

Common analysis of ground rotation, dynamic strain and translation from near source large earthquakes and its possible implications

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and C.C. Liu

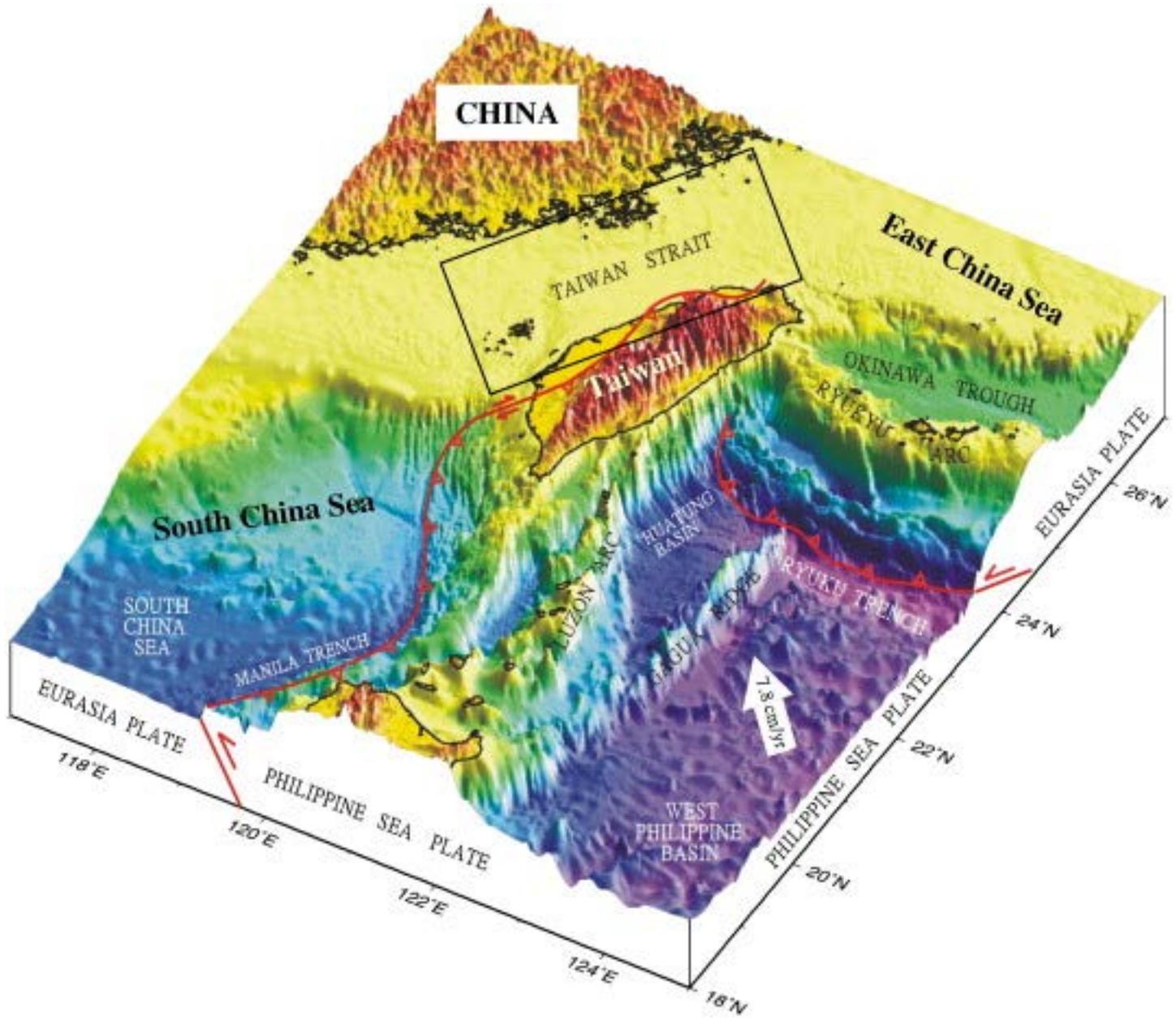
Institute of Earth Sciences,
Academia Sinica, Taiwan



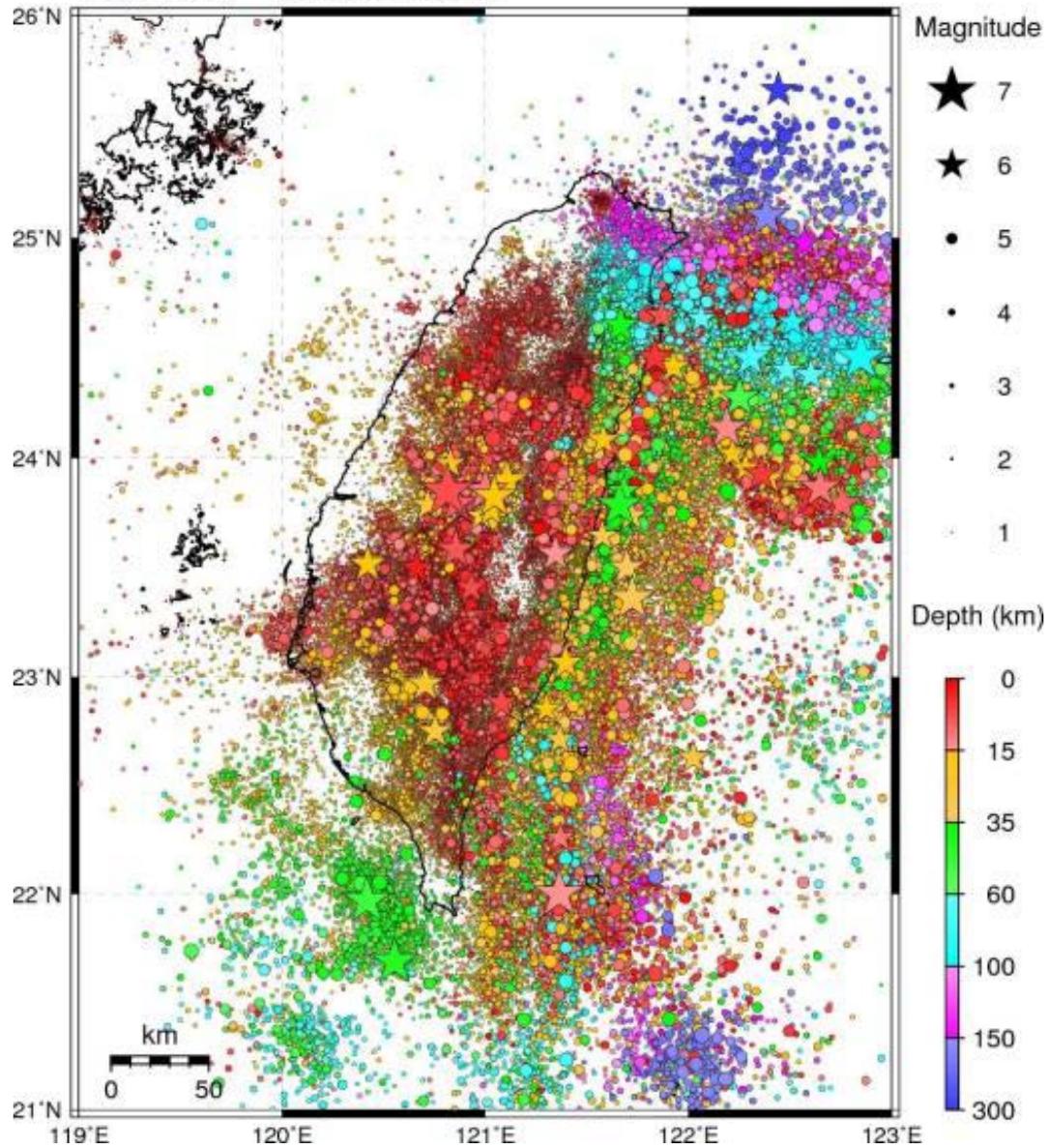
Outline

- Seismic Observations of the 1999 Chi-Chi Taiwan Earthquake
 - Array analysis for rotation and strain for this event
 - Possible implications for source rupture
-

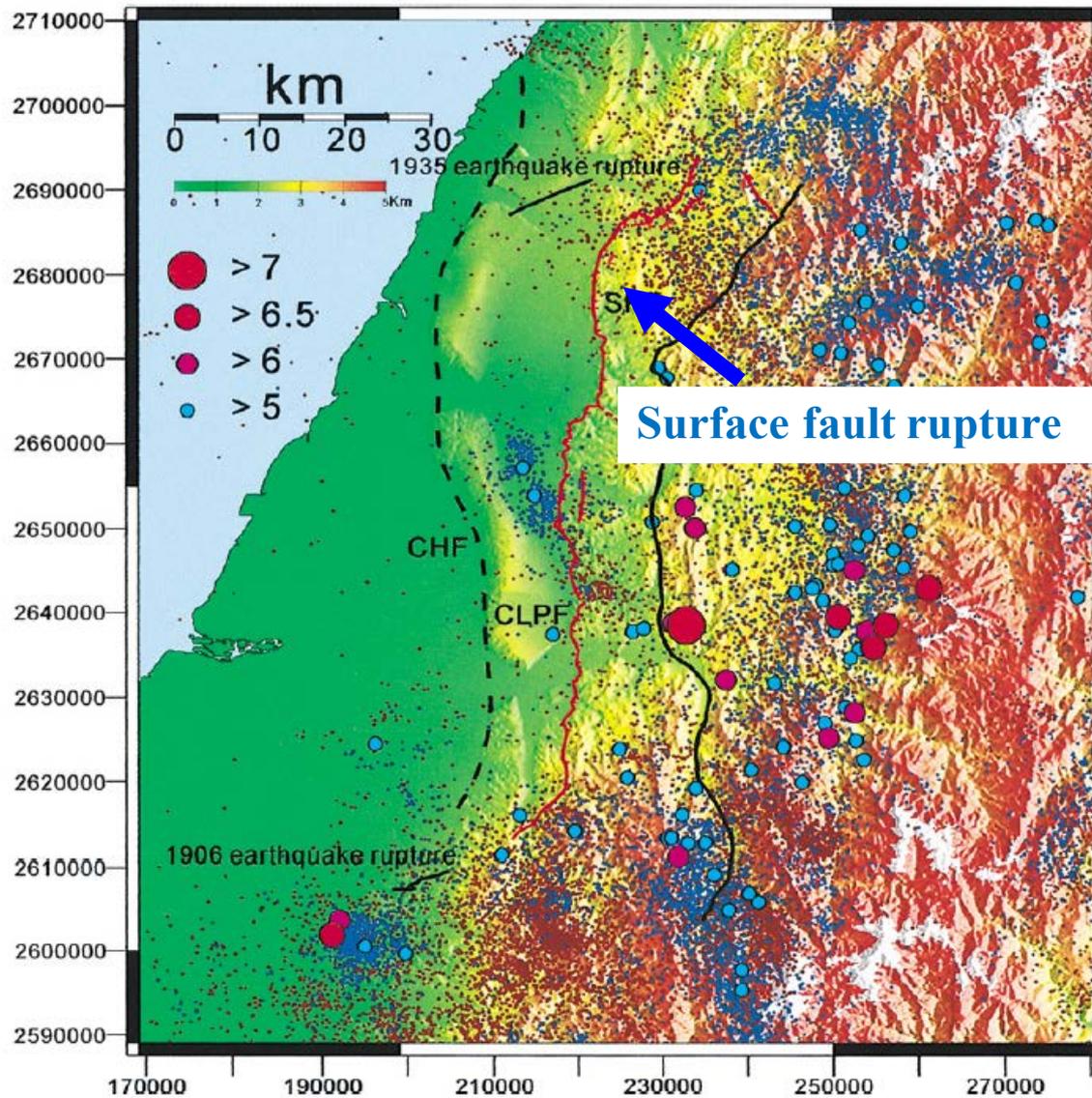
Seismological Introduction of the Chi-Chi Taiwan Earthquake



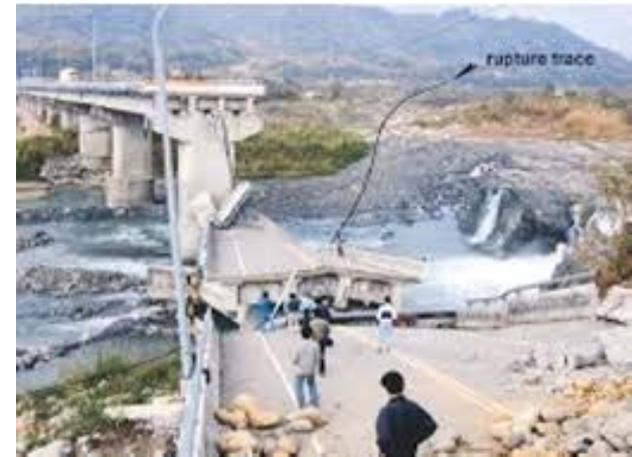
1991-2013 ~ 478,363 events



The 1999 Chi-Chi Taiwan Earthquake ($M_s=7.6$)



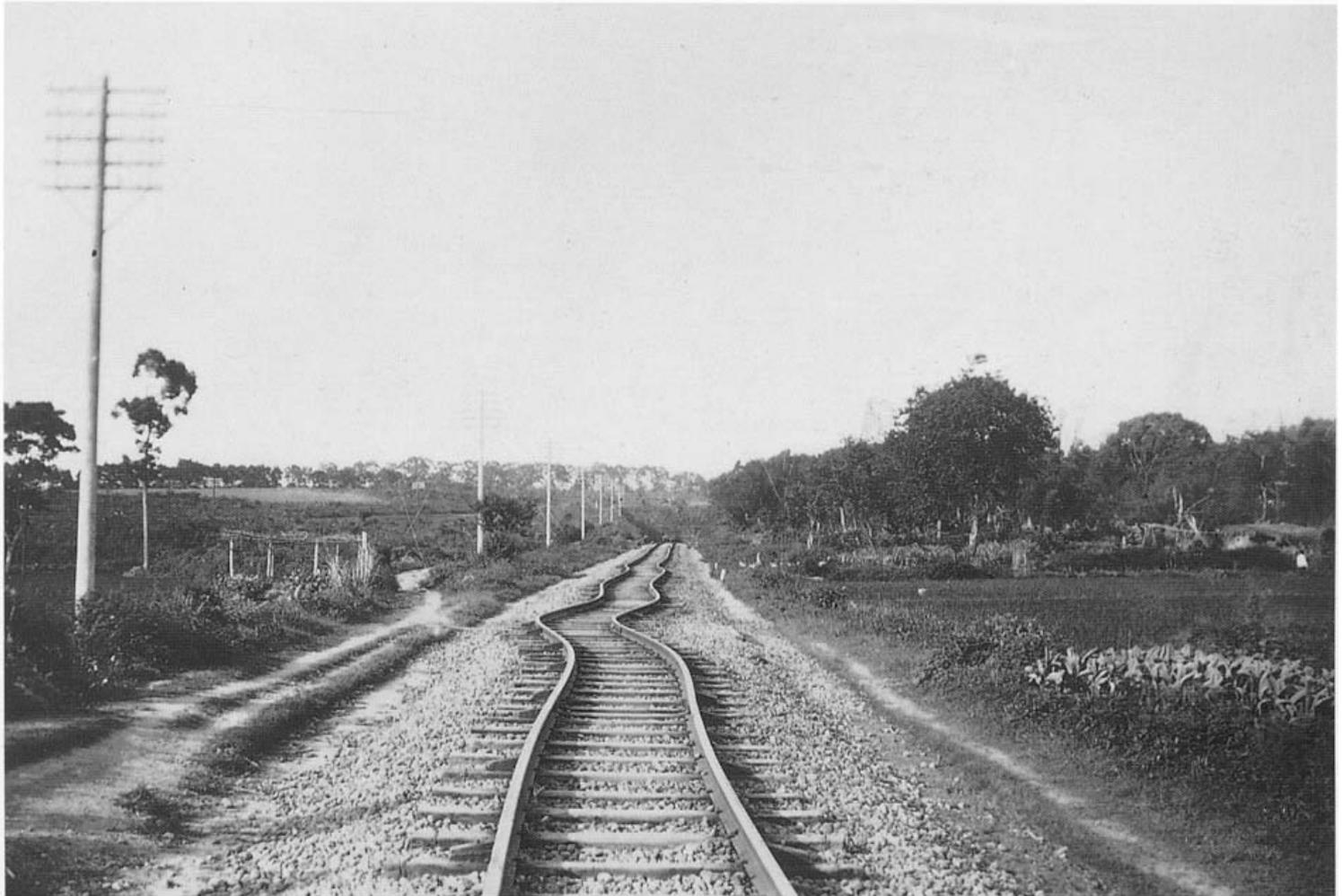
Damages of the 1999 Chi-Chi earthquake



1999 Chi-Chi Taiwan Earthquake



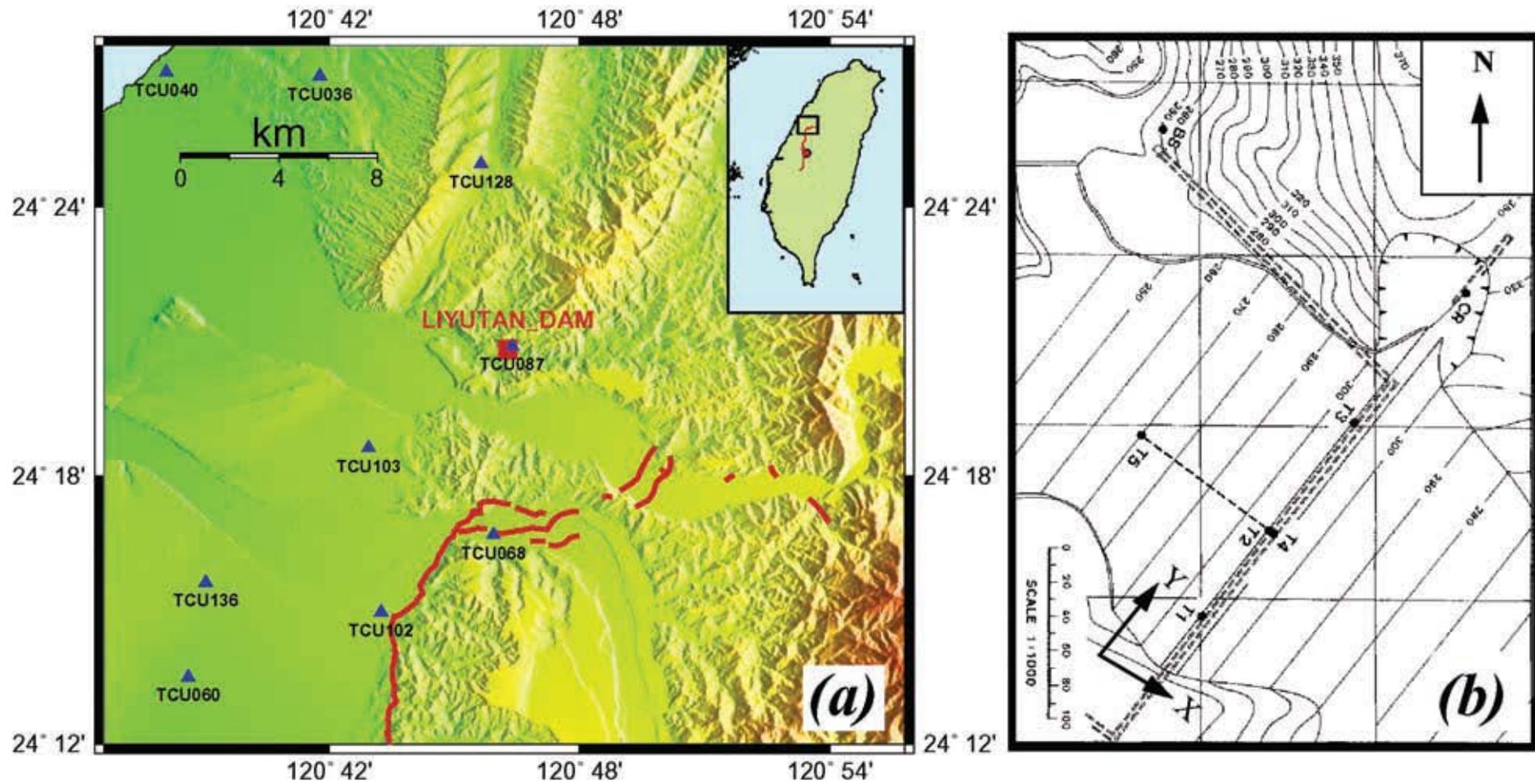
1935 Central Taiwan Earthquake



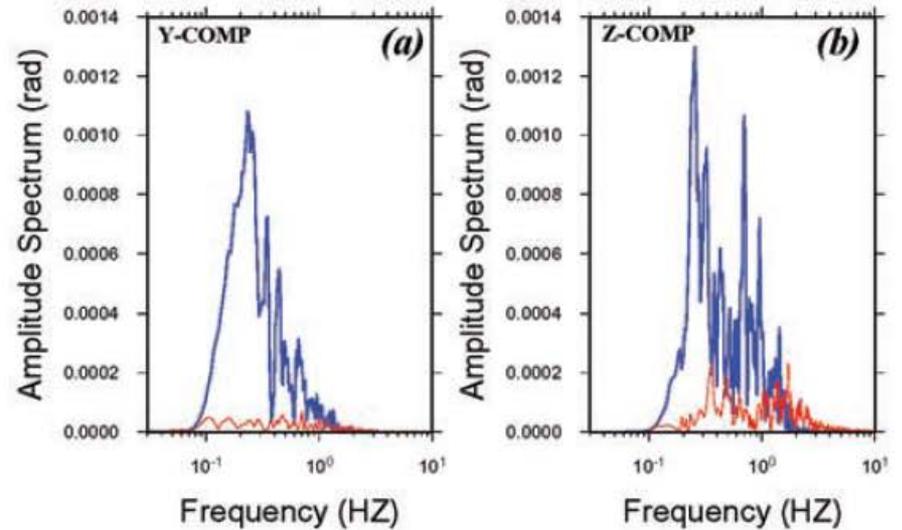
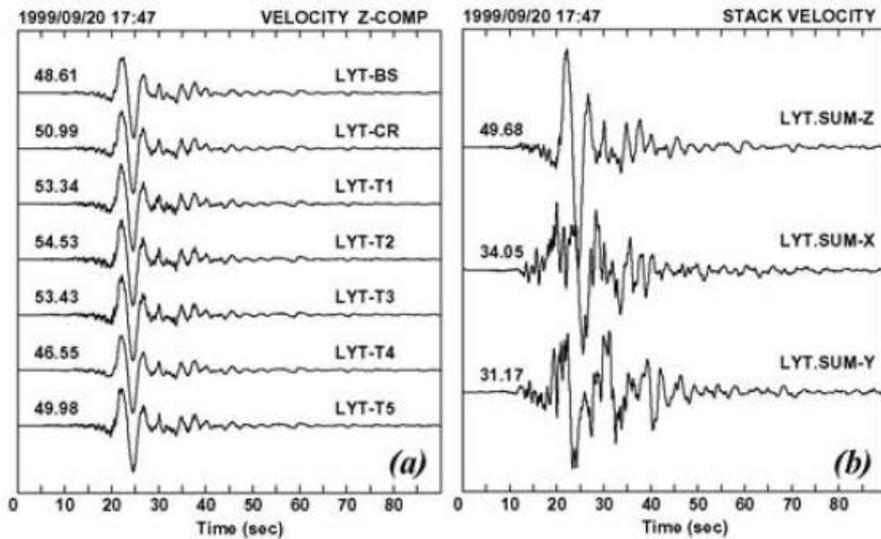
提供人 / 陳桂田先生

后里站北方第八號隧道南出口山線鐵路彎曲，這乃是「雁行斷層」呈東北—西南走向而產生的彎曲。

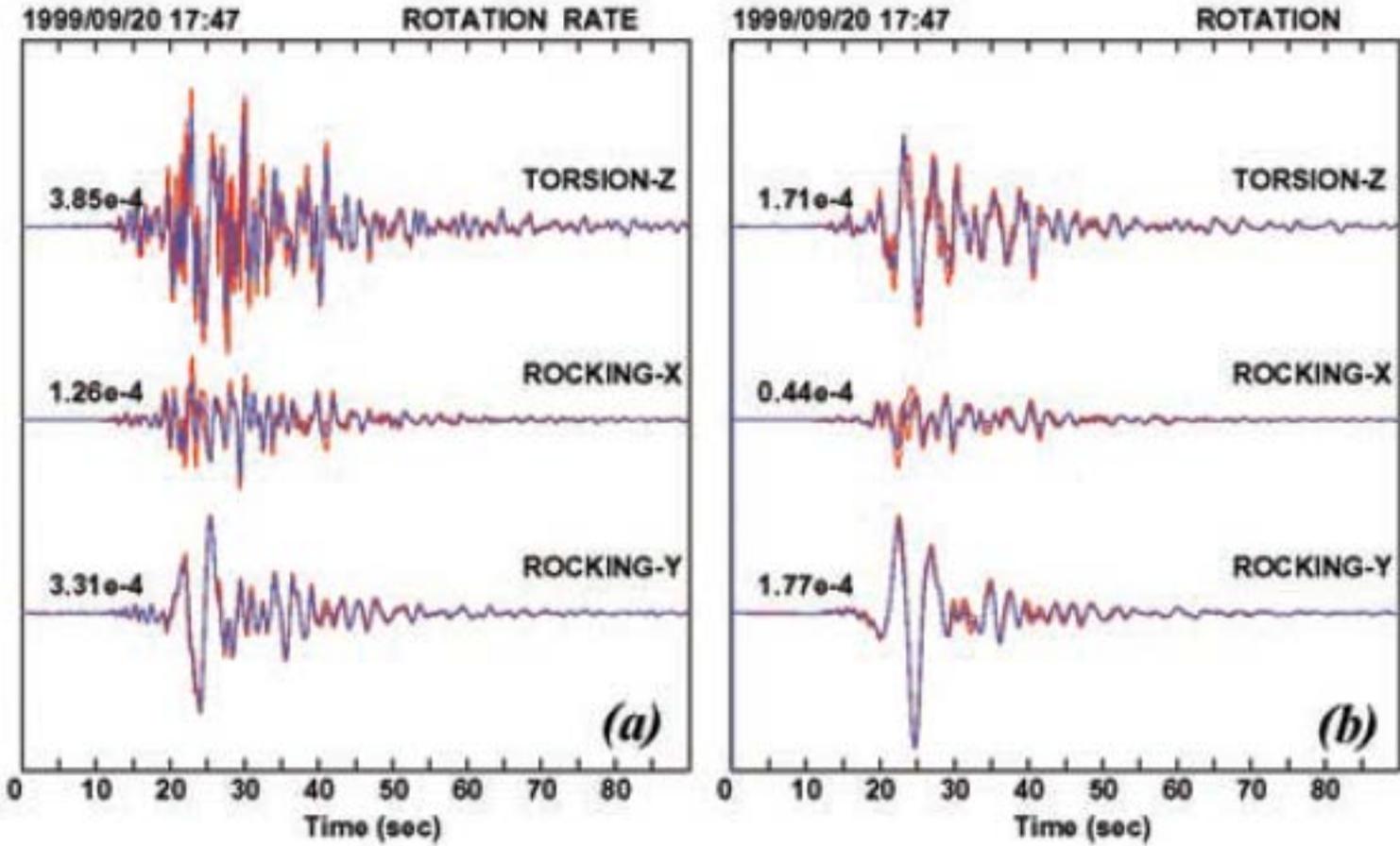
Array observations near the northern end of the earthquake fault

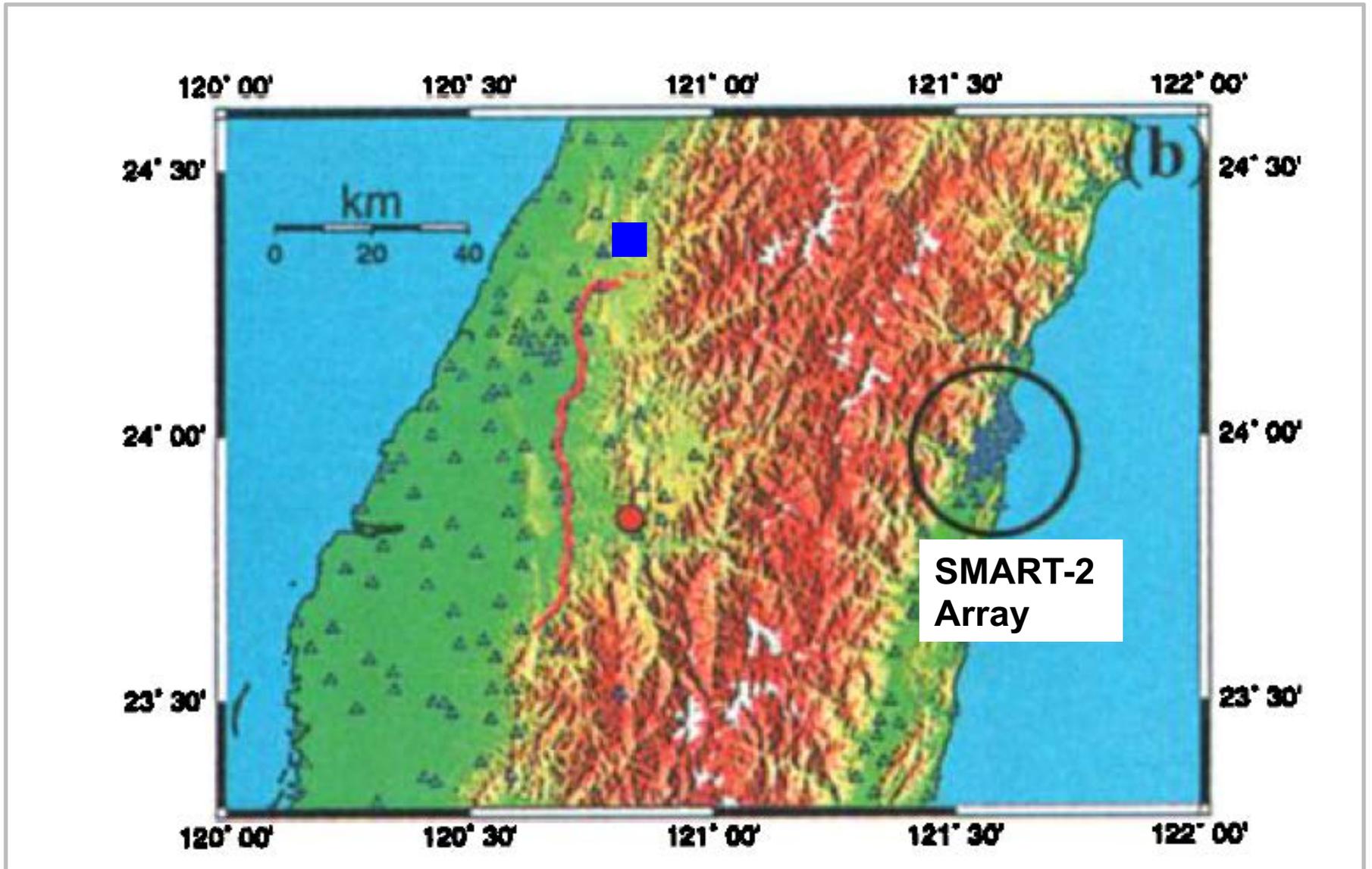


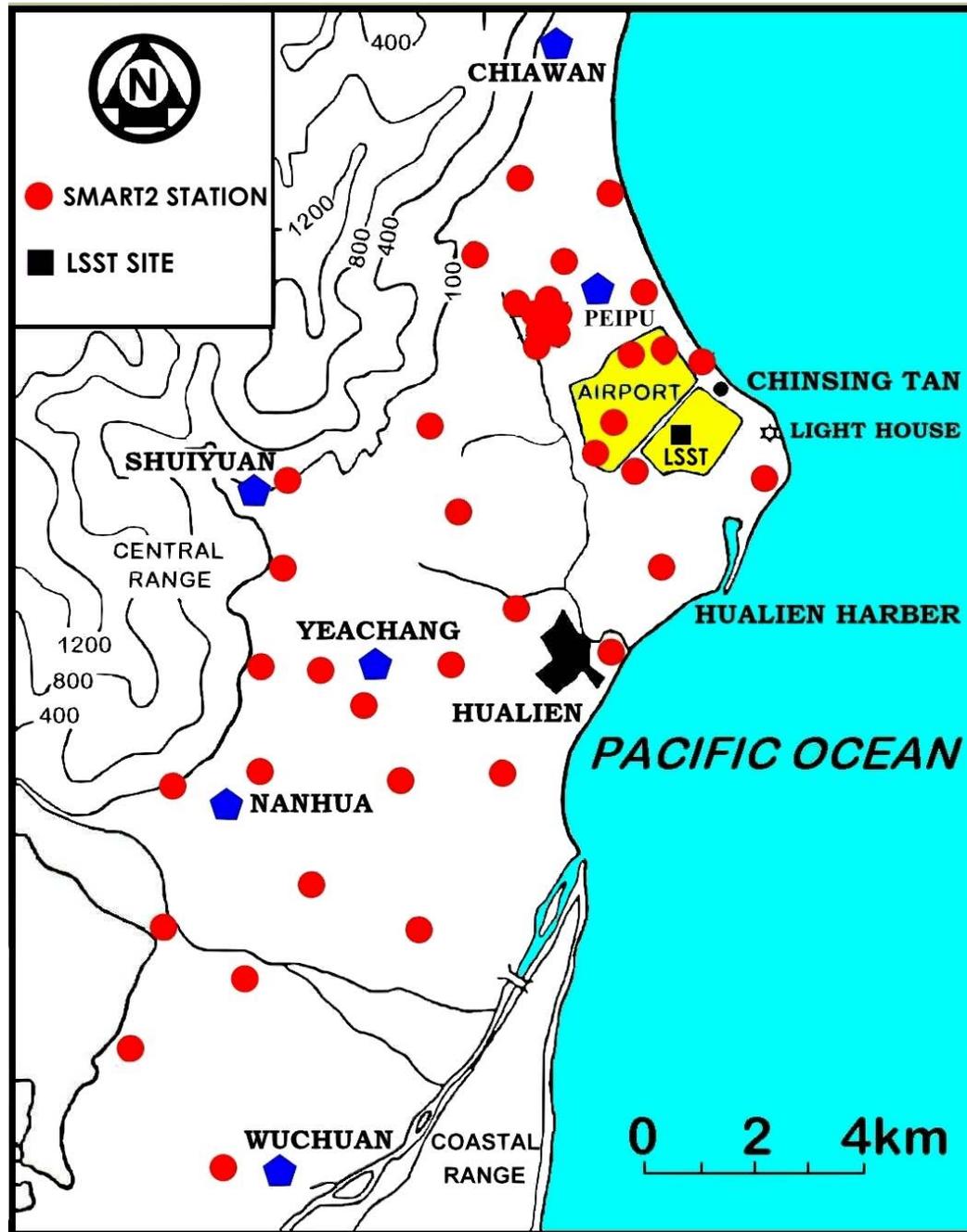
Array translation data



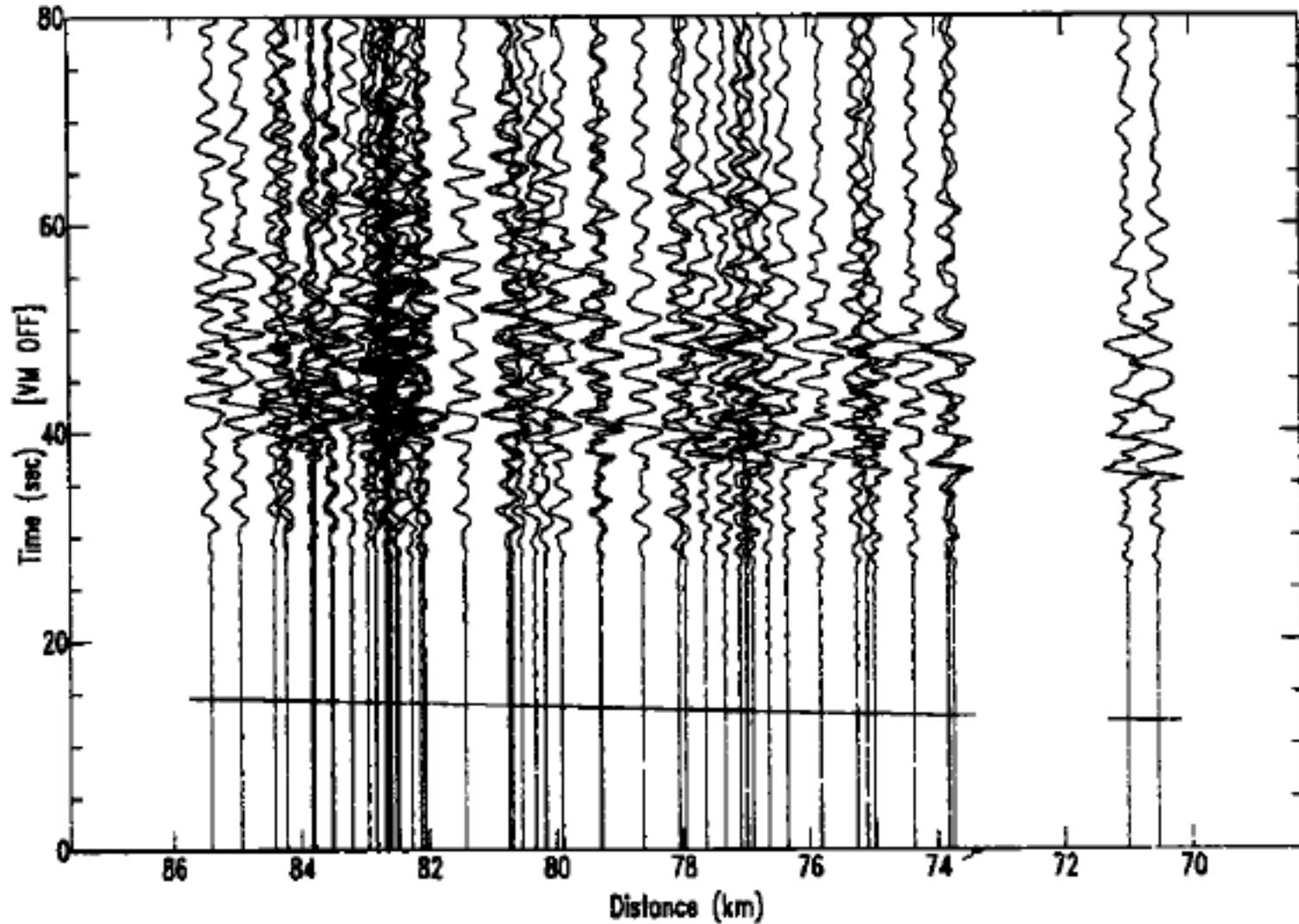
Deduced ground rotations from array observations

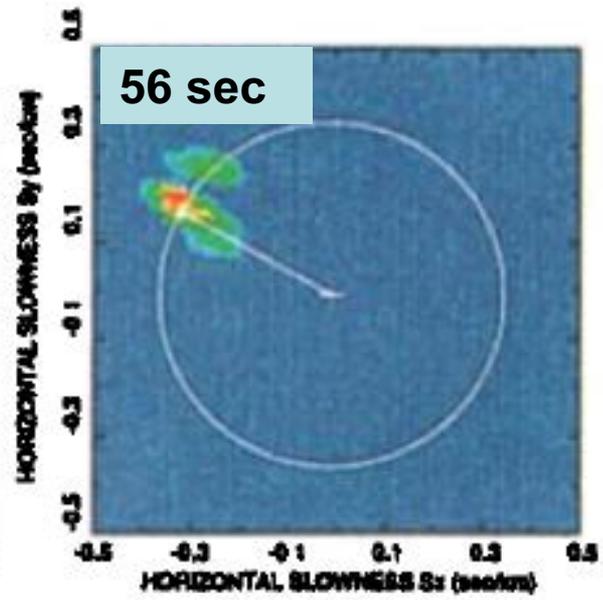
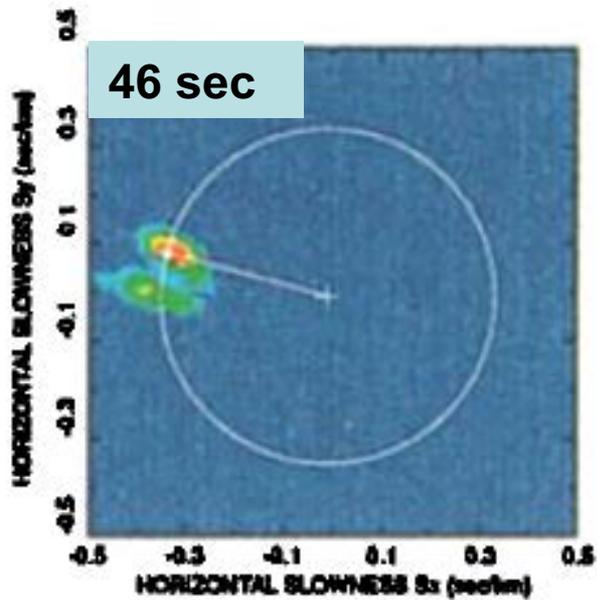
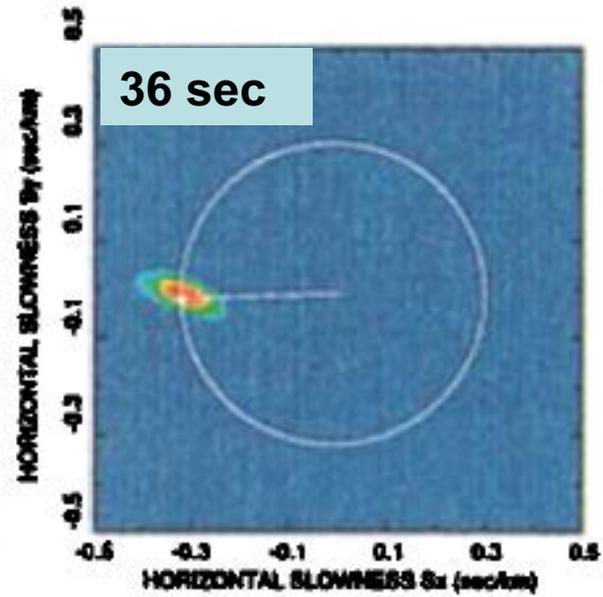
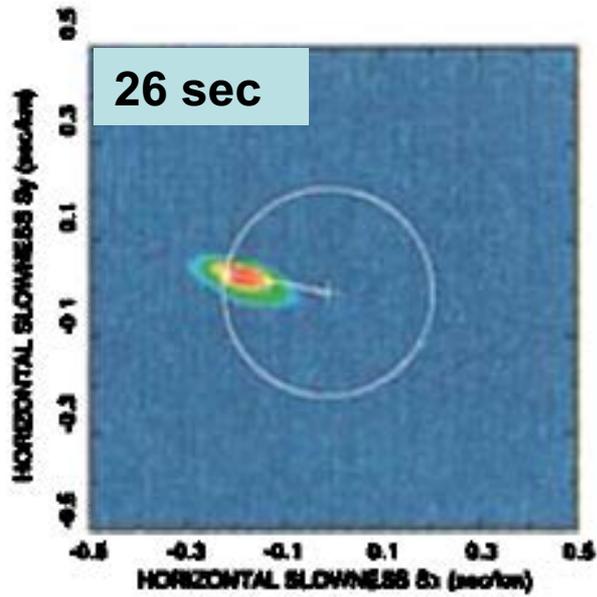




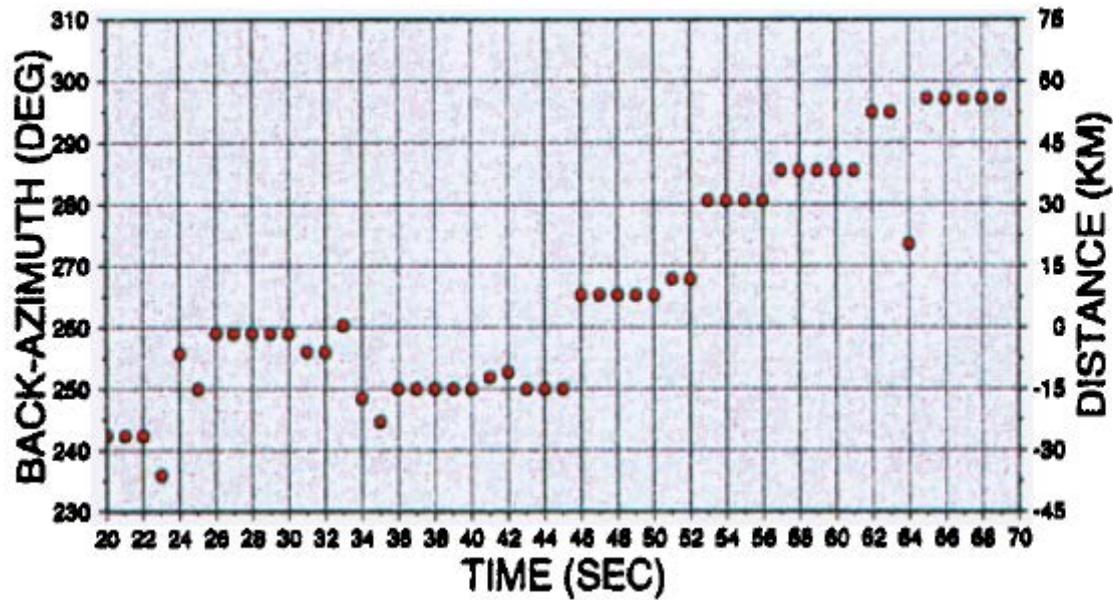


Vertical translation seismograms

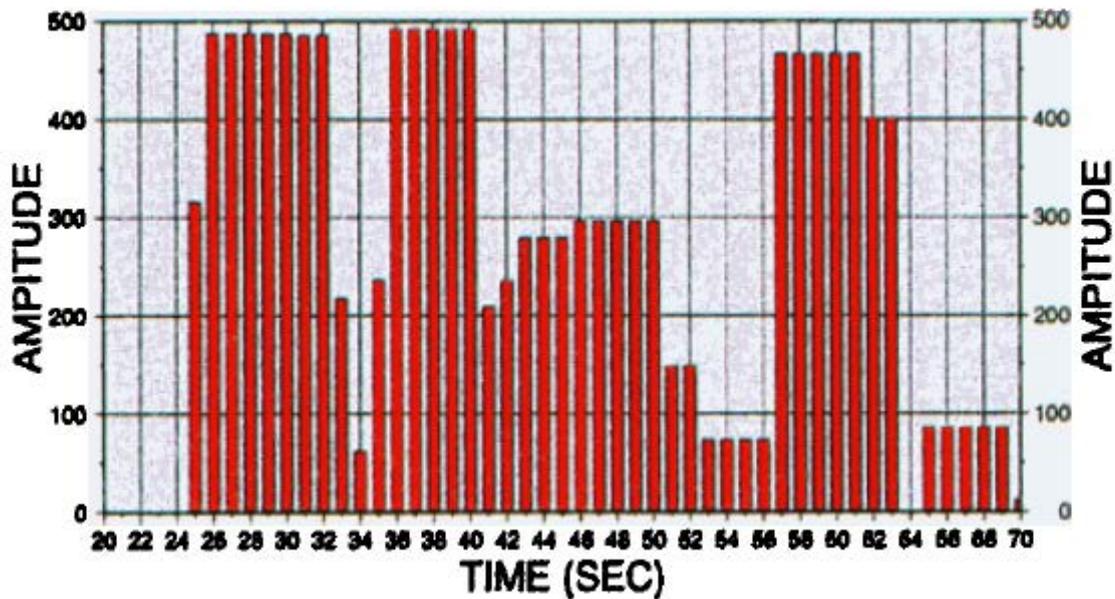


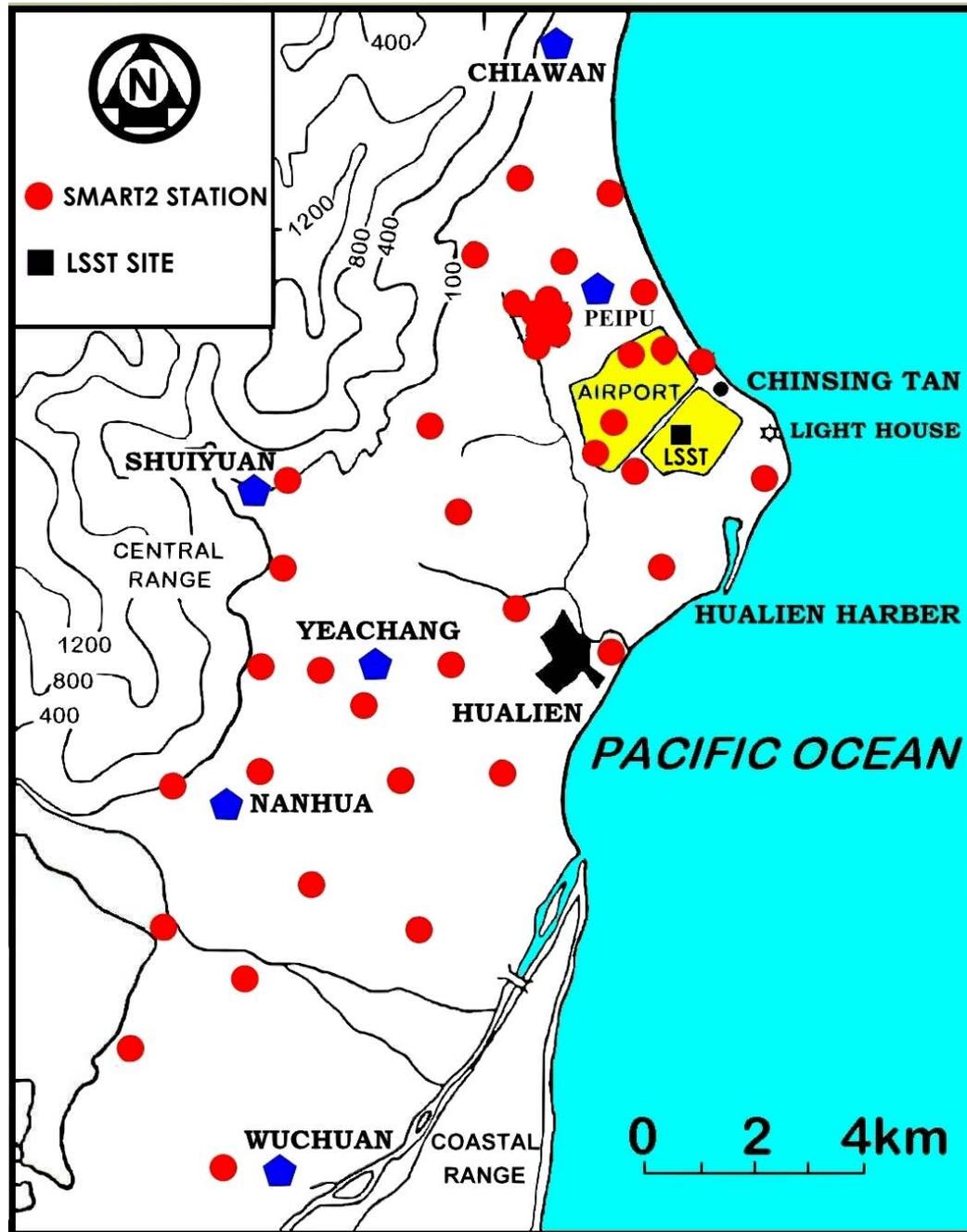


Beam Azimuth (a)

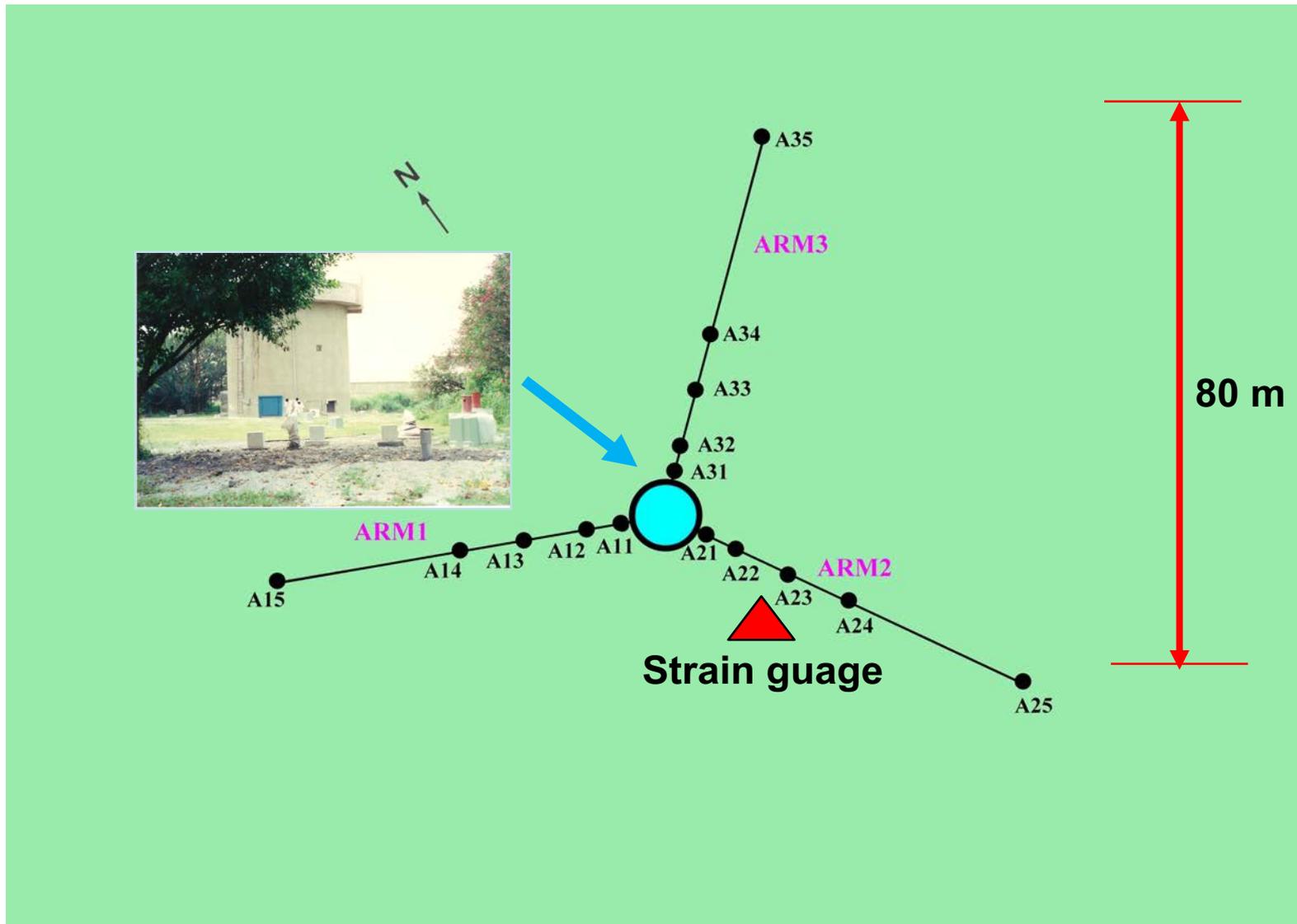


Beam Amplitude (b)

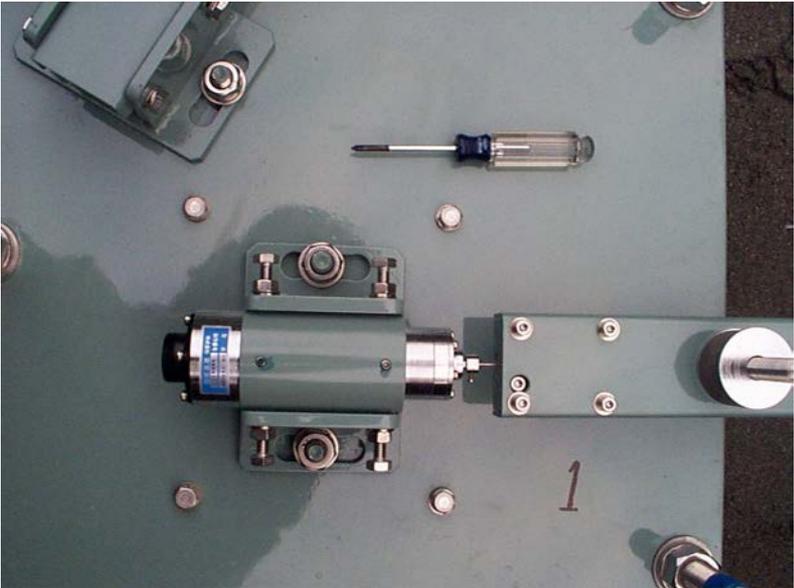
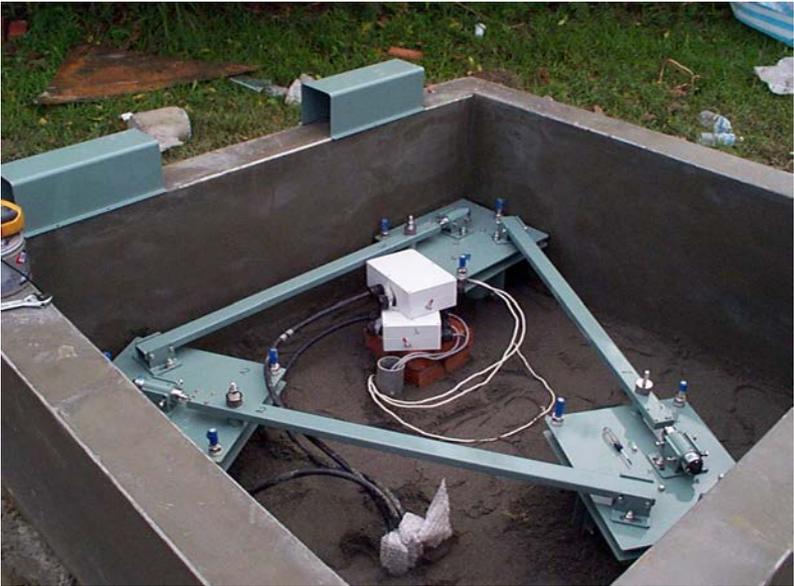




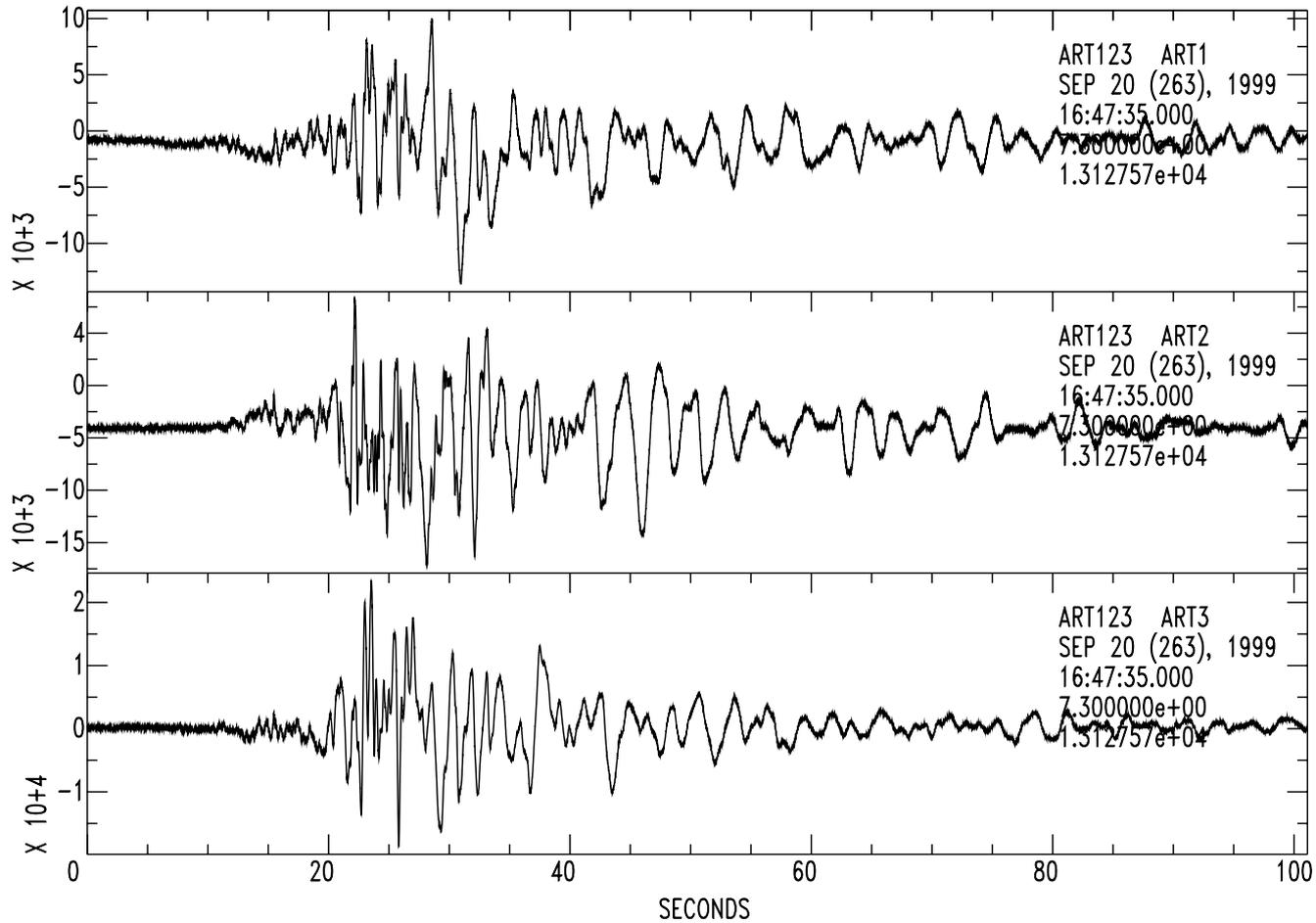
Hualien Large Scale Seismic Test (HLSST)

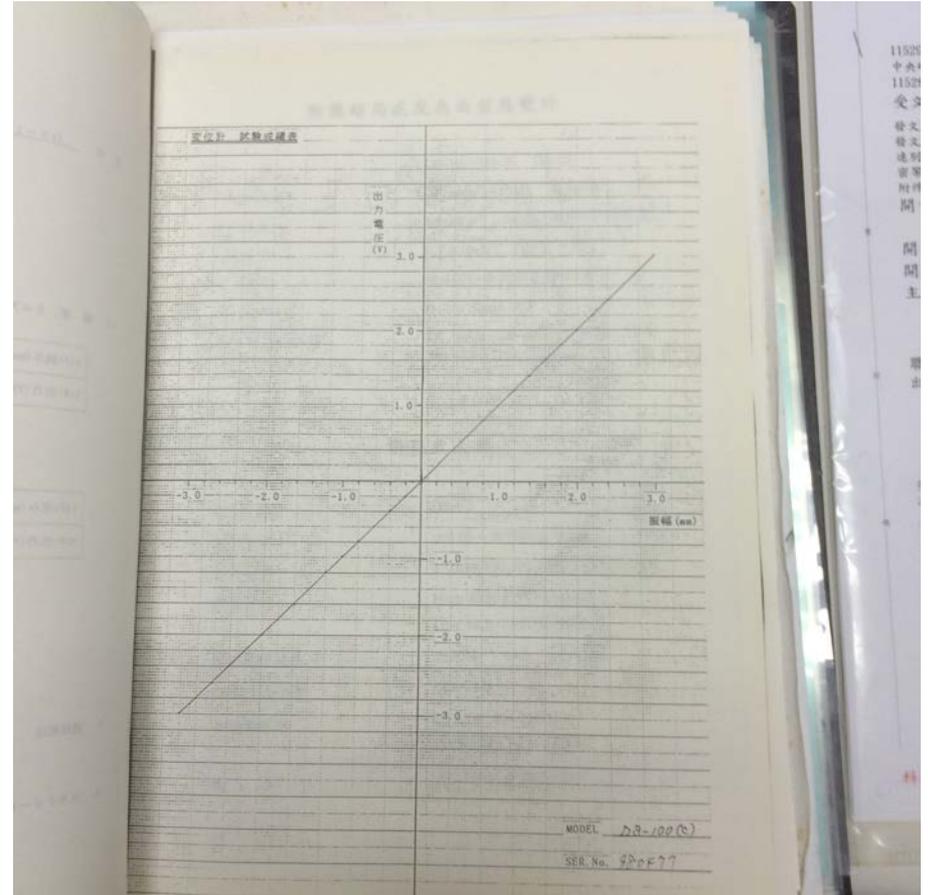
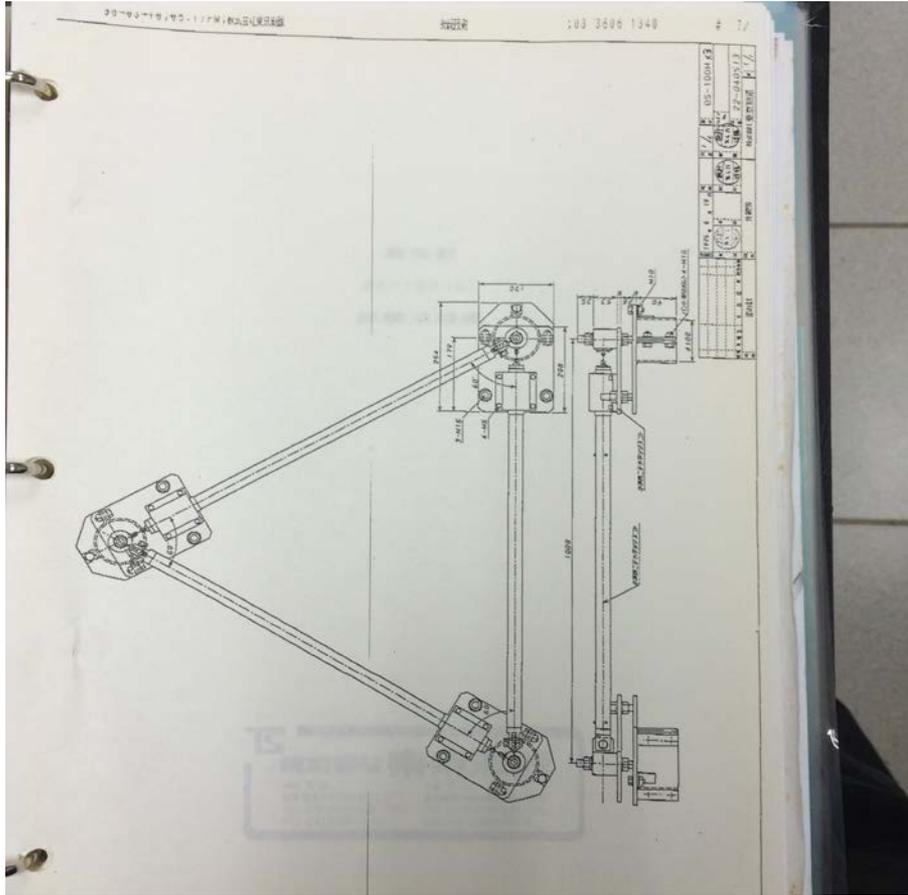


Installation of Delta Strain Guage



Delta Strain Guage recorded dynamic strain motions

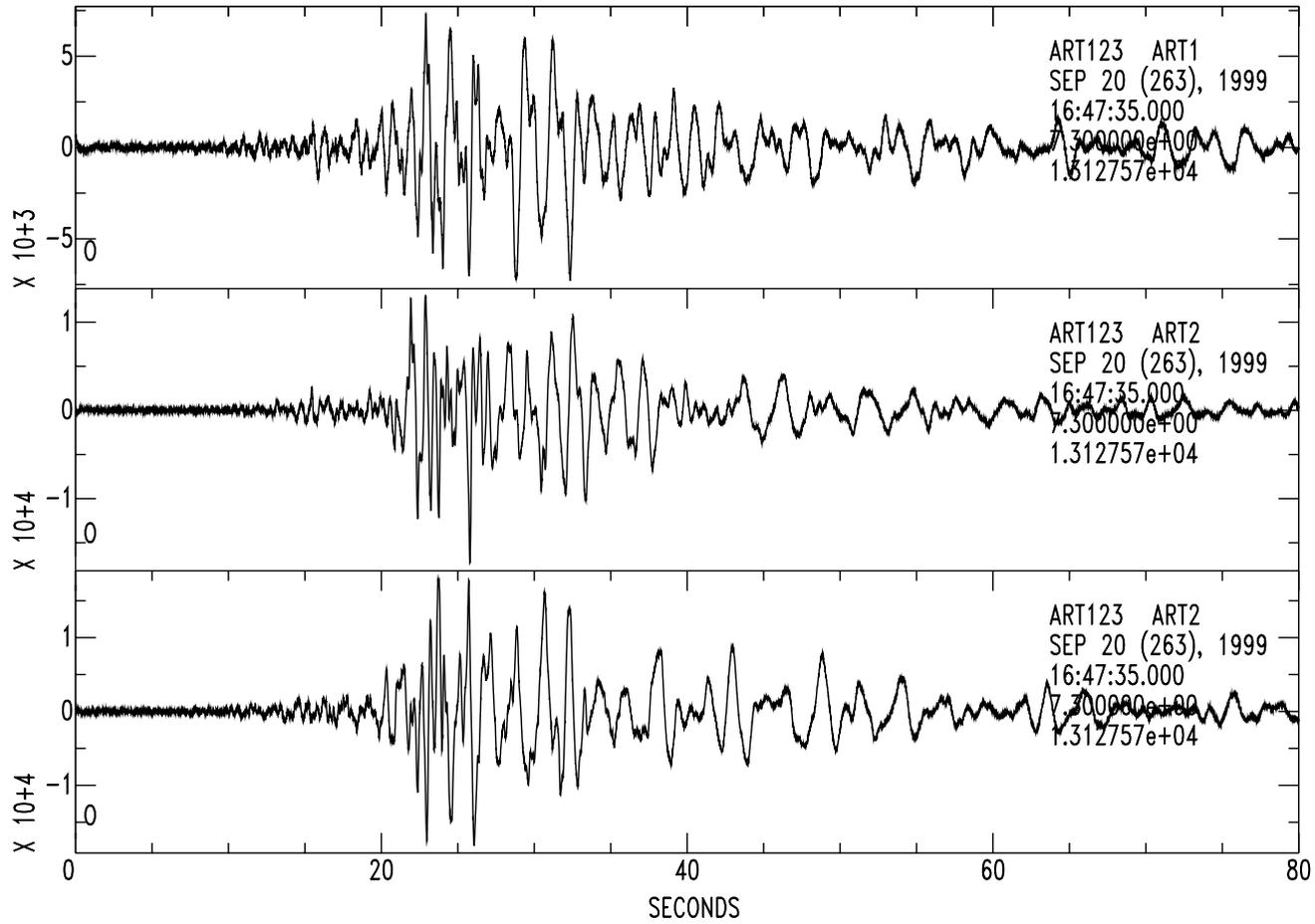




$$\varepsilon_{0^\circ} = \varepsilon_x \cos^2(0^\circ) + \varepsilon_y \sin^2(0^\circ) + \gamma_{xy} \cos(0^\circ) \sin(0^\circ)$$

$$\varepsilon_{60^\circ} = \varepsilon_x \cos^2(60^\circ) + \varepsilon_y \sin^2(60^\circ) + \gamma_{xy} \cos(60^\circ) \sin(60^\circ)$$

$$\varepsilon_{120^\circ} = \varepsilon_x \cos^2(120^\circ) + \varepsilon_y \sin^2(120^\circ) + \gamma_{xy} \cos(120^\circ) \sin(120^\circ)$$

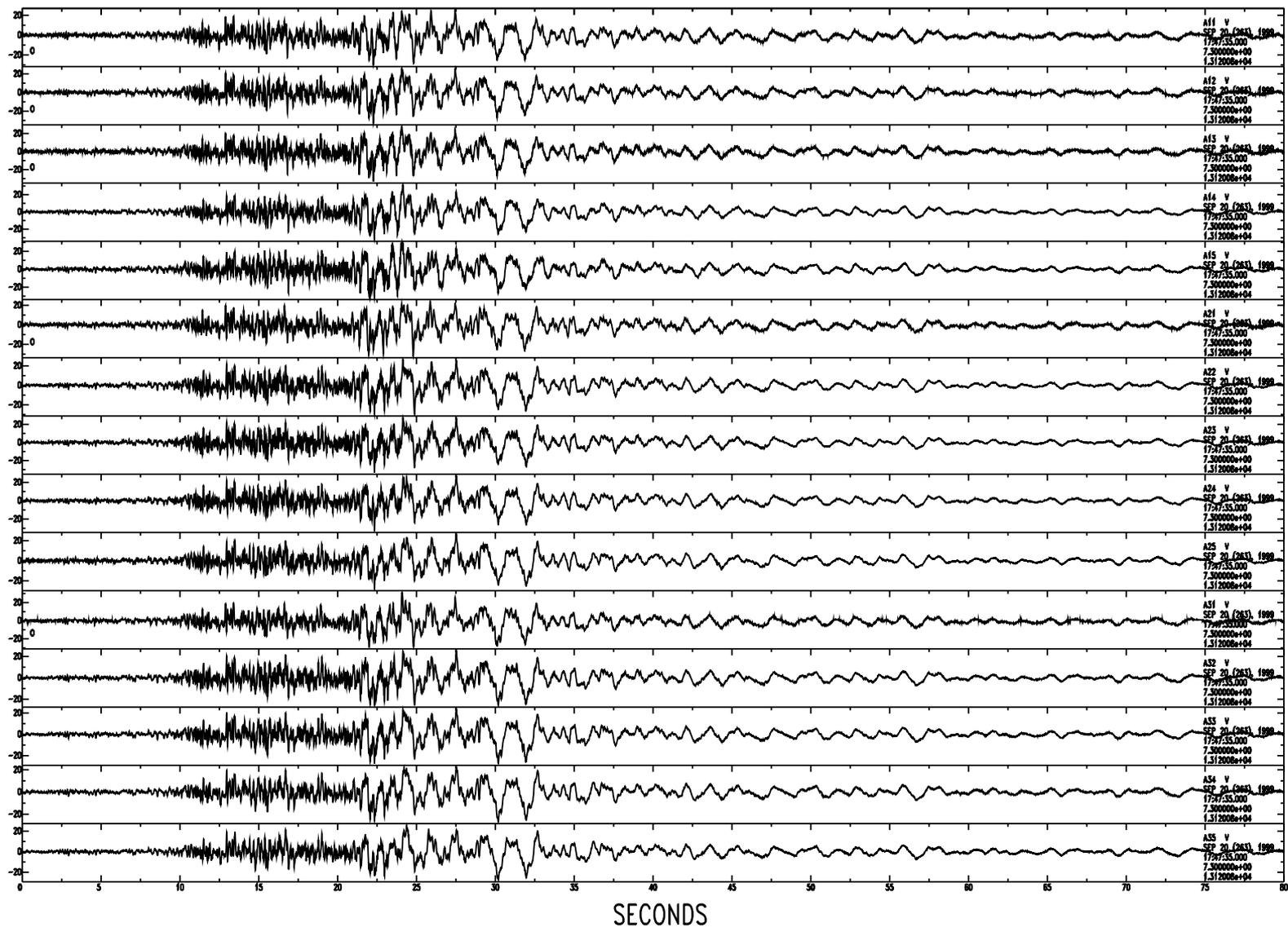


Exx

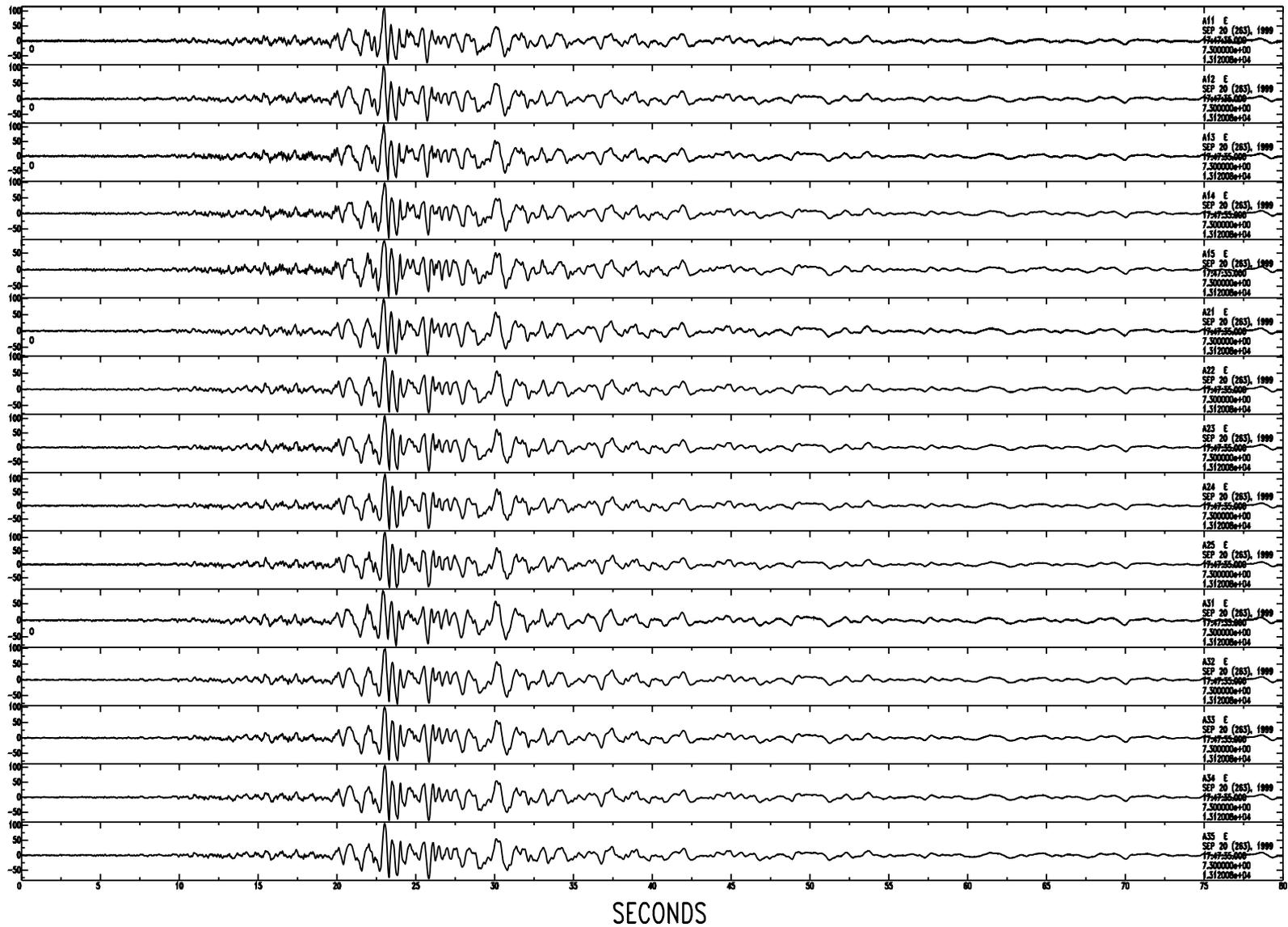
Eyy

Txy

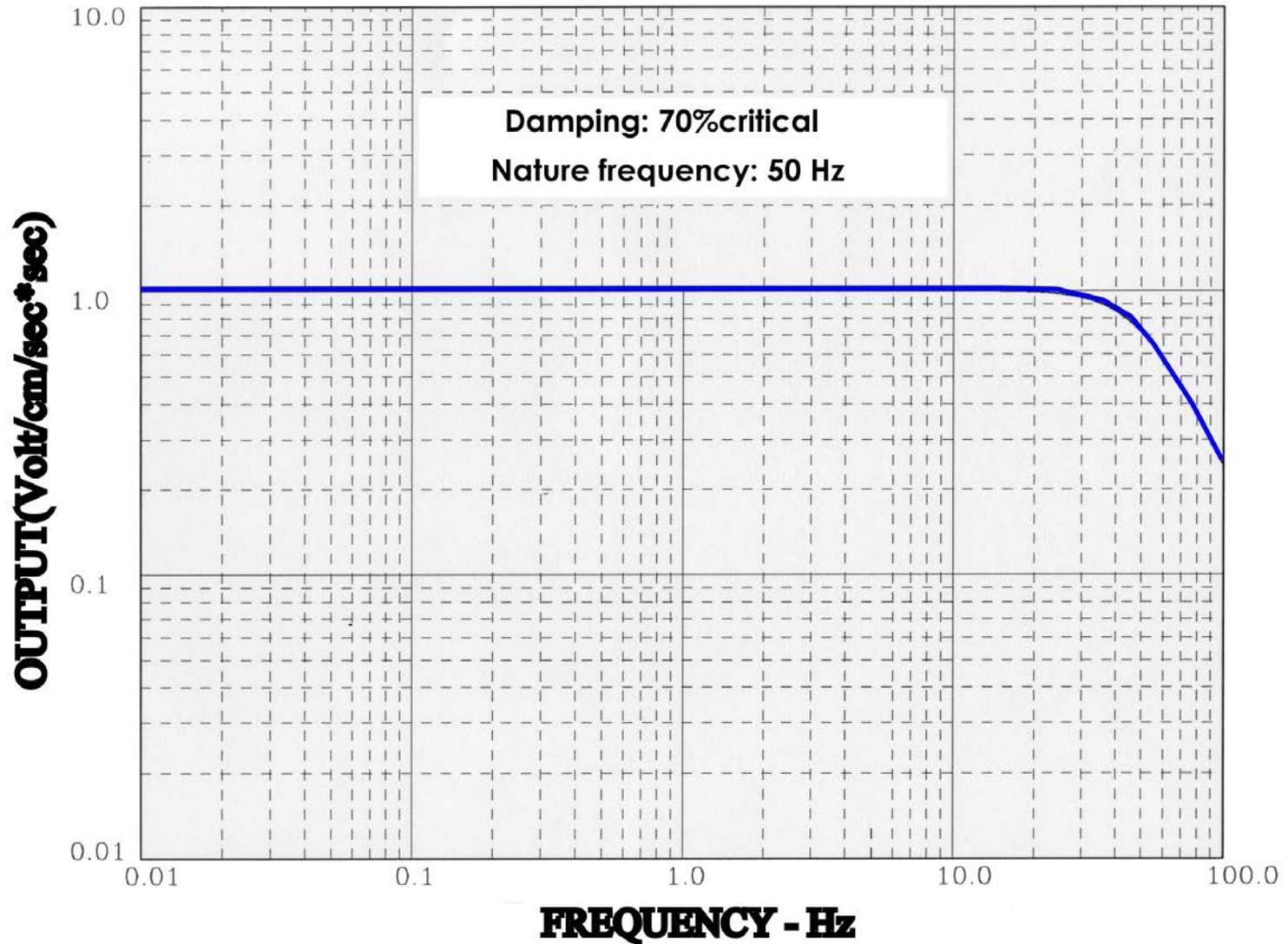
Array recorded translation ground motions (Vertical component)

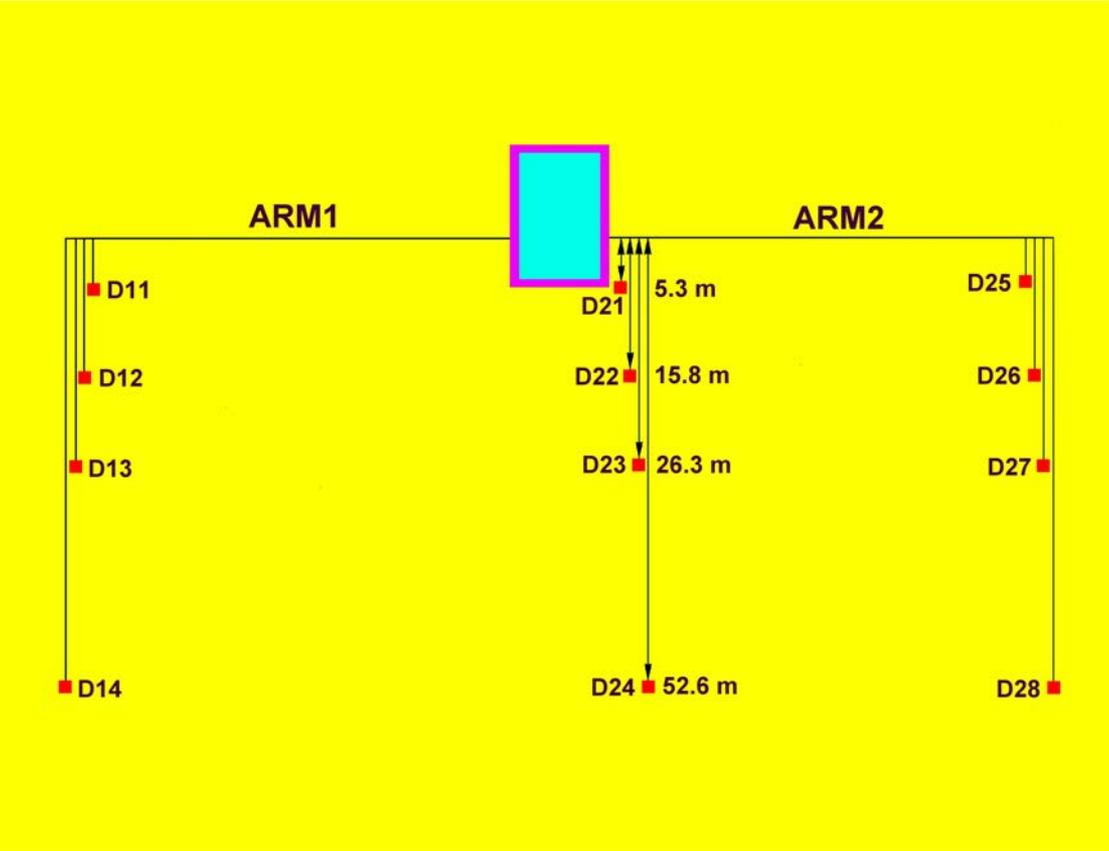


Array recorded translation ground motions (EW component)

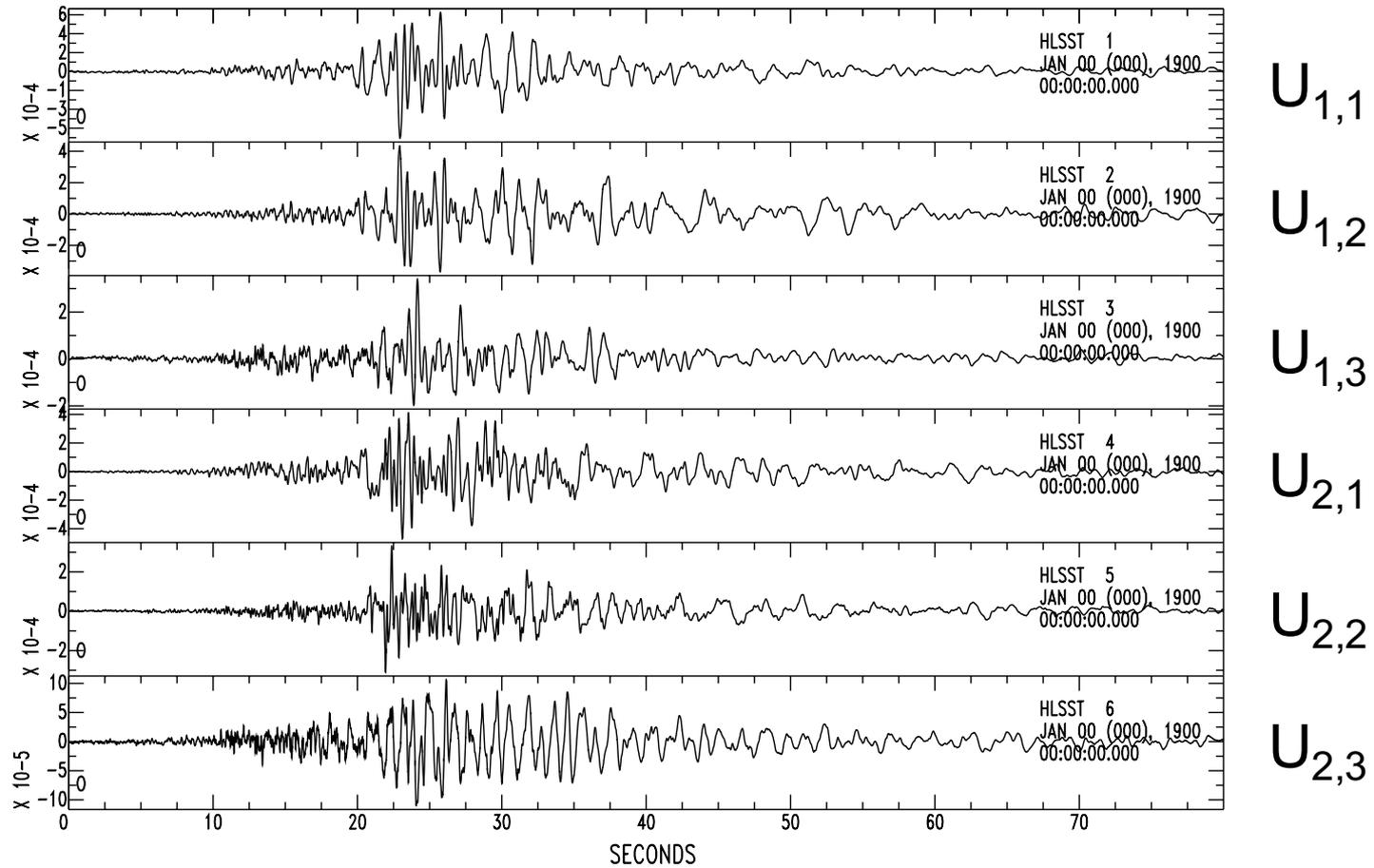


Array Instrument: Accelerometer

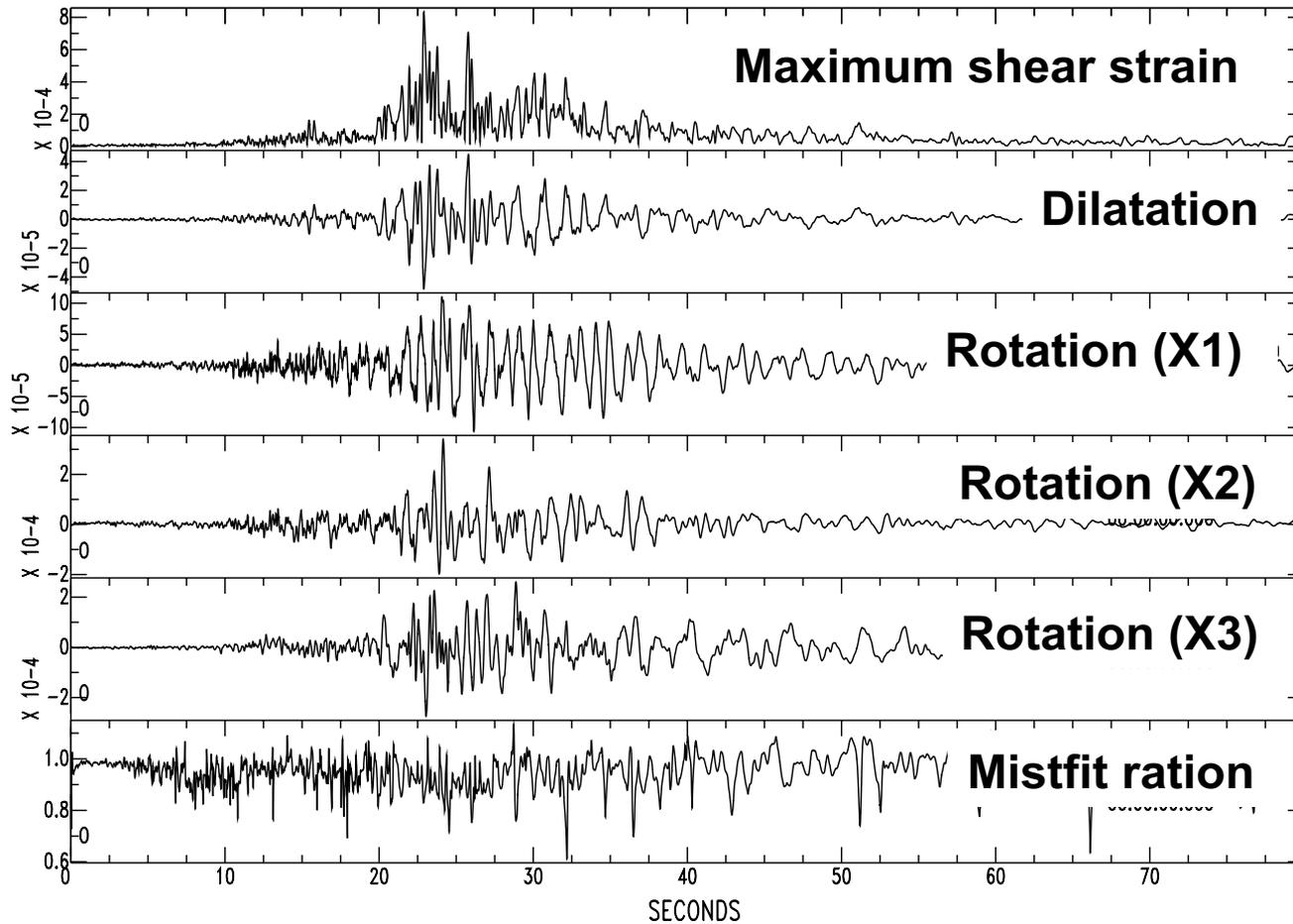




Velocity gradients derived based on definition of Spudis et al. (1995)

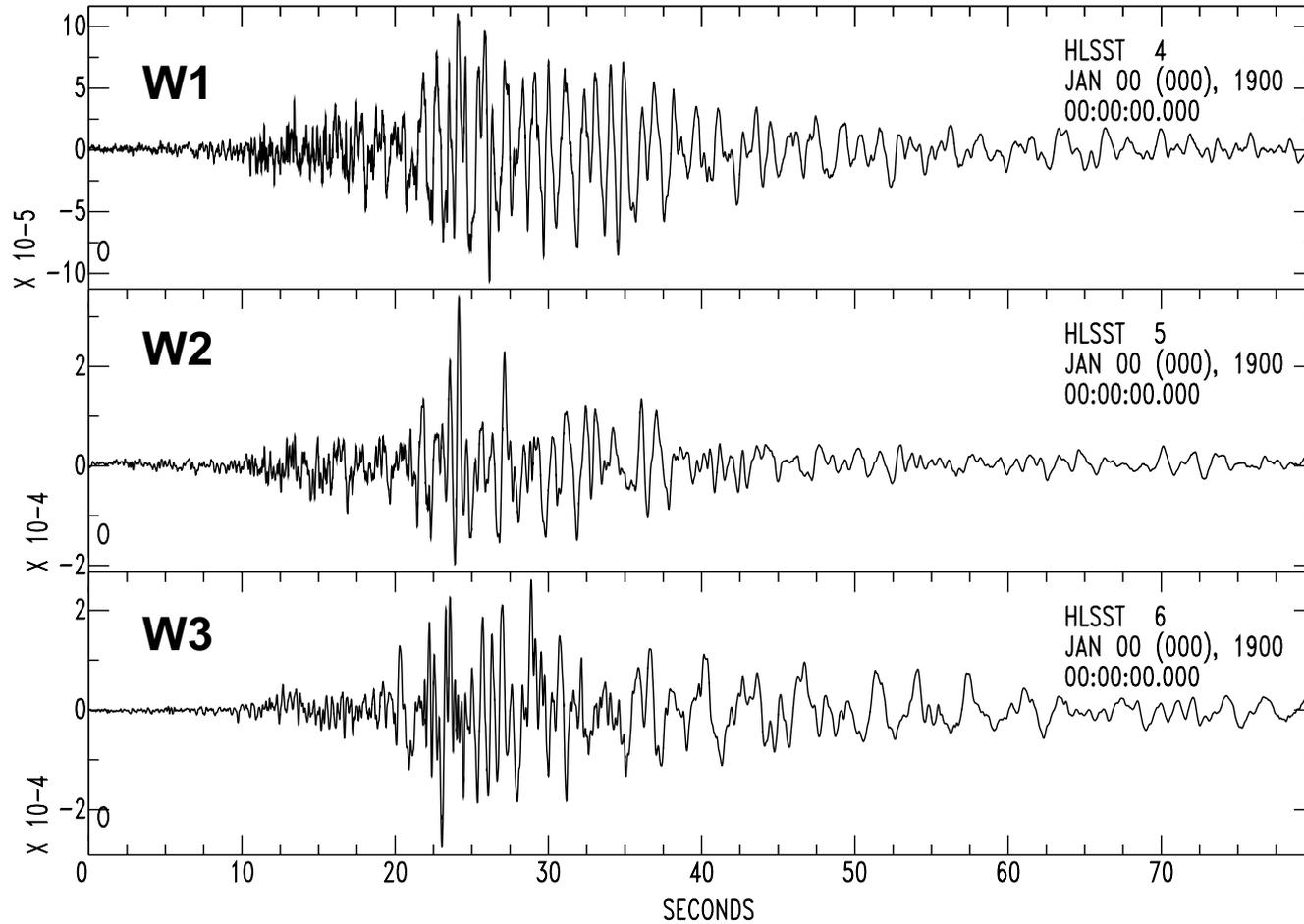


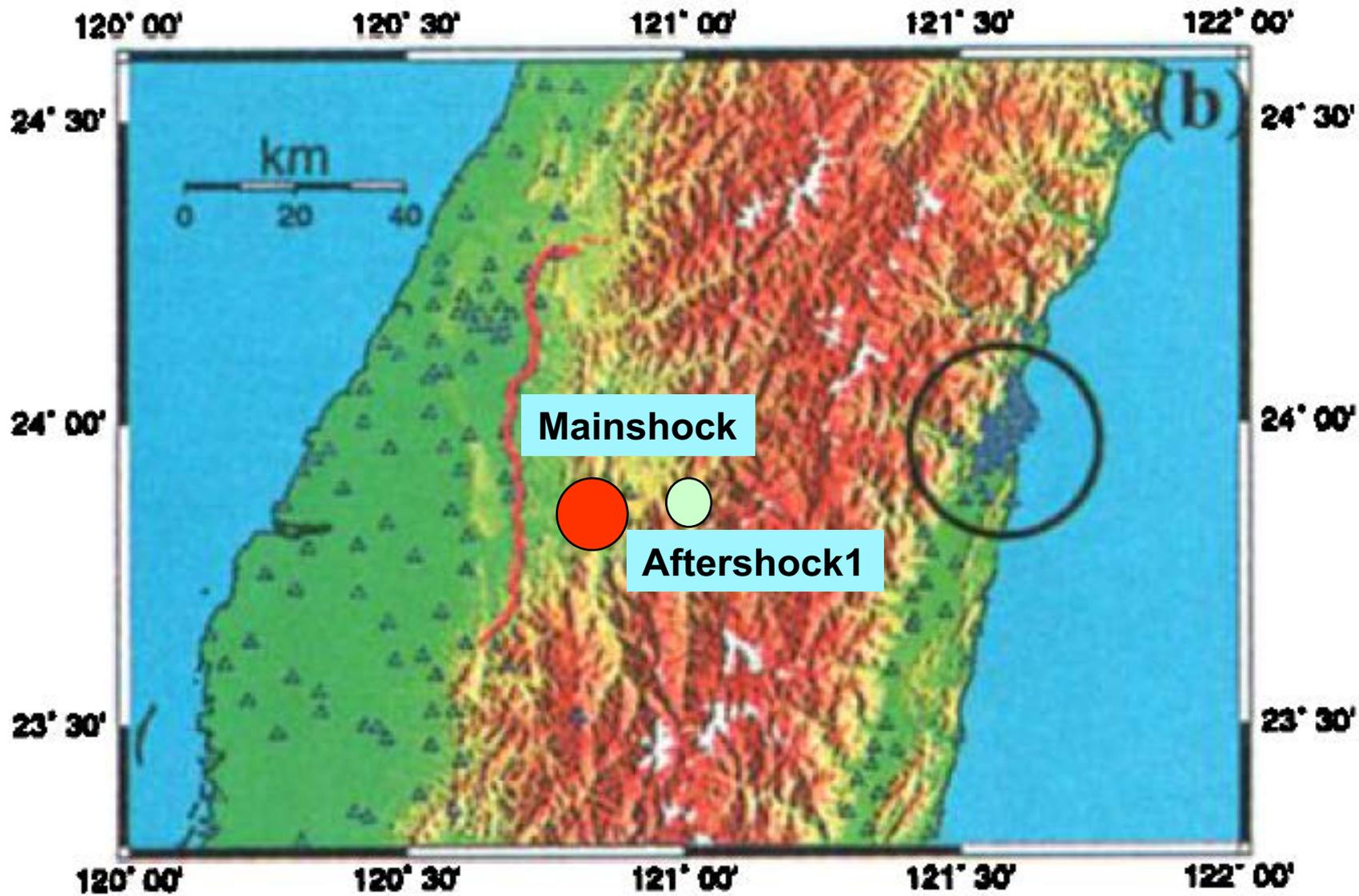
Dynamic Strains and rotations



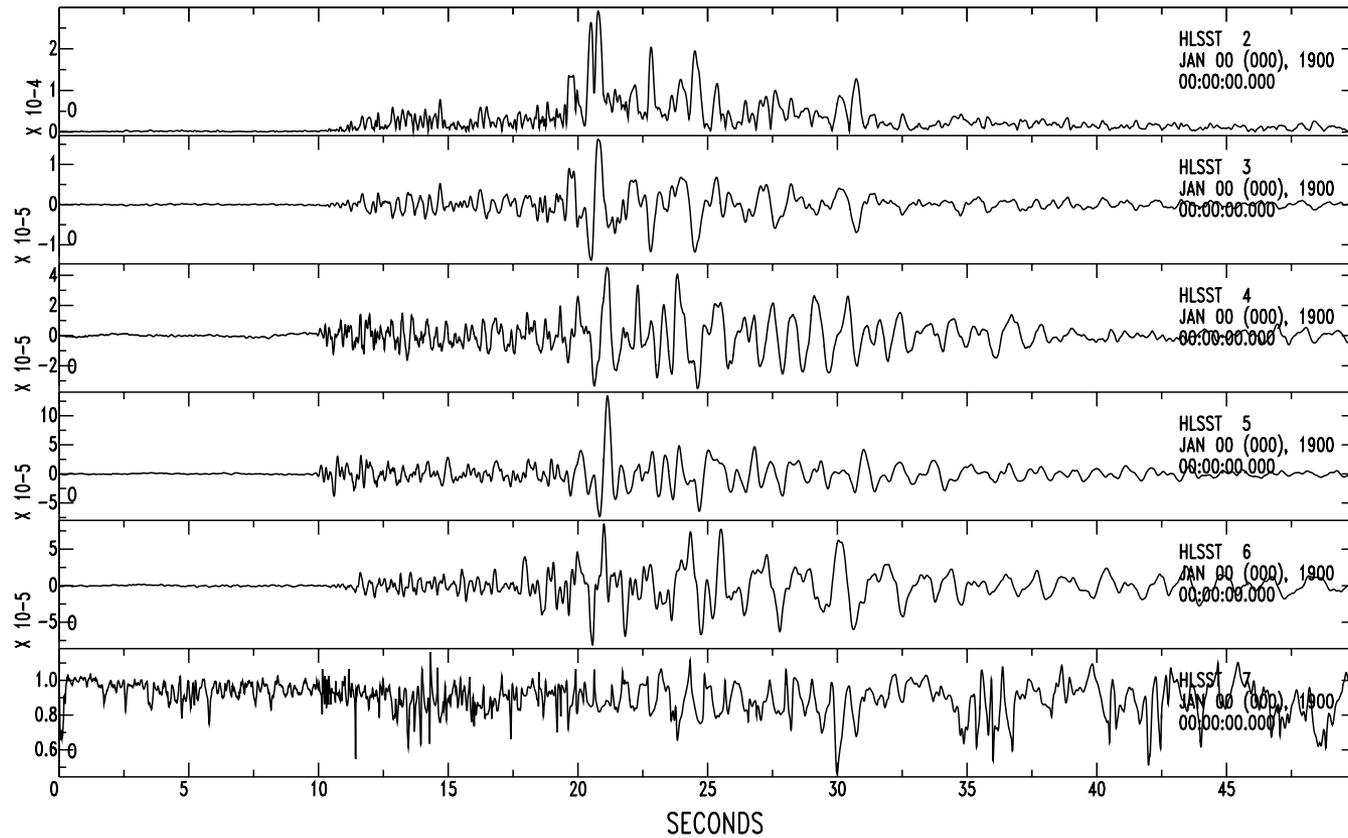
MATLAB script of Spudich and Fletcher (2009)

Rotation Rate

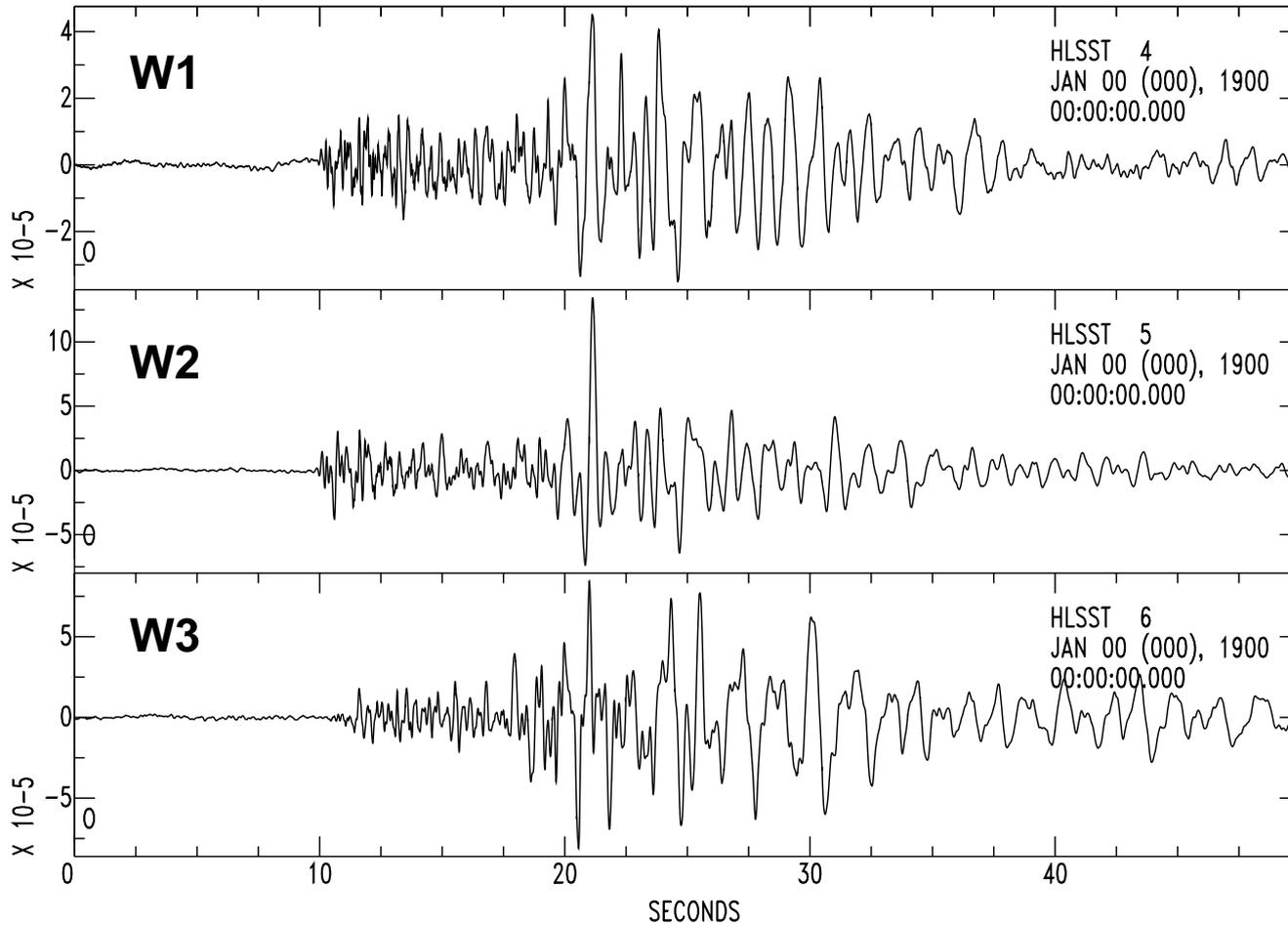




Dynamic Strains and rotations (aftershock)

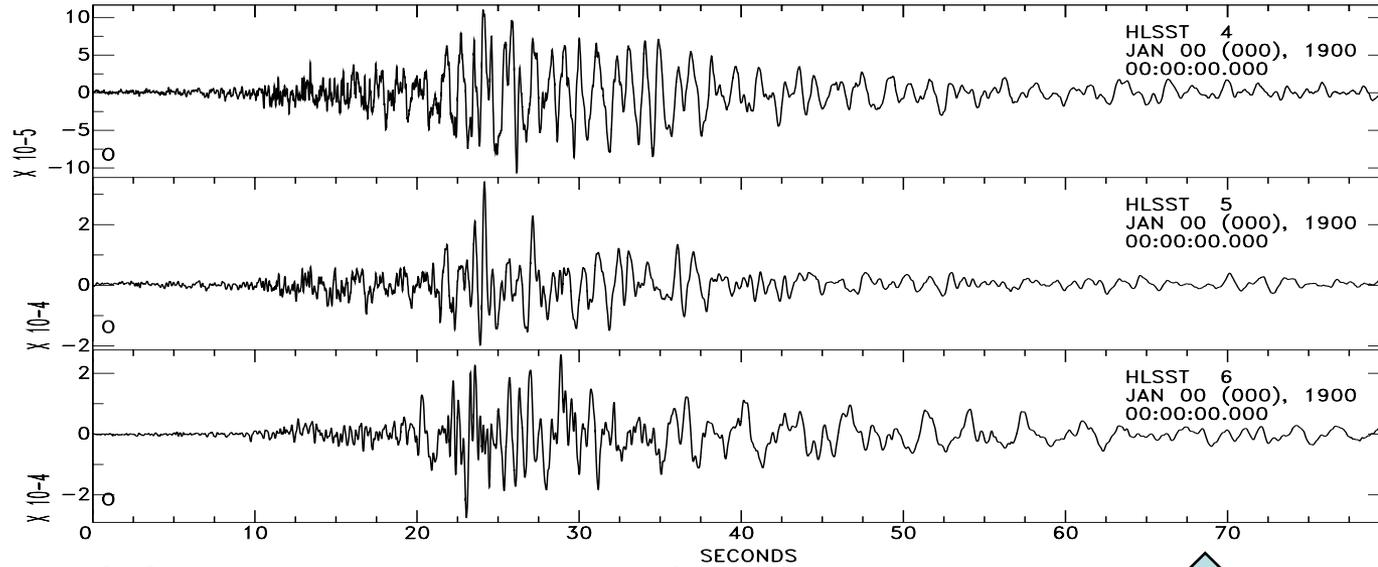


Rotations (aftershock)

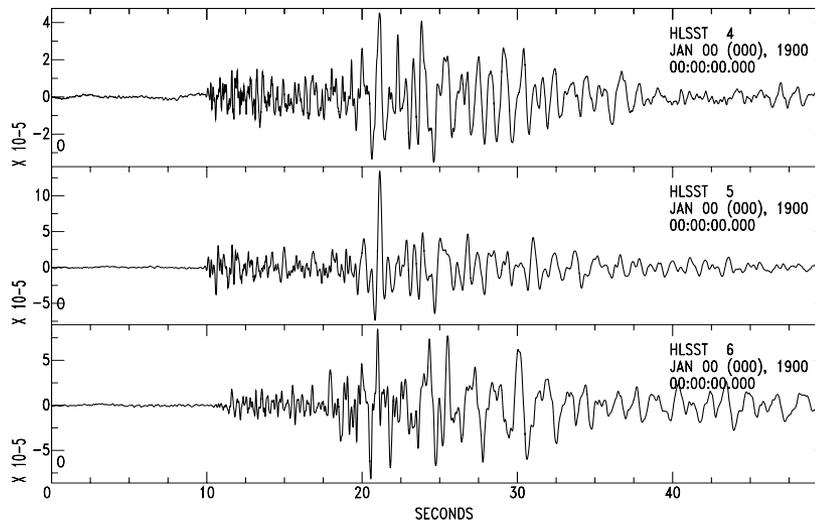


Rotations

(mainshock)

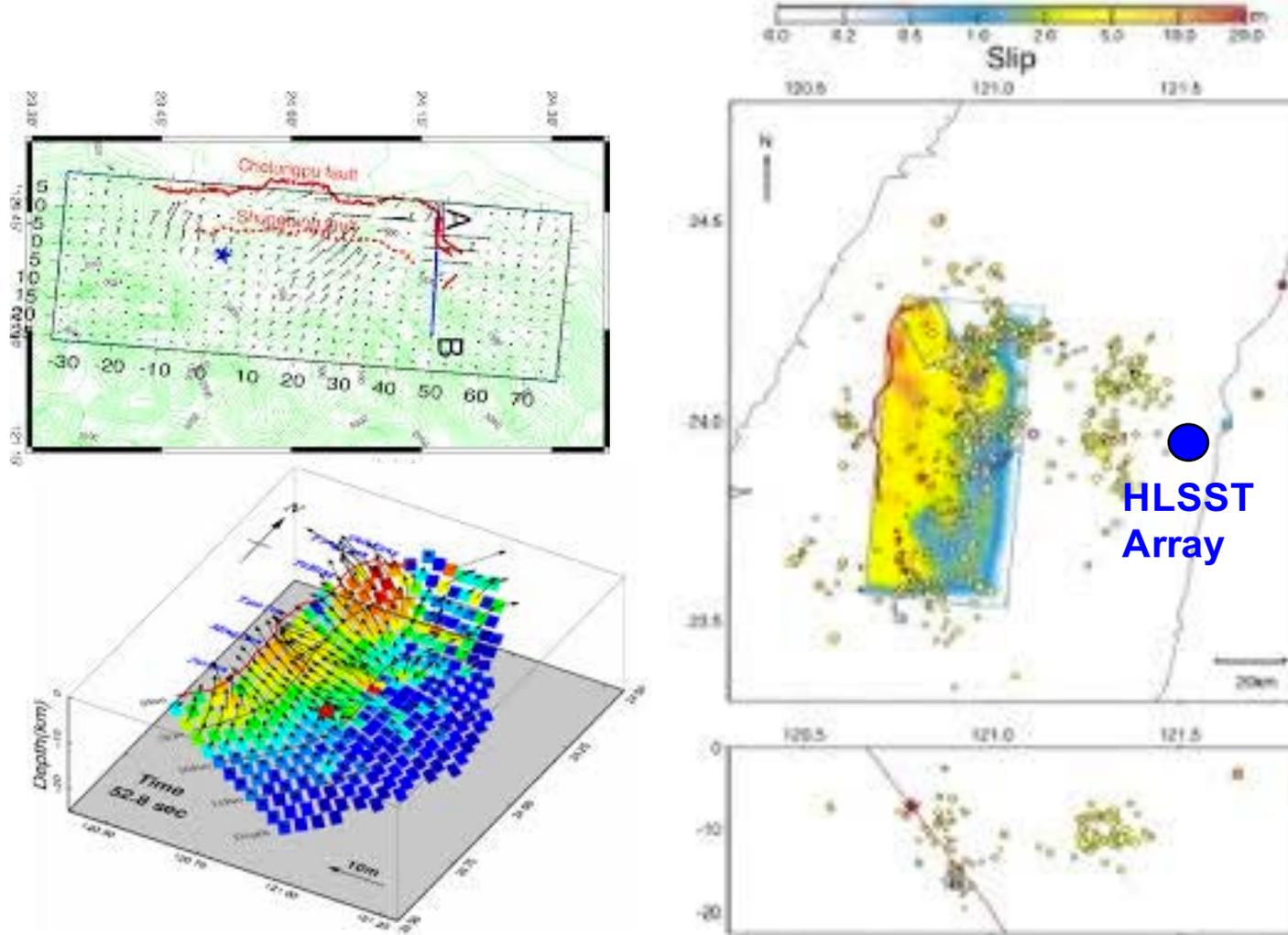


(aftershock, point source)

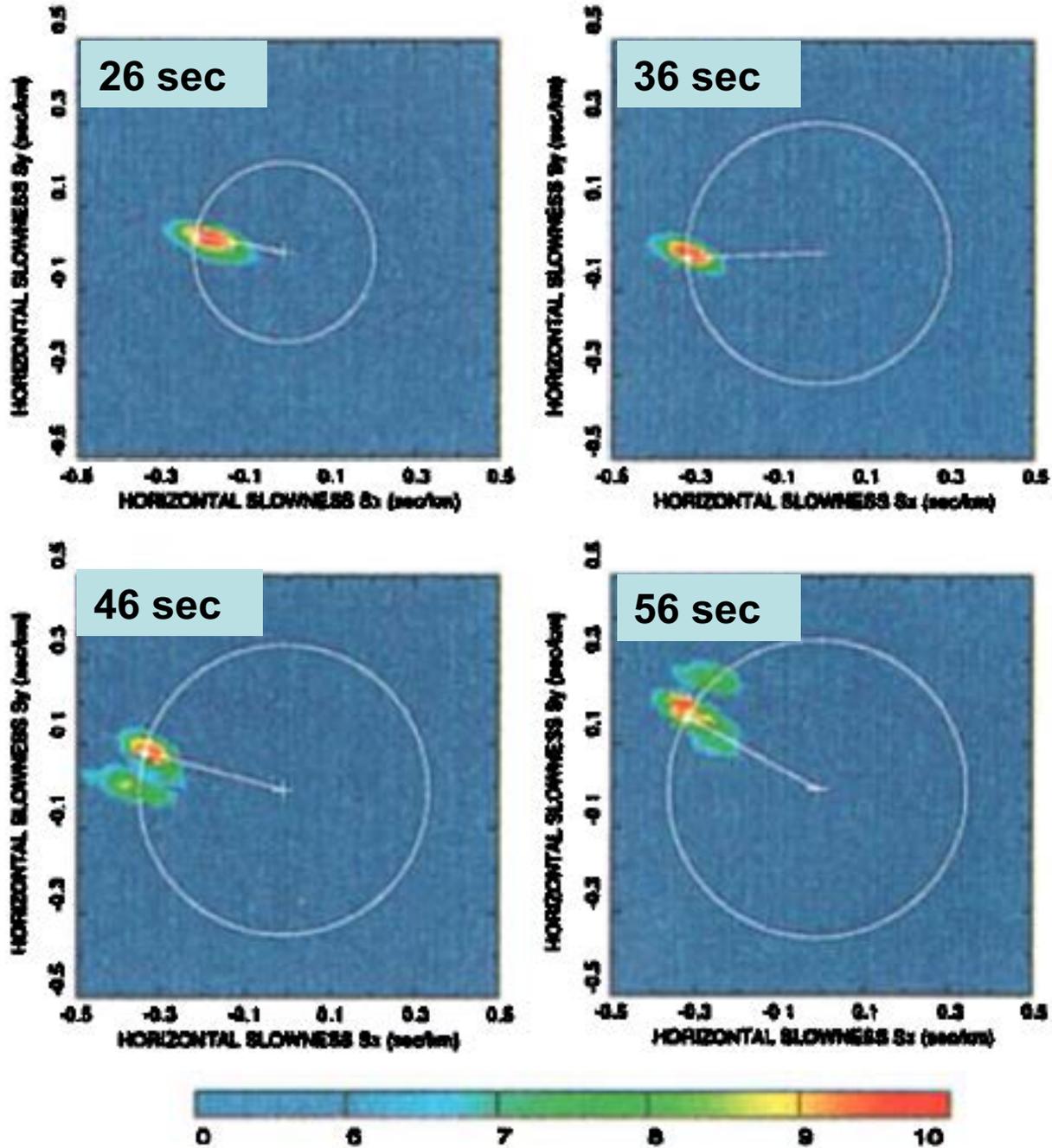


Rotation waveforms of main shock should include information of Source rupture process

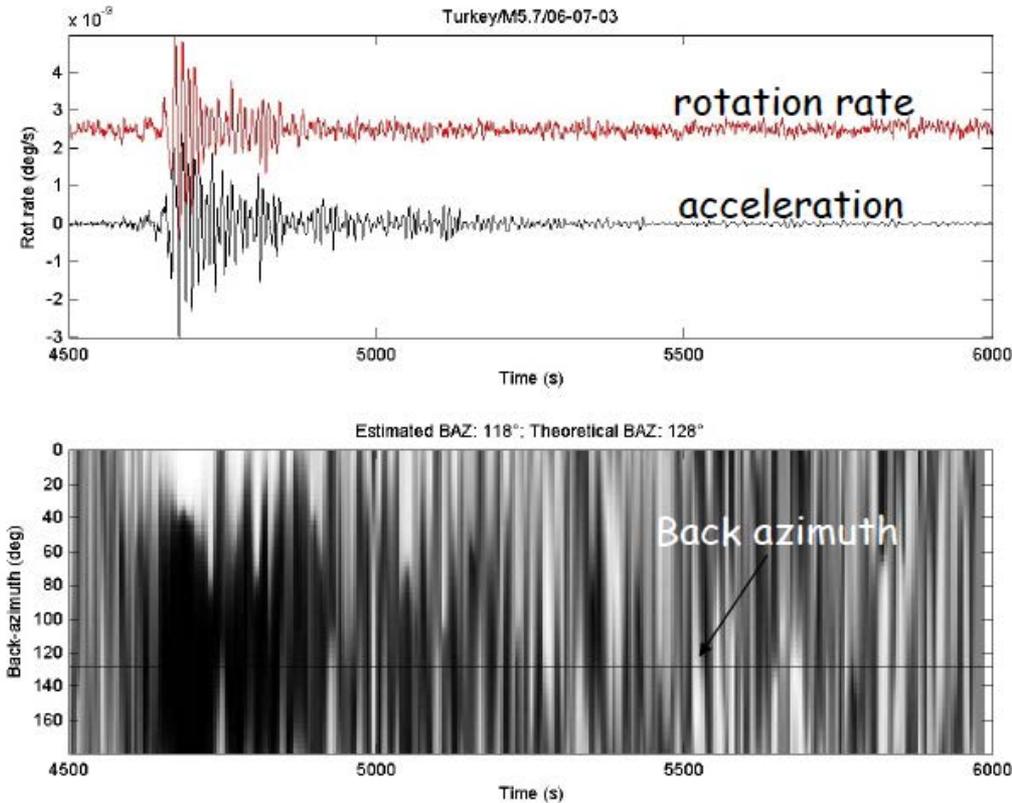
Previous Rupture process reports of the Chi-Chi EQ



Translation waveform analysis



Direction of propagation of transversely polarized energy

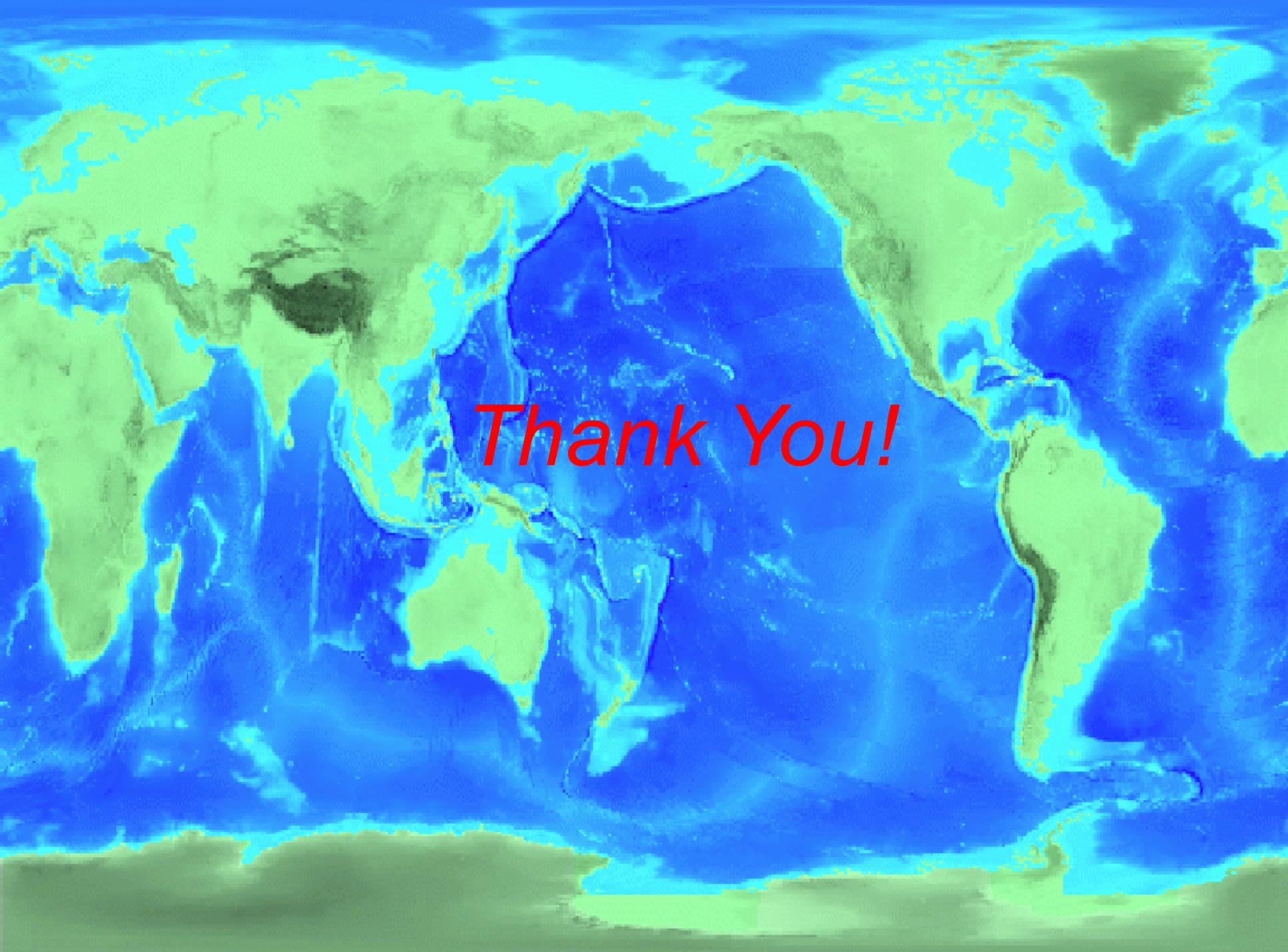


Max. cross-corr. coeff. as a function of time and propagation direction

(From : pres_Heiner_Igel)

Discussions and Implications

1. Backazimuths of incident waves can be determined using single 6C (translation + rotation) observation
 2. To determine near source rupture, translation dense array observation ~ single 6C observation (point seismic array)
 3. Compare to the dynamic strain, the rotations provide more direct information of near source rupture information
 4. Further near fault 6C seismic array is significant for source rupture imaging
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A world map with a color gradient from blue to red, overlaid with a grid. The text "Thank You!" is centered in red.

Thank You!