency waveforms in the fore arc area (Fig. 2). [e.g., Furumura and Kennett, 2005]. Therefore, large-amplitude and high-frequency waves guided by subducted plate can be used to explain the anomalous ground shaking from deep earthquakes and provides useful information for plate configuration. What are the characteristics of guided waves in the Taiwan subduction zones? If the subducted PSP/EP plays the significant role of efficient waveguide for high-frequency and large-amplitude seismic waves, then we are able to find the anomalous intensity in Taiwan, and furthermore, provide information for the spatial extent of EP underneath Taiwan.

2. Observations and preliminary results

We first select the M>5 and deeper than 80 km earthquakes in southern Taiwan offshore during the study period of 1991-2009 for the following analyses on the seismic waveforms and strong motion records (Fig. 3). The detailed information of the selected M>5 events are shown in Table 1.

- **Peak Ground Acceleration (PGA):**

We choose two M>5 earthquakes with different focal depth to compare their peak ground acceleration (PGA) patterns. As shown in Fig. 5, there appears to be a clear difference in the PGA patterns between the shallow and intermediate events. The shallow event (25.4 km deep)shows the

PGA concentrating near the epicenter in the southeastern Taiwan, whereas the intermediate event (133.2 km deep) moves towards to western Taiwan. Such difference indicates very different travel path, and likely associated with the role of subducted EP.

- **Seismic wave characters:**

In order to understand the possible causes of such PGA anomaly for intermediate event, we display vertical component seismograms at stations located in the west and east of Central Range. Fig. 6 illustrates seismic characters in the west of Central Range. The seismograms in the stations where high PGA concentration took place are rich in high-frequency energy, as shown by the spectrum in Fig. 6. Fig. 7 illustrates seismic characters in the east of Central Range. The seismograms and spectrum shown in Fig. 7, however, shows much less high-frequency content. The difference in seismic characters between eastern and western stations indicates that the PGA anomaly corresponds to high frequency signals.

The different seismic characters can be better viewed by the cross-section in Fig. 8, where we select the M5.51 event on 1999/05/18 with depth of 84.34 km. We cut a cross-section from SE to NW, A to A', with the width of 100 km, where four stations (TTN, WTP, CHN7, and WTC) are sampled. Their waveforms show large difference in frequency content, As shown in Fig. 9, The WTC and CHN7 are rich in high frequency energy, which is likely a result of excitation of high-frequency signals while propagating along the plate.

3. Summary

In this study, we examine the seismic wave characteristics and ground motion data for the deep earthquakes from the subducted EP underneath Taiwan and investigate the possible relationship between these observations. The good spatial correlation between the strong PGA and guided effect found in seismograms implies that a partial guiding across the southern portion of Taiwan carrying a modest amount of high frequency energy and a slowed decay of coda, that explains the PGA anomaly. Guided waves observation provides critical inputs to connecting with the seismic intensity anomalies for ground motion and earthquake hazard estimation. Therefore, how to quantify the characteristics of guided waves is important for a better understanding of the interaction between EP and PSP, which is our future work

Table. 1. Information for the 7 selected earthquakes in this study

Occur date (UTC)	Depth (km)	Magnitude M_L
1993/05/18	188.59	7.12
1993/11/12	184.65	5.88
1994/10/14	124.45	5.65
1998/03/08	173.72	6.05
1999/05/18	84.34	5.51
2003/09/10	85.36	5.76
2005/11/16	133.2	5.46

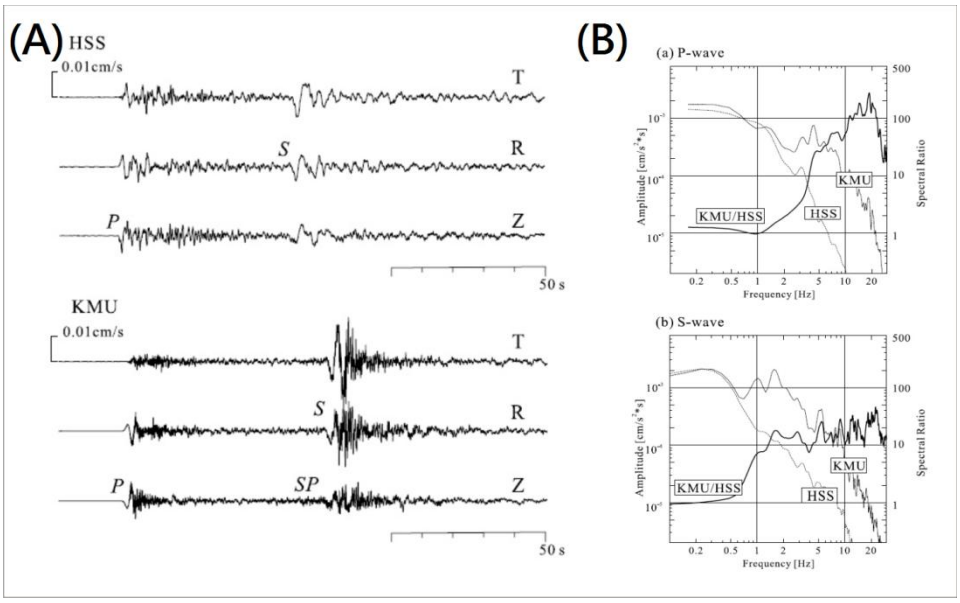

Fig. 1. (A) Three-component broadband seismograms for the 2 February 2002 event recorded at HSS in the backarc region and KMU in the forearc region. (B) Fourier spectrum of the broadband records at HSS and KMU shown in (left) for (a) P waves and (b) S waves and the spectral ratio of KMU relative to HSS (thick line). [Furumura and Kennett, 2005].

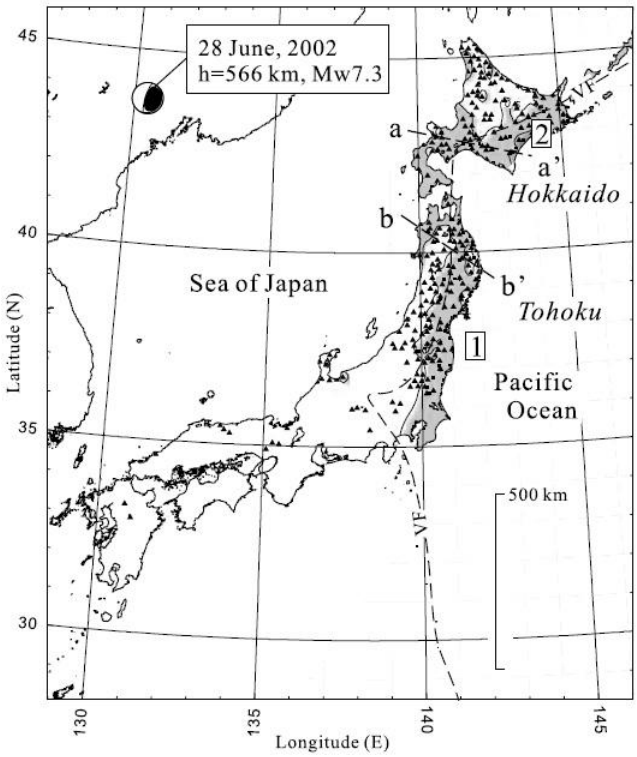

Fig. 2. Anomalous seismic intensity pattern for deep earthquake on 28 June., 2002 (depth=566 km). The triangle indicates the strong motion station. The dashed line indicates the volcanic front. Number in the small box indicates the seismic intensity. The region of large intensity is far away from the epicenter [Furumura and Kennett, 2005].

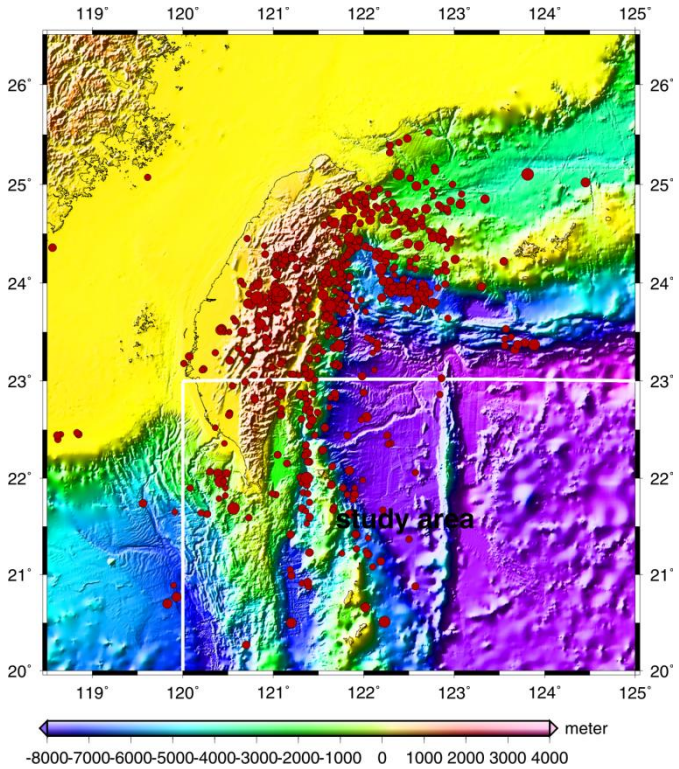

Fig. 3. M>5 earthquakes recorded at CWBSN (Central Weather Bureau Seismic Network) and BATS (Broadband Array in Taiwan for Seismology). Dark red circles in the white box indicate the 1991-2009 M>5 earthquakes used in this study.

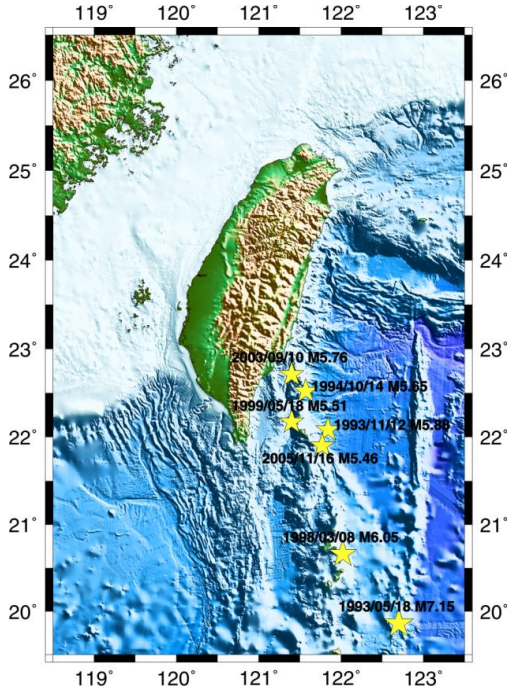

Fig. 4. The 7 deeper than 80 km earthquakes selected in the waveform analysis of this study.

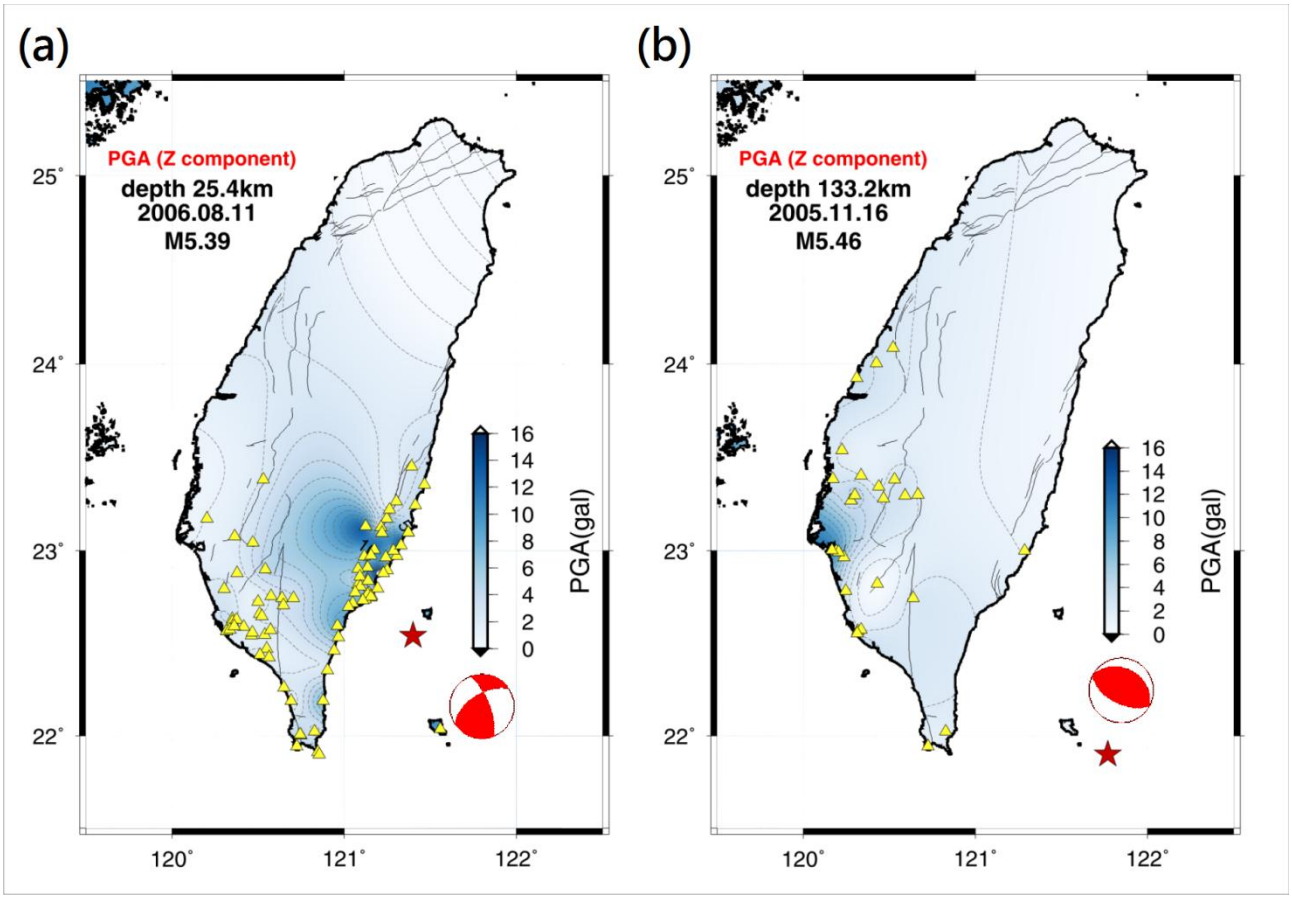

Fig. 5. Examples of different PGA patterns for the shallow and intermediate events. (a) 2006/8/11 M5.39 earthquake at a depth of 25.4 km. (b) 2005/11/16 M5.46 at a depth of 133.2 km. Epicenter is denoted by red star with focal mechanism. Strong motion stations are denoted by yellow triangles.

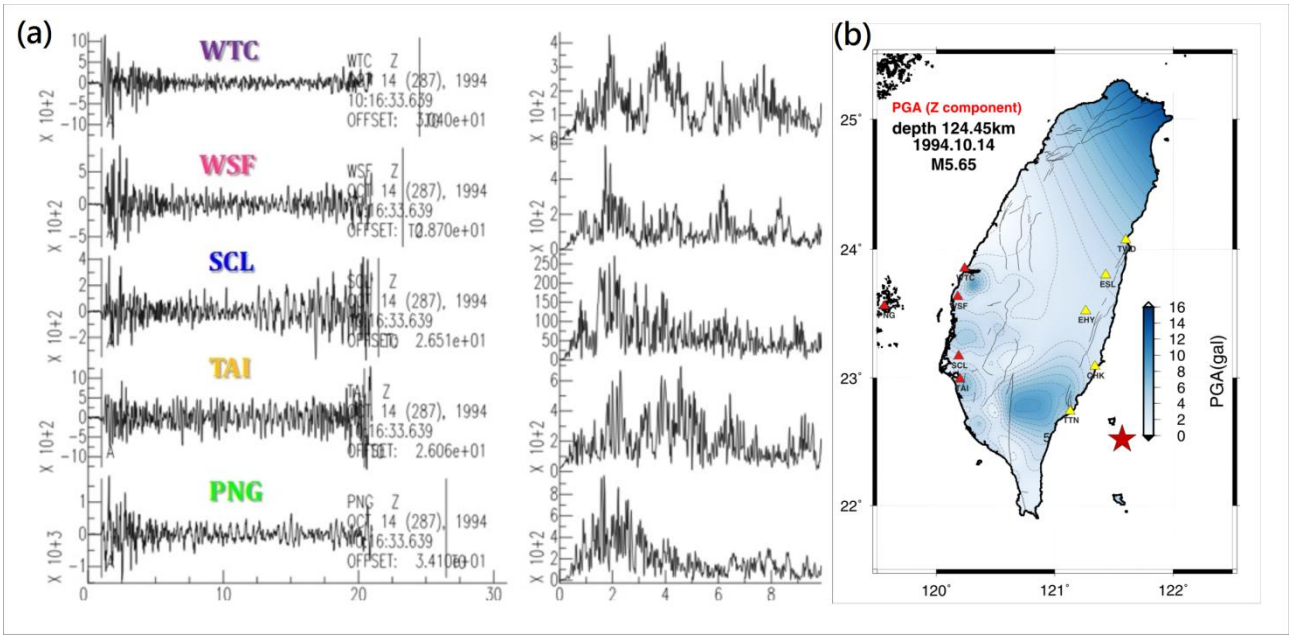

Fig. 6. Seismic characters of a M5.65 event (124.45 km deep) recorded at the stations in the west of Central Range (a) The 20-s-long seismograms and spectrums for the stations denoted by red triangles in (b). (b) The PGA pattern for this event. Red star indicates the epicenter.

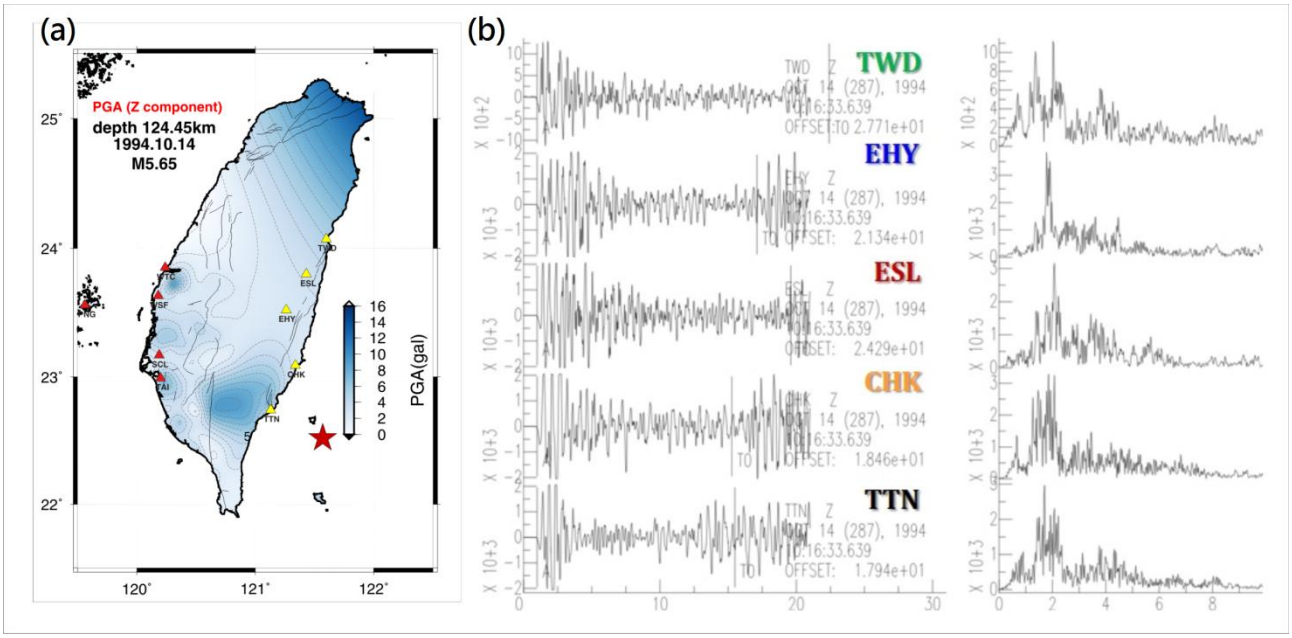

Fig. 7. Seismic characters of a M5.65 event (124.45 km deep) recorded at the station in the east of Central Range. (a) PGA pattern. (b) The 20-s-long seismograms and spectrums for the stations denoted by yellow triangles in (a).

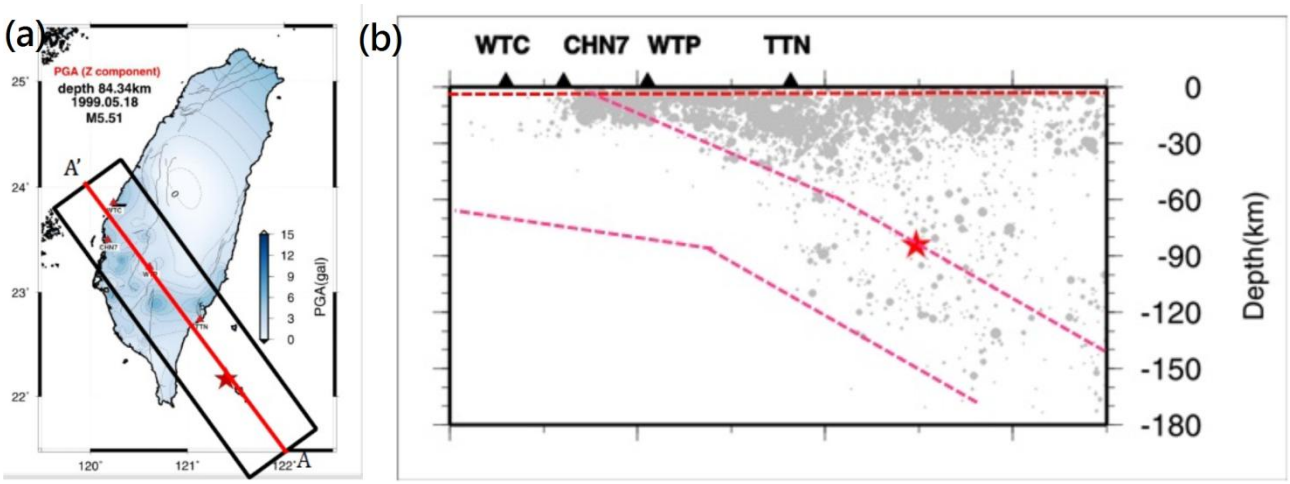

Fig. 8. (a) PGA pattern for a M5.51 event (focal depth: 84.34 km). (b) Cross section A-A'. Red star indicates the hypocenter and the pink dashed line display the possible plate configuration. The seismic wave characteristics are illustrated in Fig. 9.

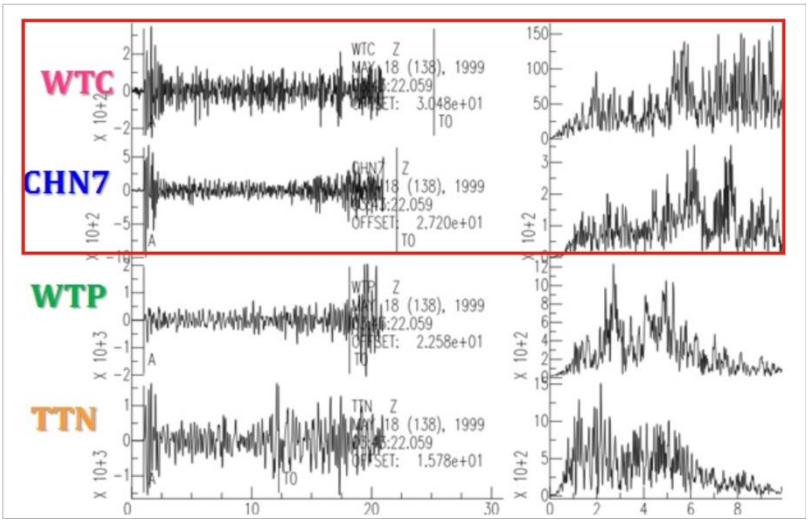

Fig. 9. Seismogram (left) and spectra (right)for the four stations along the A-A' cross-section in Fig. 8. The WTC and CHN7 stations revealed anomalous PGA concentration are rich in higher frequency.