Abnormal intensities distributions in subduction zone

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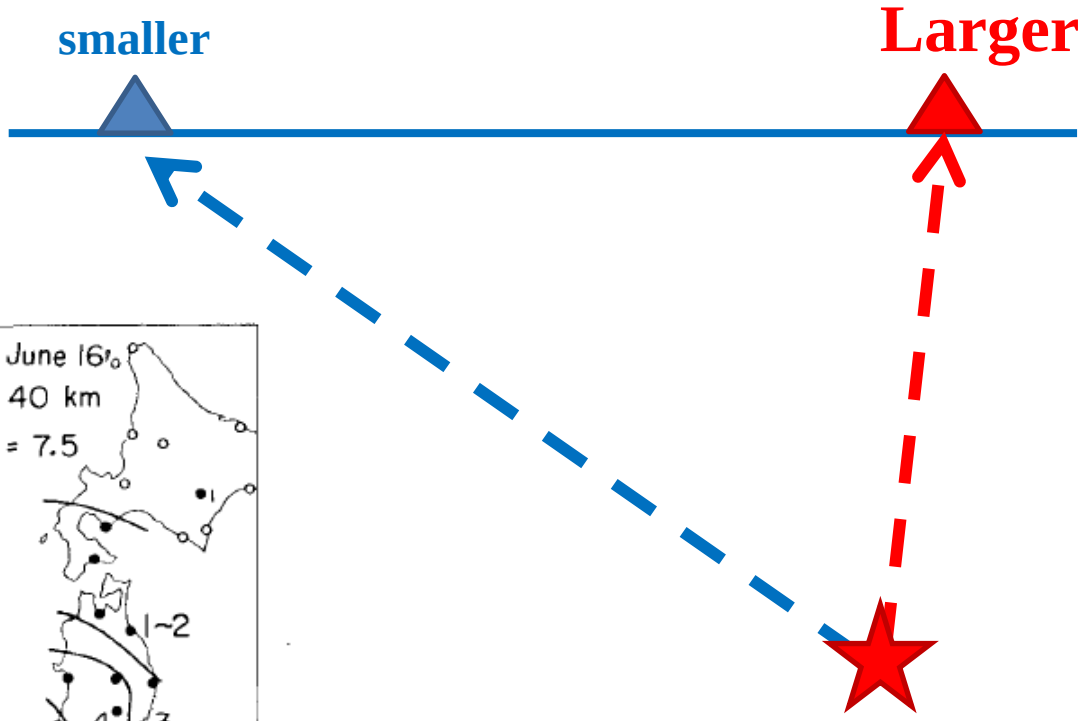
Normal intensities distribution



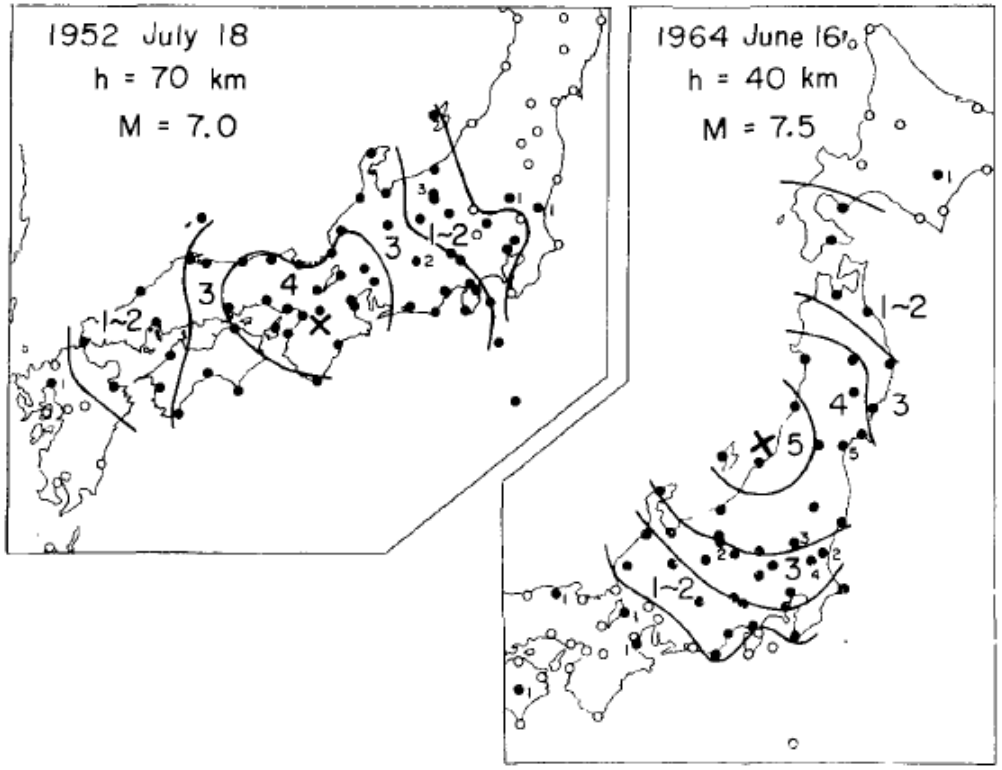


Fig. 14.

Fig. 15.

JAPAN

Some conclusions

- 1. The zone where abnormal high intensities are observed extends on the Pacific side.

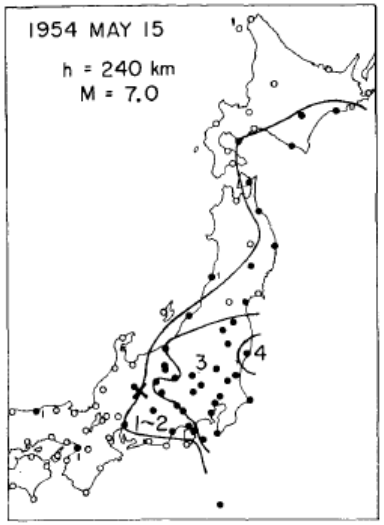


Fig. 1.

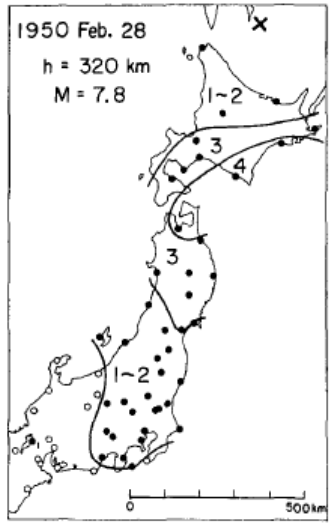


Fig. 2.

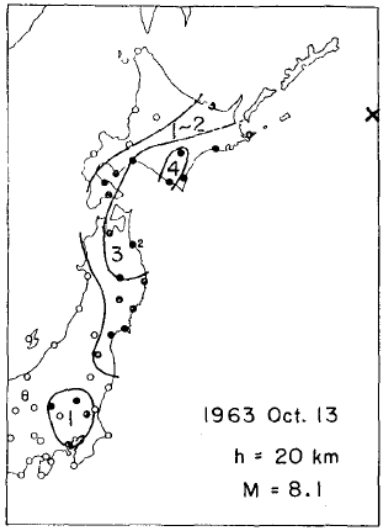


Fig. 9.

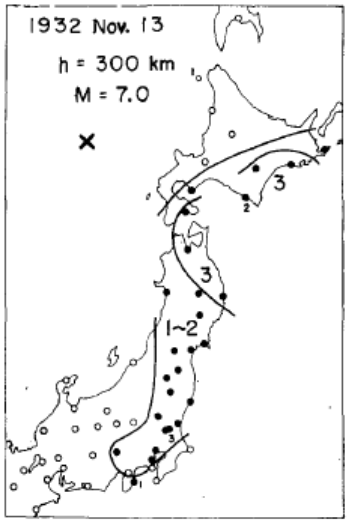


Fig. 3.

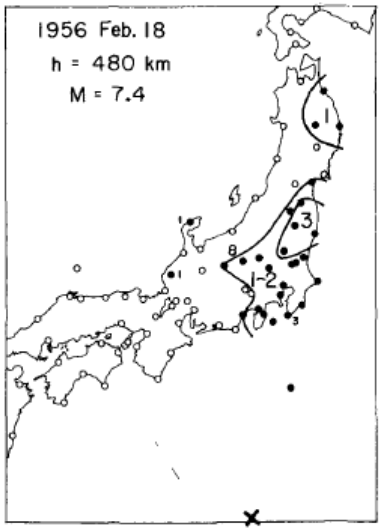


Fig. 4.

Distributions of seismic intensities. ×: epicenter.

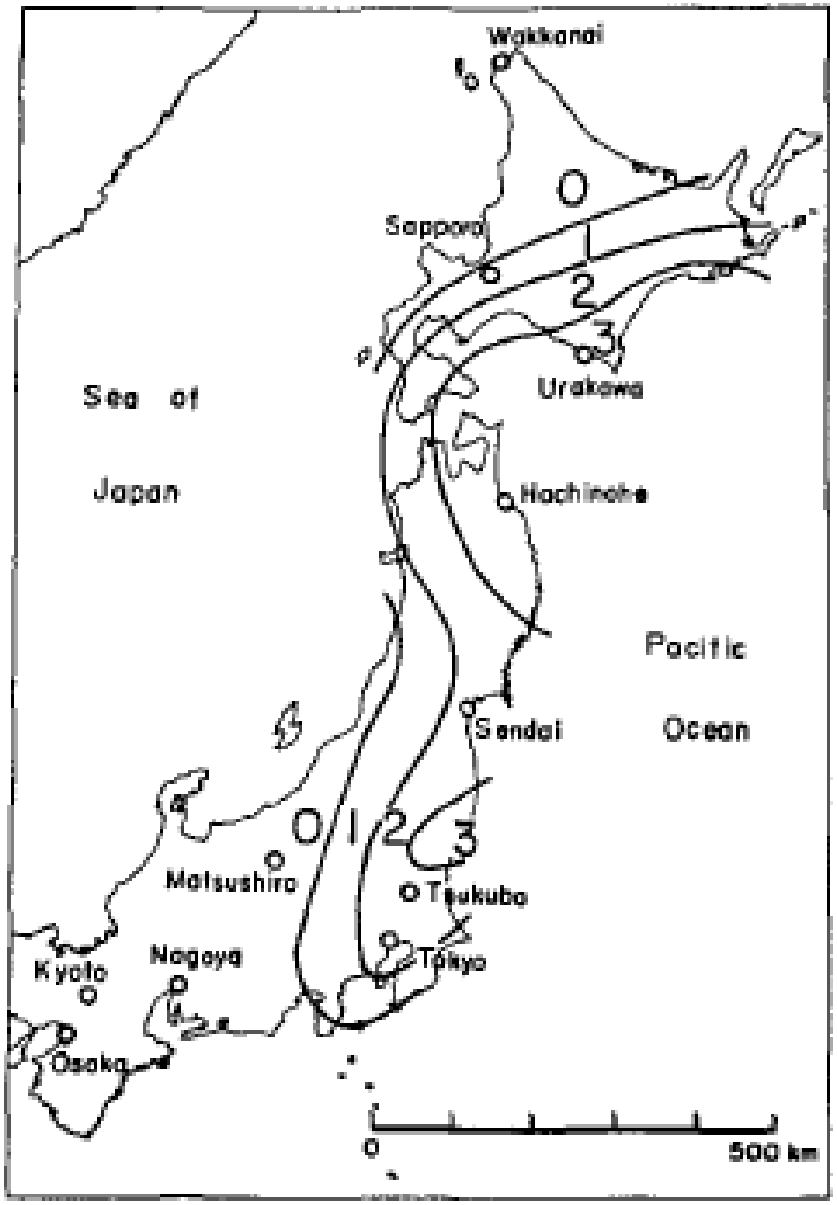


Fig. 6. Map showing the average intensity anomalies.

Some conclusions

- 2. The records in the anomalies zone contain high frequency waves .
- 3. The anomalous zone seems to have some connection with some geophysical phenomena, for example island arc, trench ,earthquakes foci, volcanoes , gravity anomalies , etc .

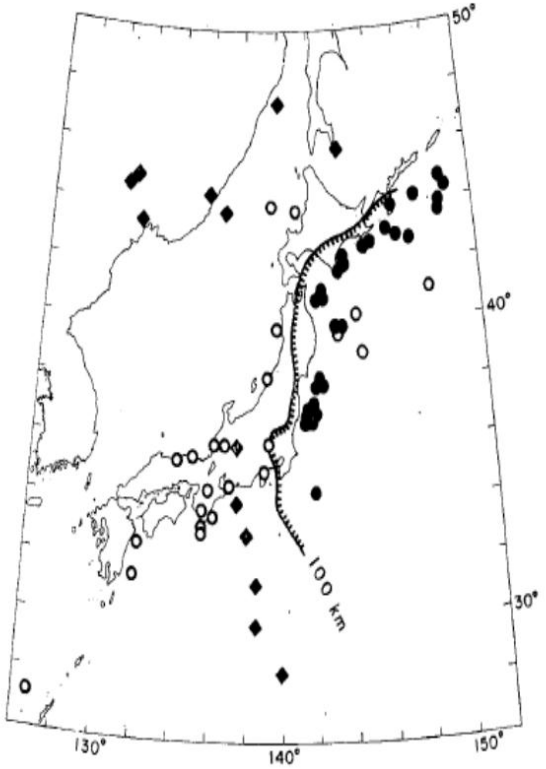
Two explanation

- 1. Multiple reflections in thin layers having low velocity and density.
- 2. Absorption of seismic waves in the crust or upper mantle varies regionally

- i. There are no common differences in ground conditions between stations inside and outside the anomalous zone.

Fig. 6. Map showing the average intensity anomalies.

- ii.The geophysical phenomena which have some connection with anomalous zone are believed to be related to the structure of the crust and upper mantle.
- iii. The observation indicate strong azimuthal effects.

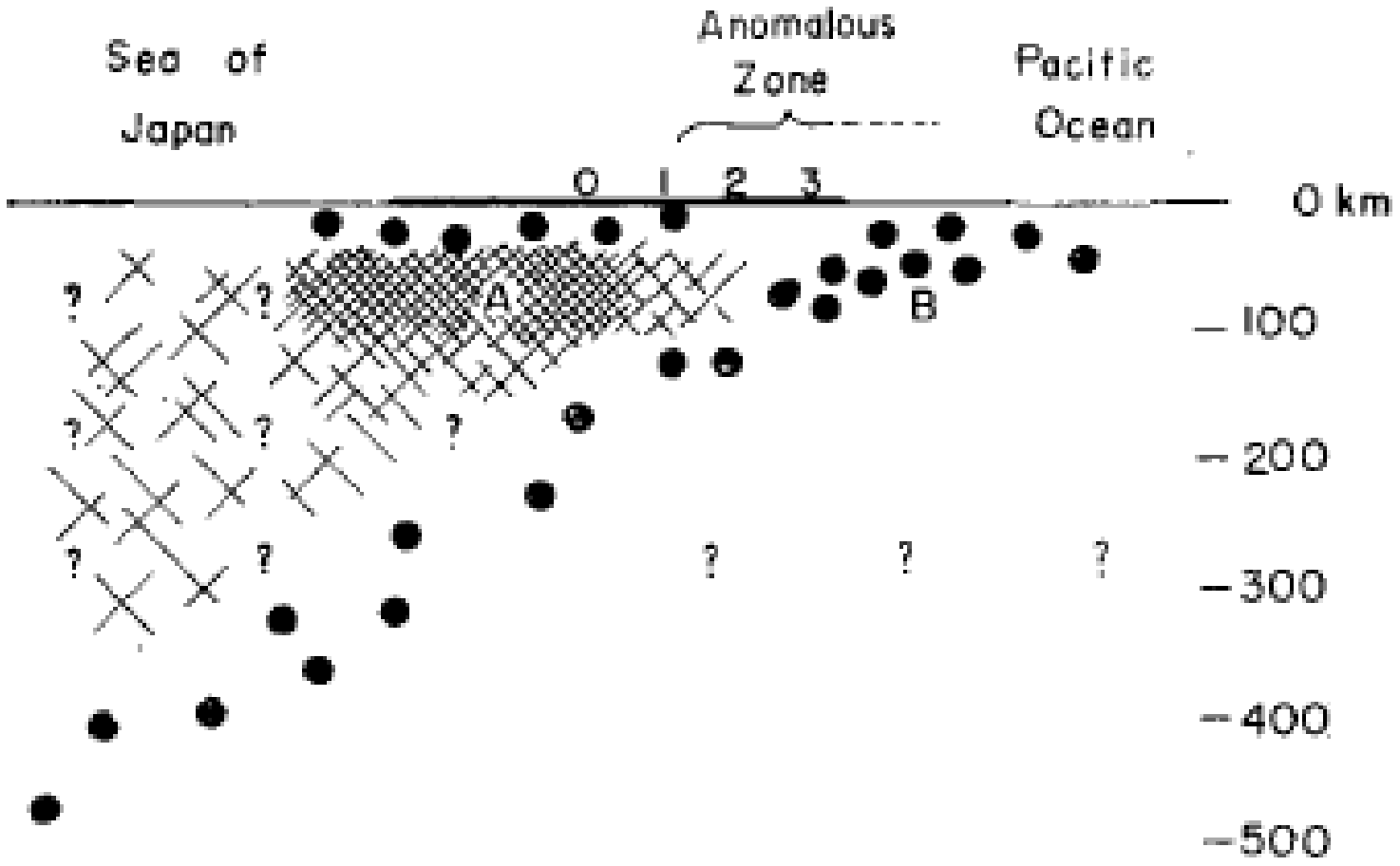


Two explanation

- 1. Multiple reflections in thin layers having low velocity and density.
- 2. Absorption of seismic waves in the crust or upper mantle varies regionally

(Katsumata, M. 1958)
There is a high absorption layer in the upper mantle at depths between 100~200km

(Wadati, K. and Hirono, T. 1956)
Increased absorption was found near the surface and at depths of around 100km

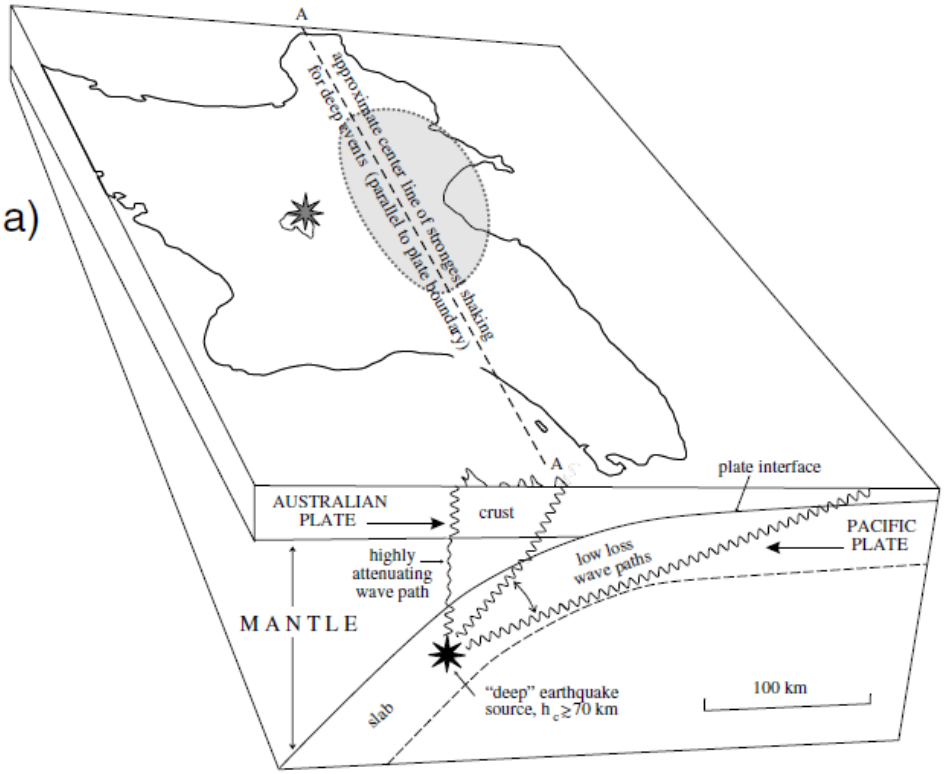


Summary

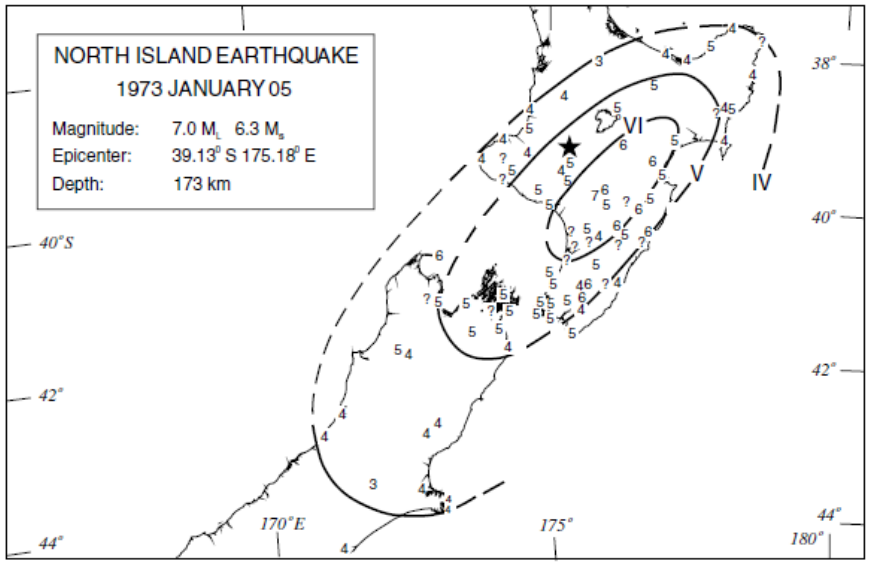
- The abnormal intensity is caused by high absorption zone in the upper mantle

New Zealand

a)


A
approximate center line of strongest shaking for deep events (parallel to plate boundary)
A
plate interface
AUSTRALIAN PLATE
crust
PACIFIC PLATE
highly attenuating wave path
low loss wave paths
MANTLE
slab
"deep" earthquake source, h c ≥ 70 km
100 km

b)


NORTH ISLAND EARTHQUAKE
1973 JANUARY 05
Magnitude: 7.0 M L 6.3 M s
Epicenter: 39.13° S 175.18° E
Depth: 173 km
VI
V
IV
40°S
42°
38°
40°
42°
44°
170°E
175°
180°
44°

Method

Standard Response Spectral Model (McVerry et al 2000)

Model for Crustal earthquakes at weak rock sites (Abrahamson and Silva 1997)

$$\ln SA(T)_{standardNZcrustal} = C_1(T) + C_{4AS}(M-6) + C_{3AS}(T)(8.5-M)^2 + C_5(T)r + (C_8(T) + C_{6AS}(M-6))\ln(r^2 + C_{10AS}{}^2(T))^{1/2} + C_{46}(T)r_{vol}$$

Model for Subduction-zone earthquakes at weak rock sites (Youngs et al 1997)

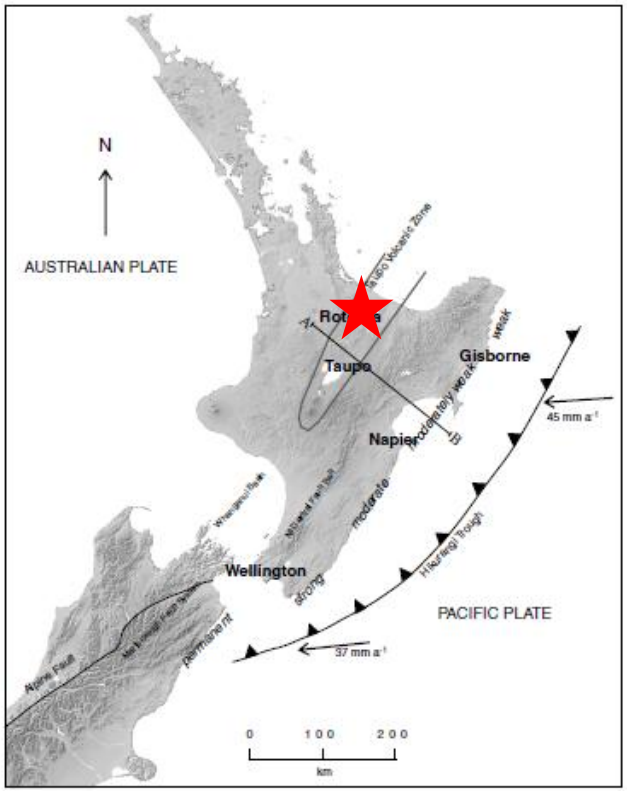
$$\ln SA(T)_{standardNZsubductionzone} = C_{11}(T) + C_{12}(T)(M-6) + C_{13Y}(T)(10-M)^3 + C_{17}(T)\ln(r + C_{18Y}e^{C_{19Y}M}) + C_{20}(T)H_{C2S} + C_{24}(T)SI + C_{46}(T)r_{vol}(1-DS)$$

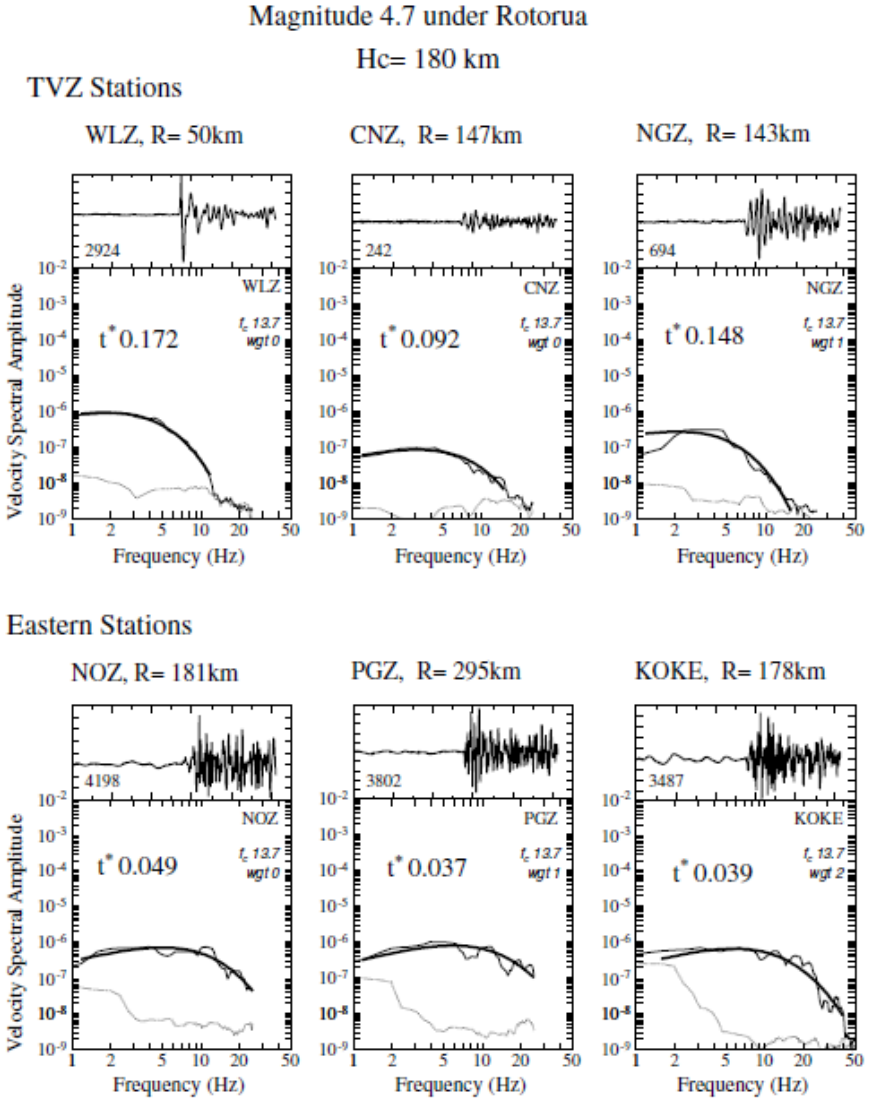
$$C_{12}(T) + C_{17}(T)C_{19Y} = C_{12Y} + C_{17Y}(T)C_{19Y}$$

Method

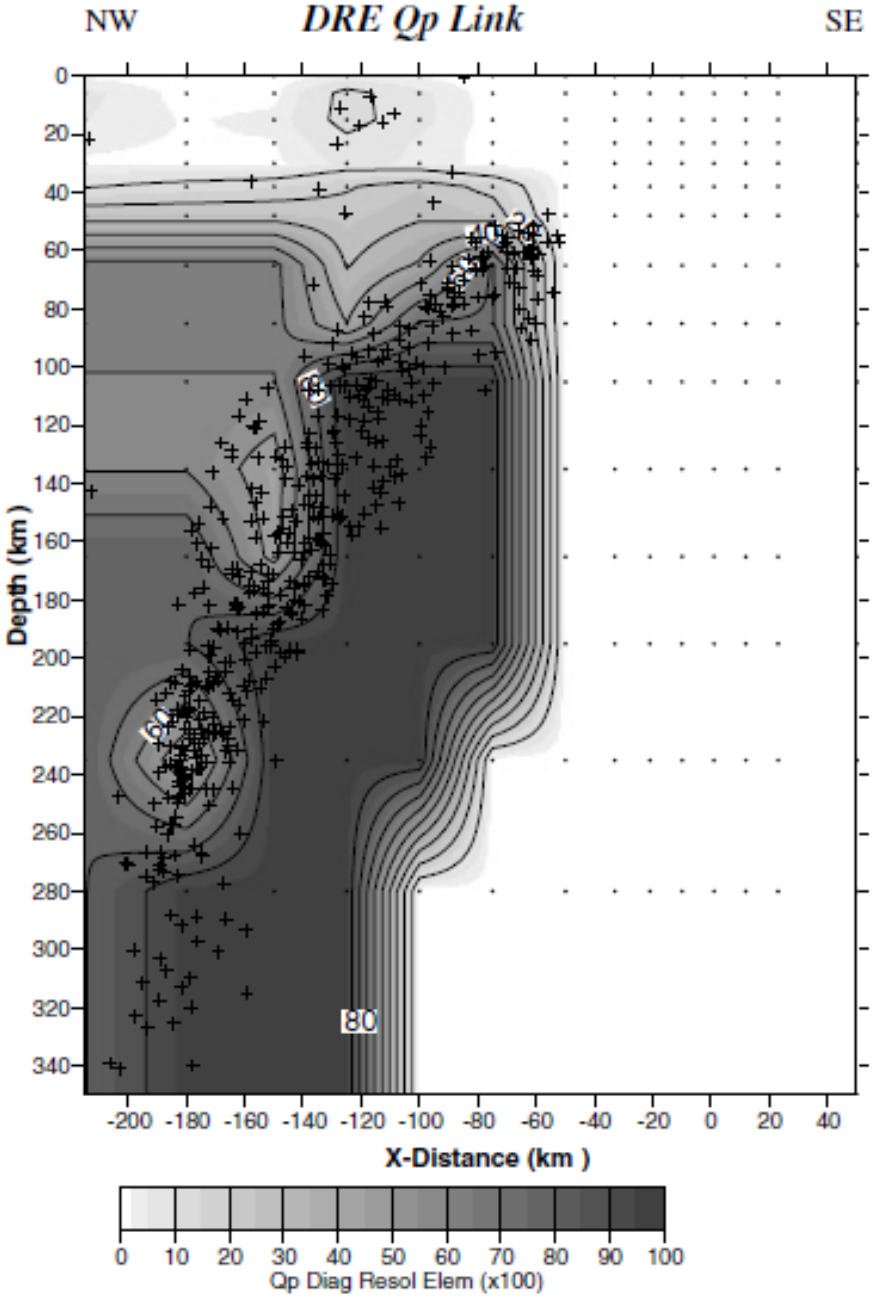
$$A(f) = 2\pi f \Omega_0 * \frac{f_c^2}{(f_c^2 + f^2)} * e^{-\pi f t^*}$$ Scherbaum,1990

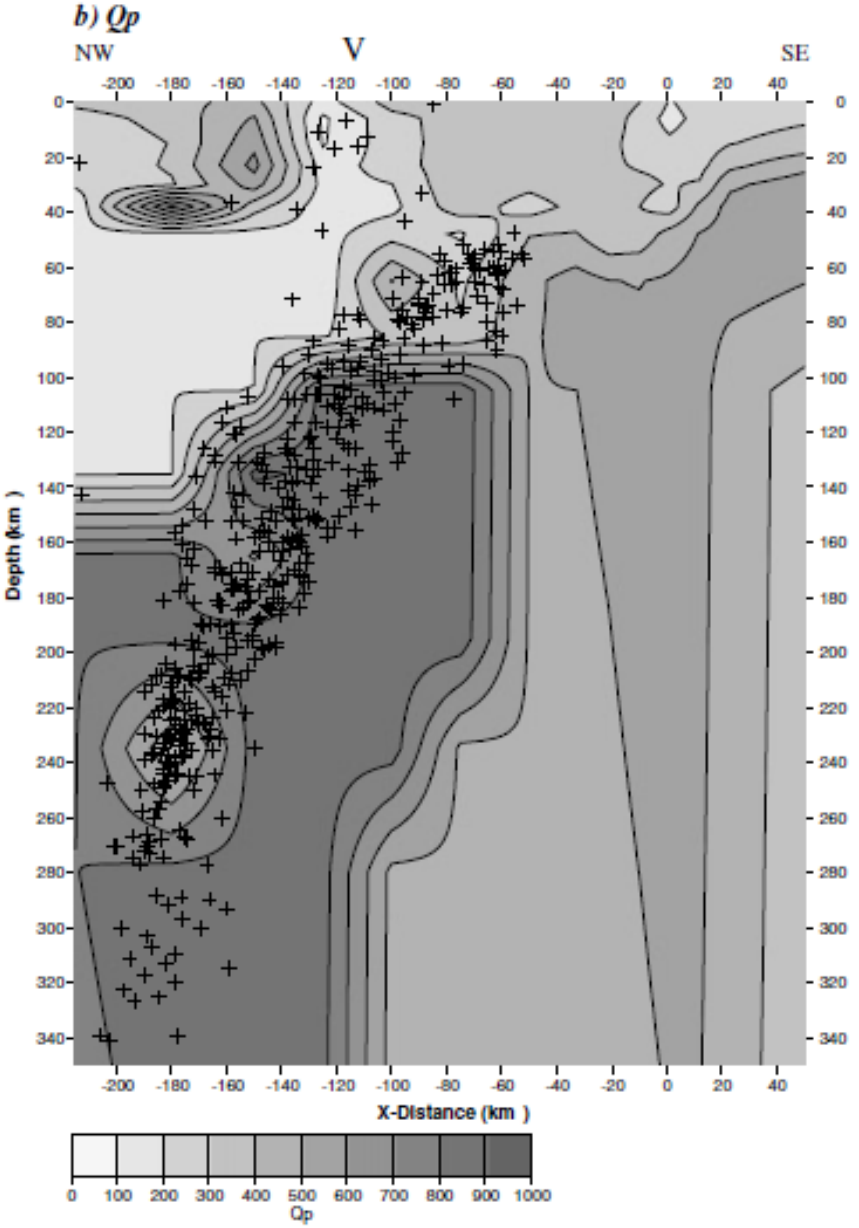
$$t^* = \int_{raypath} \frac{1}{(Q(s) * V(s))} ds$$





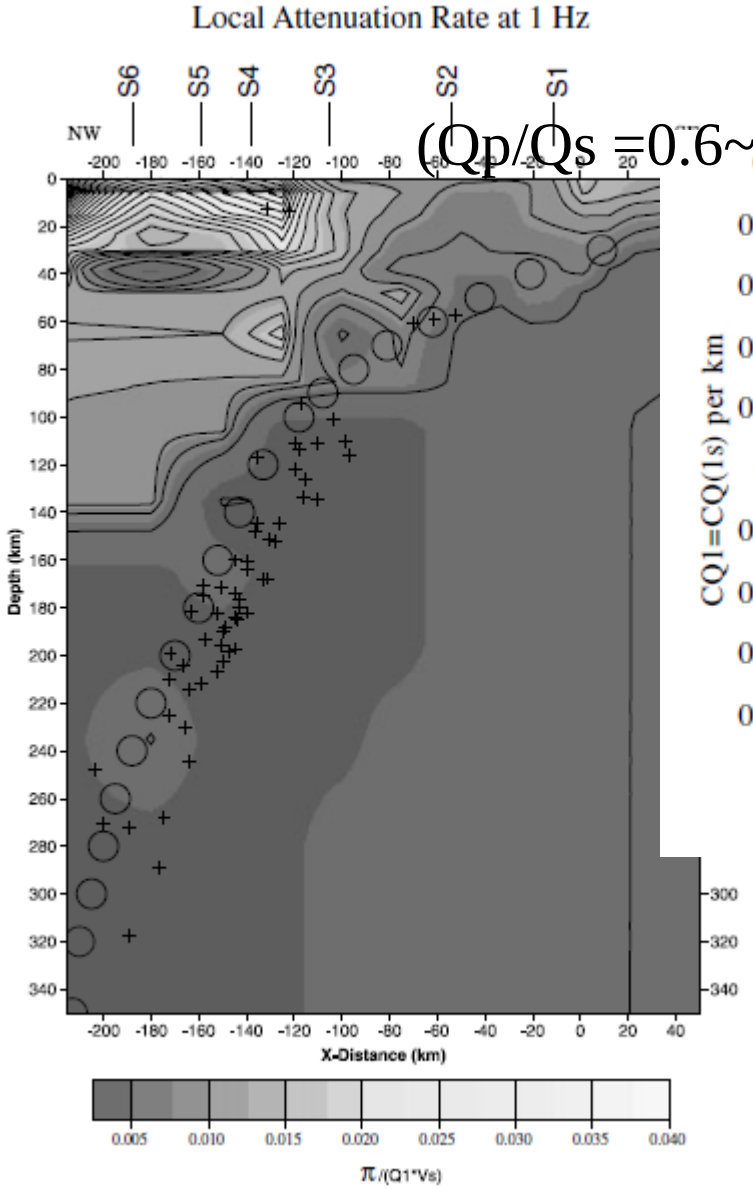
Method


NW
DRE Qp Link
SE
Depth (km)
X-Distance (km)
Qp Diag Resol Elem (x100)

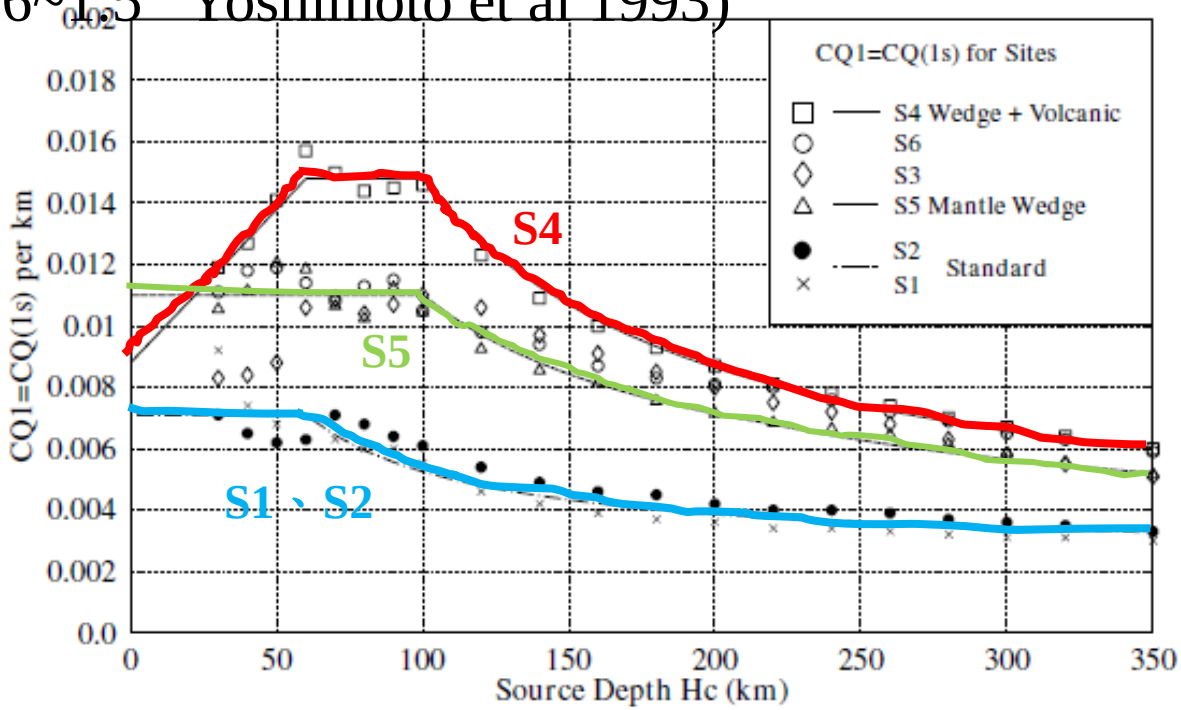

b) Qp
NW
V
SE
Depth (km)
X-Distance (km)
Qp

Method

$$\ln SA(T) = \{\text{standard model}\} - CQ(T, Hc)r$$



(Qp/Qs =0.6~1.5 Yoshimoto et al 1993)



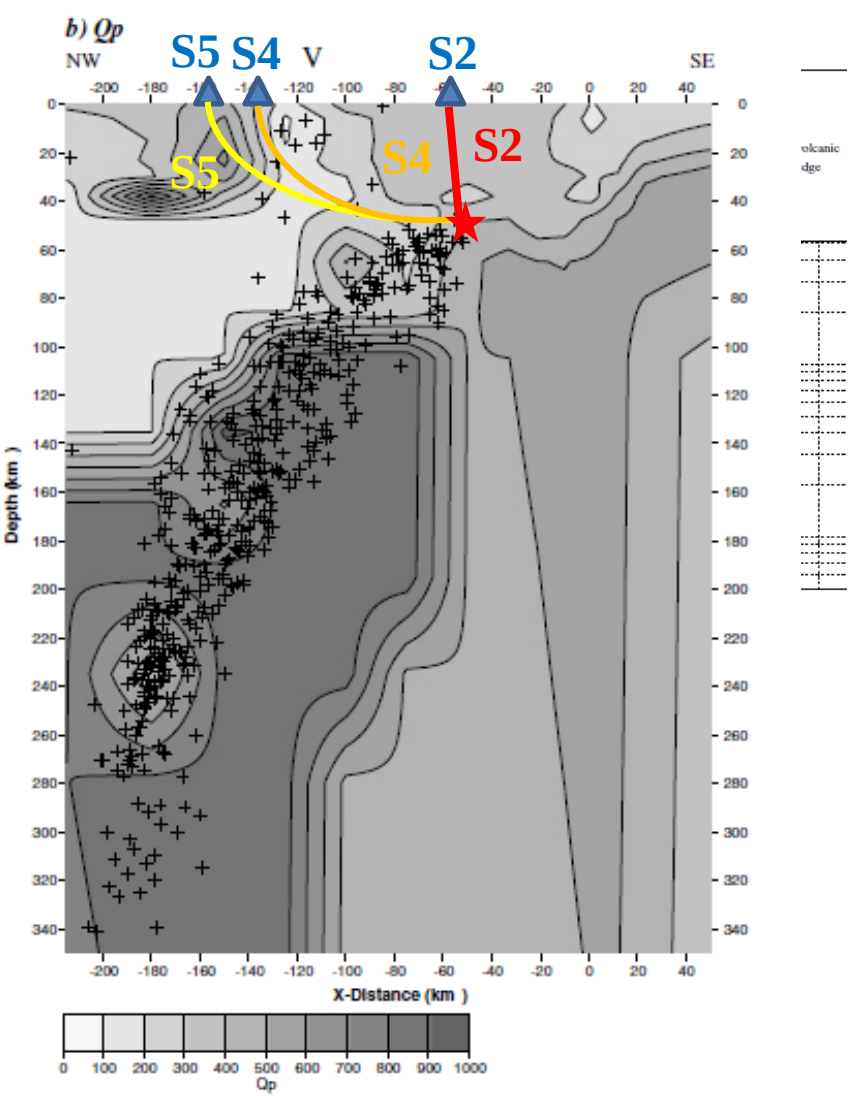
$$CQ_{site}(T, H_c) = {CQ_{1site}(H_c)}/{T^{0.3}} \quad T \geq 0.2 \text{ sec}$$

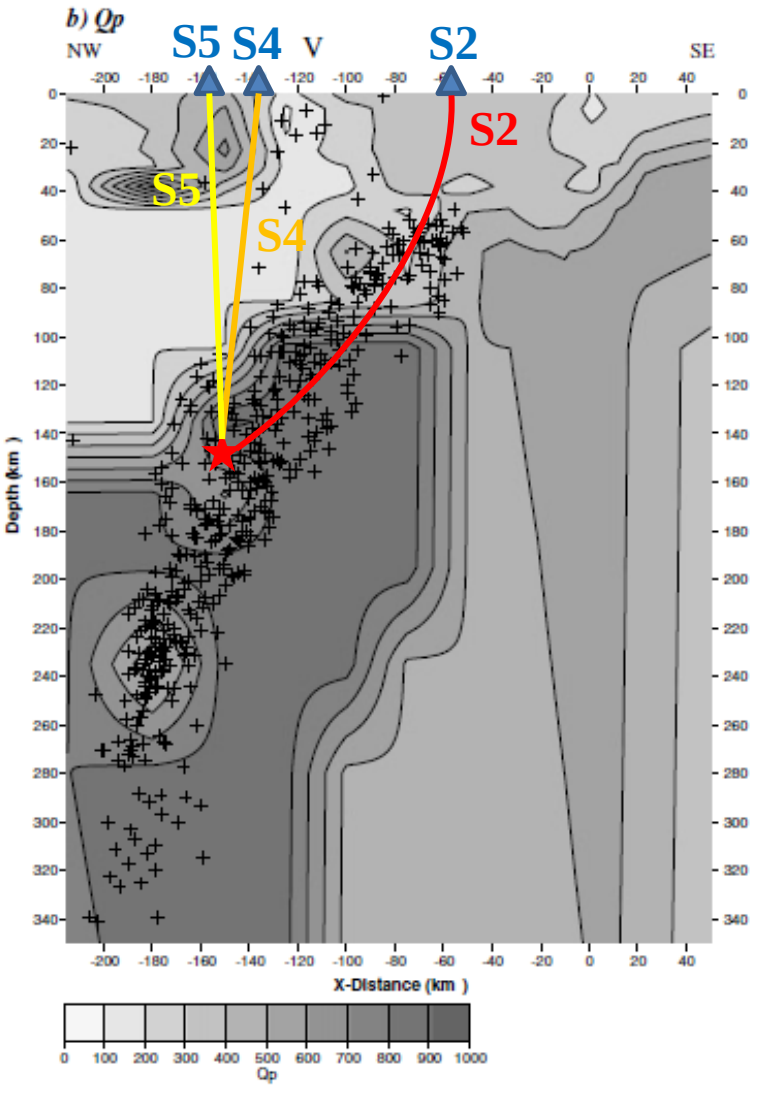
$$CQ_{site}(T, H_c) = CQ_{1site}(T = 0.2 \text{ sec}, H_c) \quad T < 0.2 \text{ sec}$$

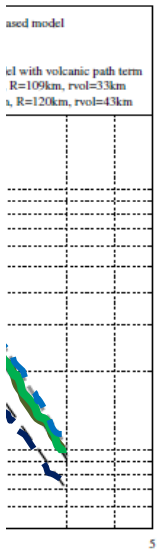
Modification to Standard Response Spectral Model

$$\ln SA(T) = \ln SA(T)_{\text{standard NZ subduction zone}} - [CQ_{\text{SITE}}(T, H_c) - CQ_{\text{STANDARD}}(T, H_c)]r$$

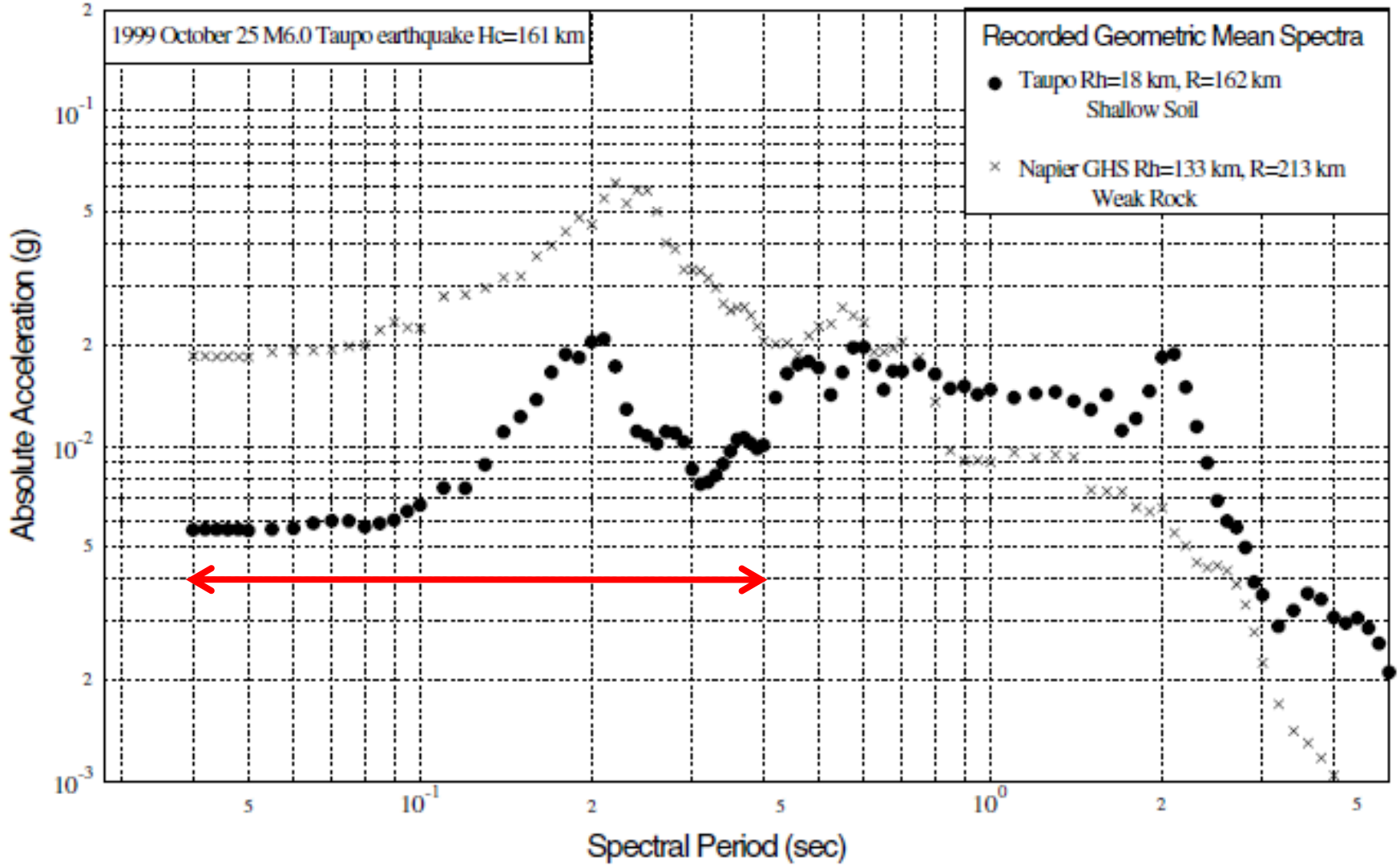
S2







Acceleration Spectra for Deep Taupo Event



Conclusion

- The abnormal intensity is caused by high absorption zone in the upper mantle
- Using seismograph network data, 3D *Q models can be* derived that image the heterogeneous attenuation
- Using actual Q-values along specified paths, appropriate terms can be computed that modify the response spectral model to adequately model the high-loss paths for deep earthquakes.

Thanks for your attention

Reference

- Phillips, D. E. , and McVerry, G., **Estimating Slab Earthquake Response Spectra from a 3D Q Model,** Bulletin of the Seismological Society of America, Vol. 93, No. 6, pp. 2649-2663, December 2003

- Utsu, T. **Regional Differences in Absorption of Seismic Waves in the Upper Mantle as Inferred from Abnormal Distributions of Seismic Intensities.,** Journal of the Faculty of Science, Hokkaido University, Japan, Ser. VII, Vol II, No. 4, 1966