S-wave Velocity Structure of Mexico City Obtained from Three-component Microtremor Measurements and Microtremor Array Measurements

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Outline

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- Analysis results
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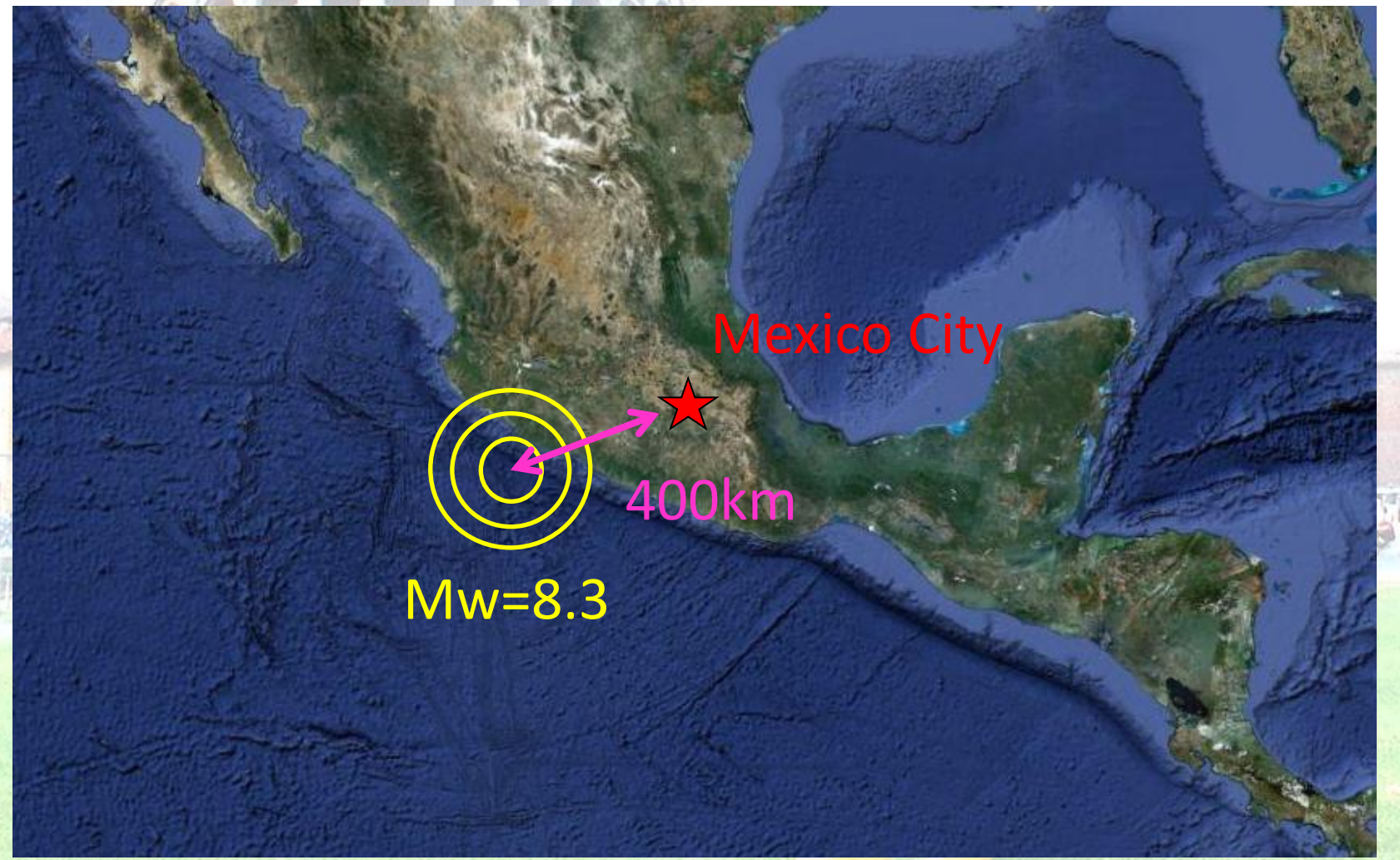
Introduction

- The earthquake that struck Mexico on 19 September 1985 caused severe damage in Mexico City although the city is located 400km away from the epicenter.
- The main reason for this damage is that the city is located on a basin filled with very soft sediments.
- Distribution of these soft sediments has been delineated by drillings and microtremor measurements.
- A small number of attempts have been made to image the S-wave velocity structure of the basin using downhole seismic loggings.
- In order to delineate S-wave velocity structure of the basin down to depth of approximately 200m, we have performed three-component micro-tremor measurements and microtremor array measurements.

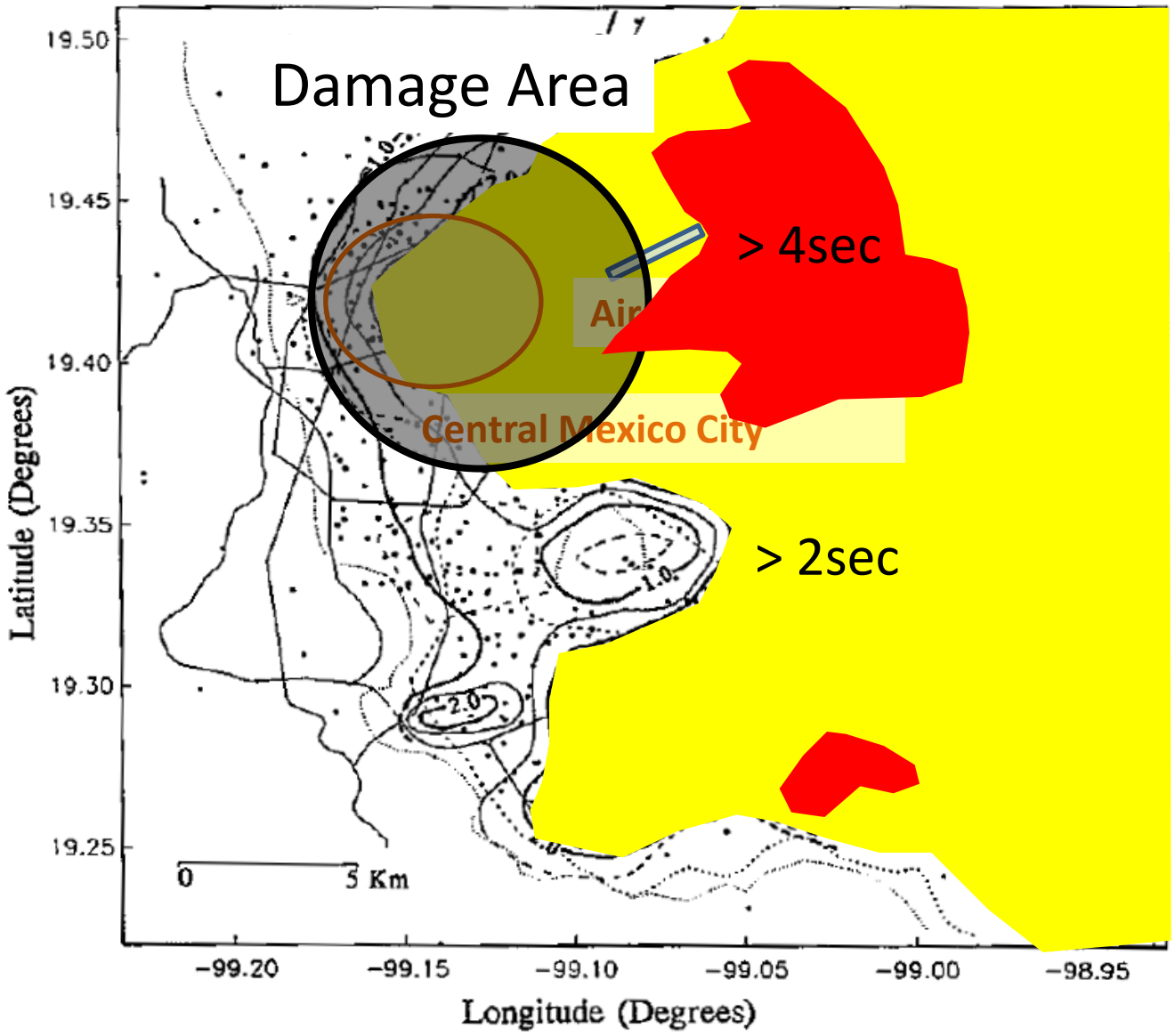
1985 Mexico Earthquake



1985 Mexico Earthquake

- Mw=8.3
- Most-often cited number of deaths is an estimated 10,000 people but experts agreed that it could be up to 40,000.
- Damage area corresponds to the western part of the lake zone within 2 to 4 kilometers of the Alameda Central.
- 6 to 15 story buildings are mainly damaged in the city due to a frequency range of 0.25 to 0.5Hz (period of 2 to 4seconds)

Natural Period (H/V) of Mexico Basin

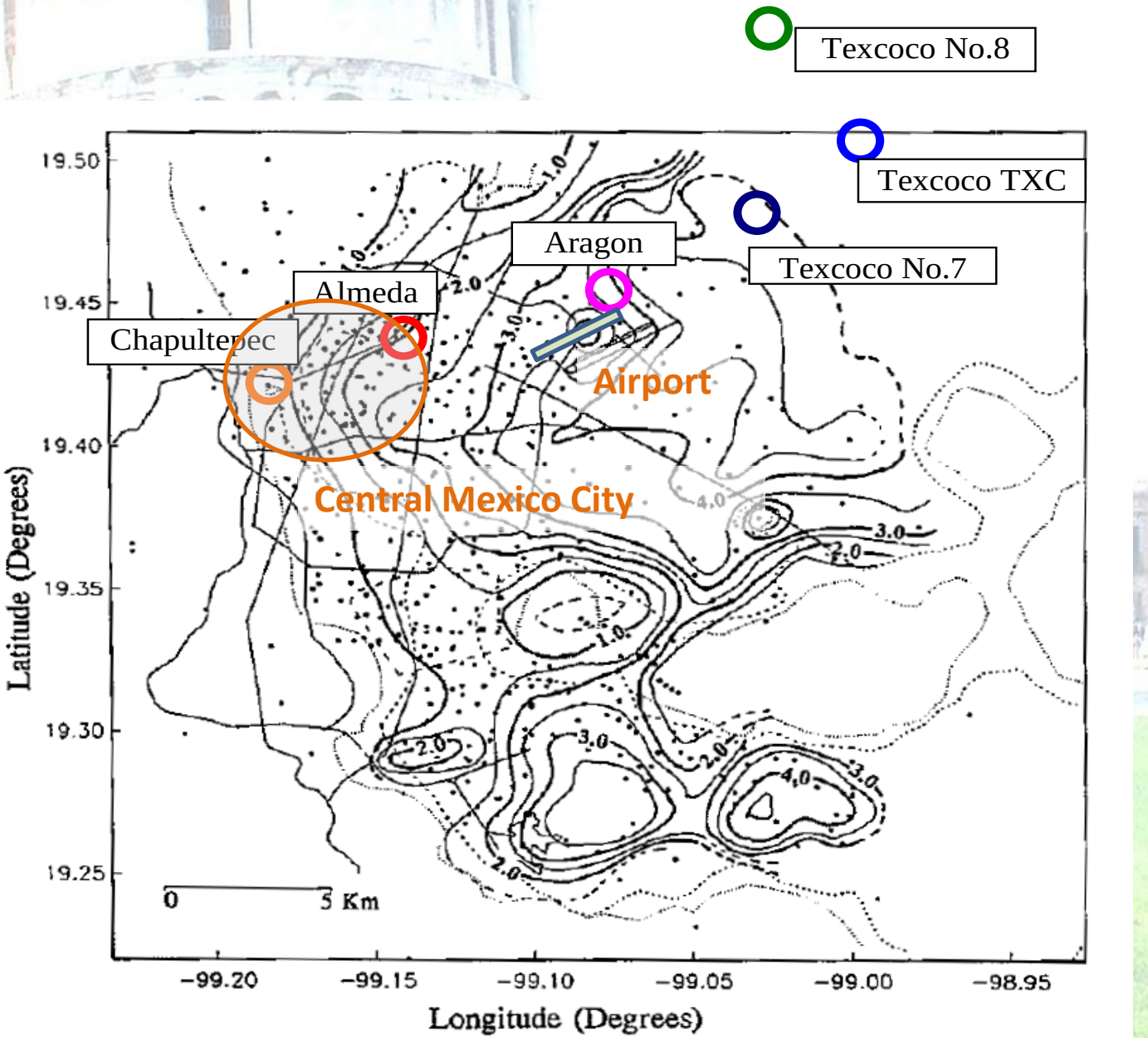


Lermo and Chavez-Garcia (1994)

Investigation Site

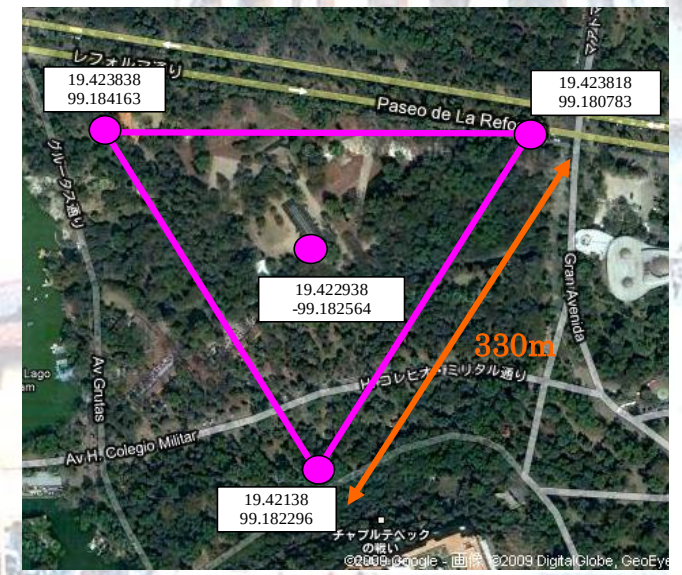
- Investigation site is placed at the downtown of Mexico City.
- 30km length survey line crosses the basin with a west-southwest to east-northeast direction.
- 3 component microtremor measurements were performed at more than 10 sites on the line.
- Microtremor array measurements were performed at 6 sites on the line.
- Microtremor array measurements used 25 to 650m equilateral triangular arrays.

Investigation Site



Example of Array Configuration

Chapultepec



Aragon

Data Acquisition

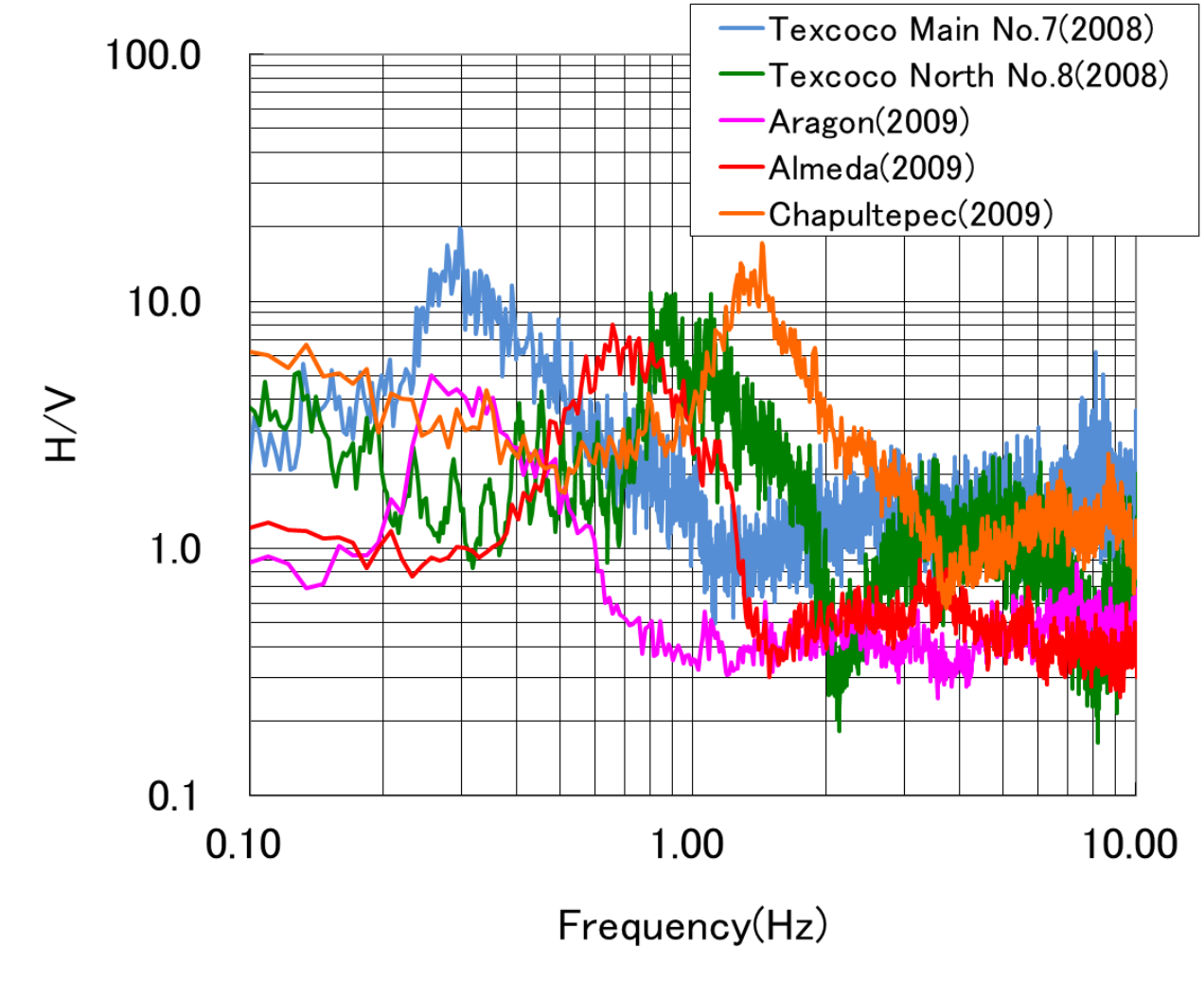
- Data acquisition was carried out during the daytime in December 2008 and December 2009.
- Microtremor measurement systems (JU210) made by Hakusan Corporation and data loggers (GPL-6A3P) made by Mitsutoyo Corporation were mainly used for data acquisition.
- Both systems use accelerometers for the sensors.
- In order to verify applicability of the accelerometers, servo-type velocity meters made by Katsujima Corporation (SD-110) and Tokyo Sokushin Corporation (VSE11F, VSE12F) were also used in the 3 component microtremor measurements.
- H/V spectra obtained through the accelerometers and the velocity meters were compared.
- 30 min. to 1 hour of microtremors were recorded for each three component measurement or array measurement.

Equipment(accelerometer)

Hakusan

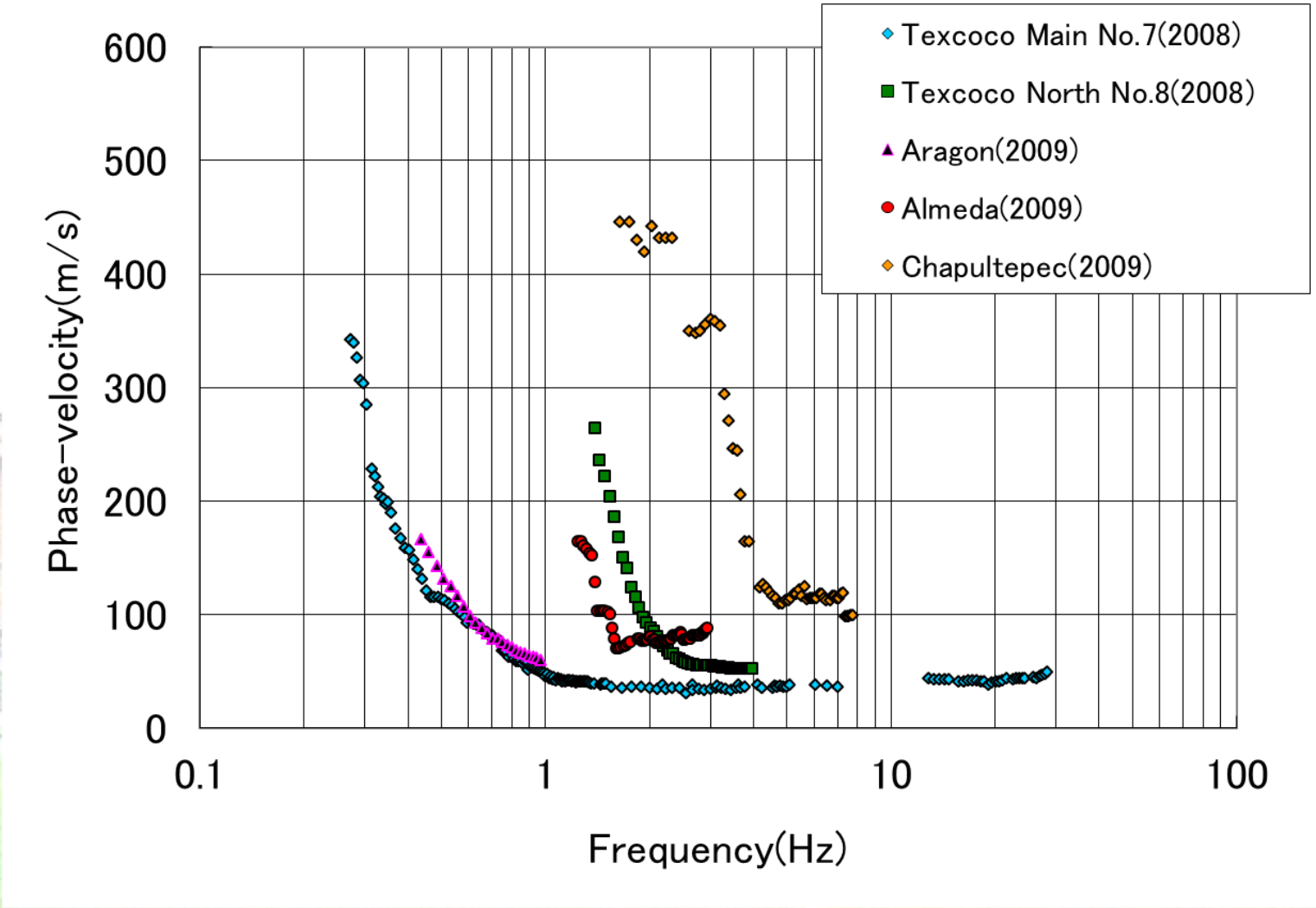
Mitsutoyo

Comparison of H/V



It is clear that peak frequency of H/V decrease from west to east (from edge to center of basin)

Comparison of Dispersion Curve



Sites where the peak frequency of H/V spectra is higher, the phase velocity of the dispersion curve is also higher

Analysis (1)

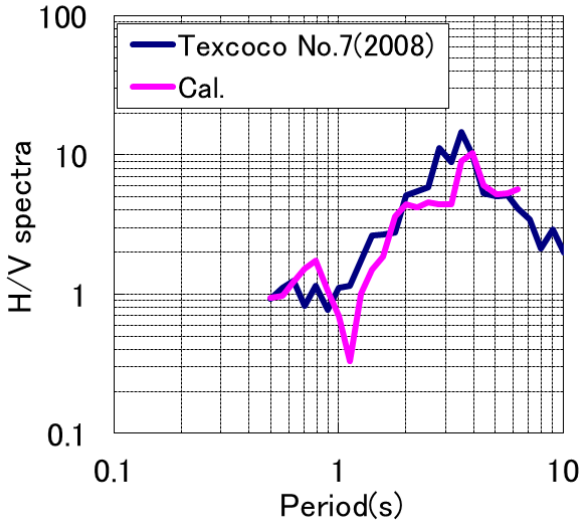
- A joint inversion was applied to the observed H/V spectra and dispersion curves, and S-wave velocity models were analyzed for six sites.
- In the inversion, phase velocities of the dispersion curves and peak frequencies of the H/V spectra were used as the observation data.
- Unknown parameters were layer thickness and S-wave velocity.
- A Genetic algorithm was used for optimization.

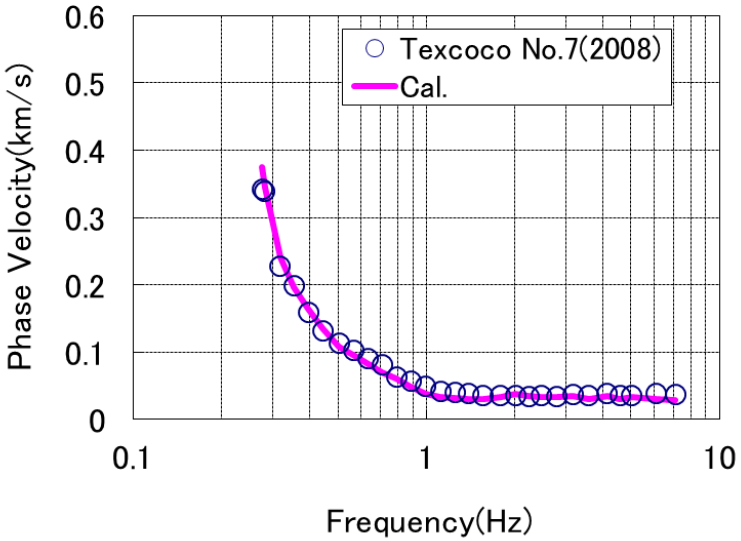
Analysis (2)

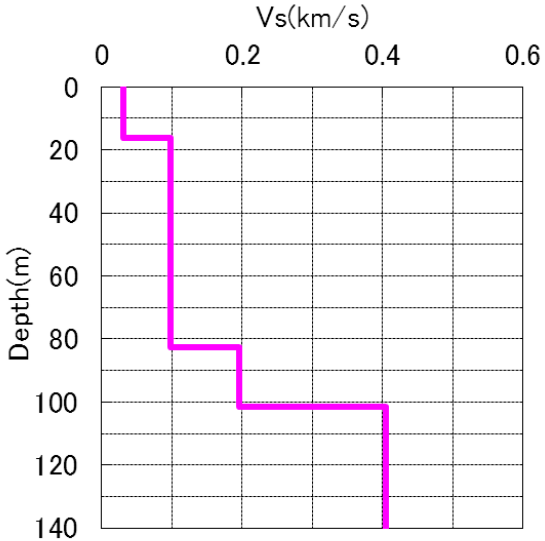
- Initial models were created by a simple wavelength transformation in which wavelength calculated from phase velocity and frequency is divided by three and plotted at depth.
- Theoretical H/V spectra and phase velocities are generated by calculating the weighted average of the fundamental mode and higher modes (up to the 4th modes) based on medium response.
- Rayleigh-Love ratio (R/L) is fixed as 0.7

S-wave Velocity Model（East）

Texcoco No.7







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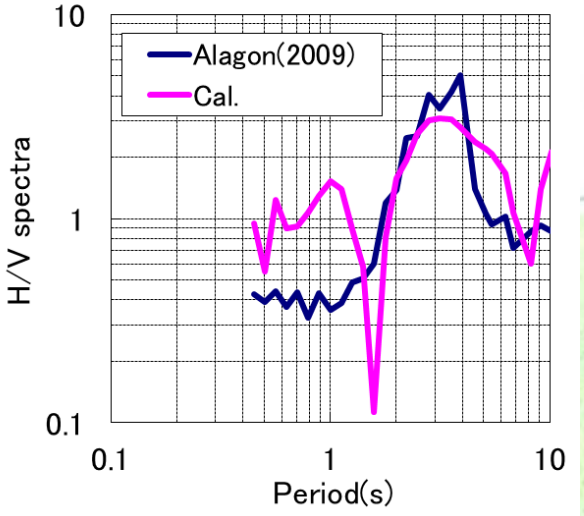
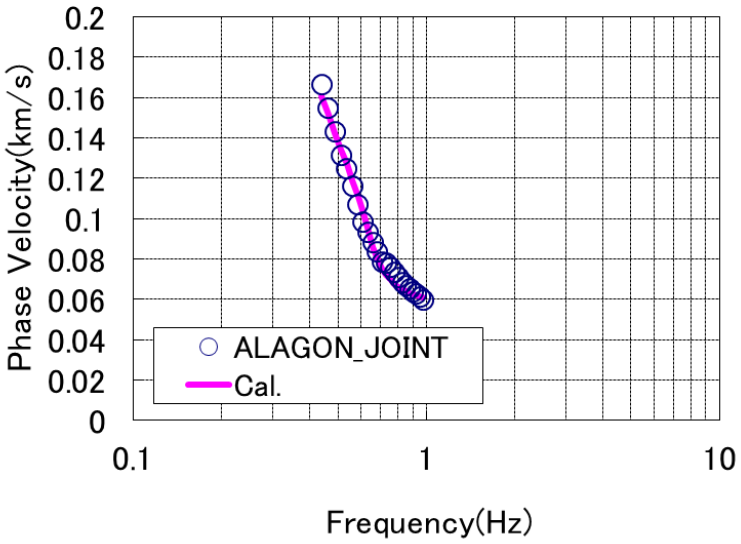
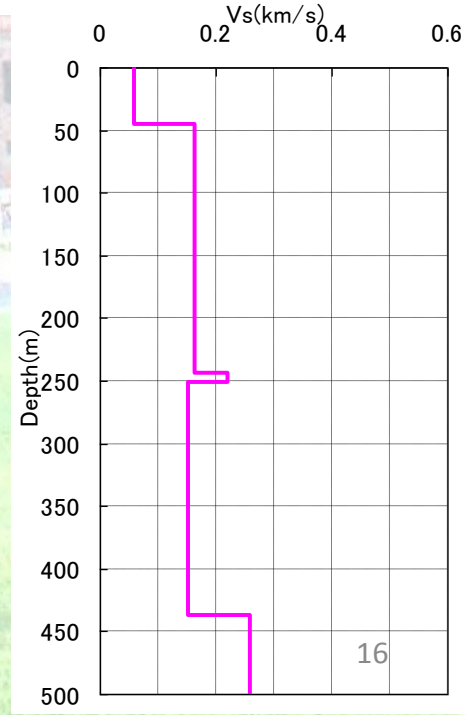
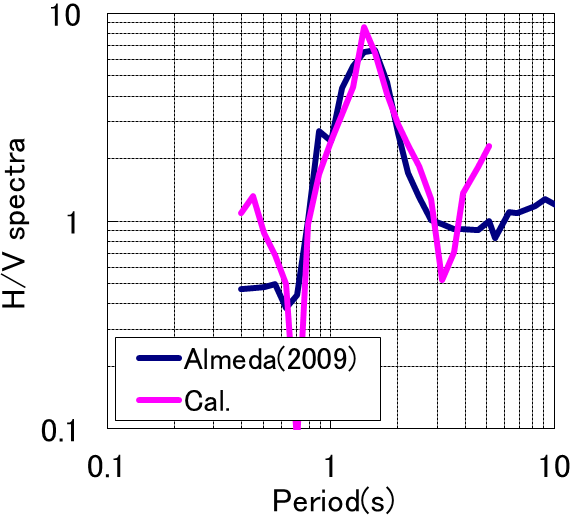


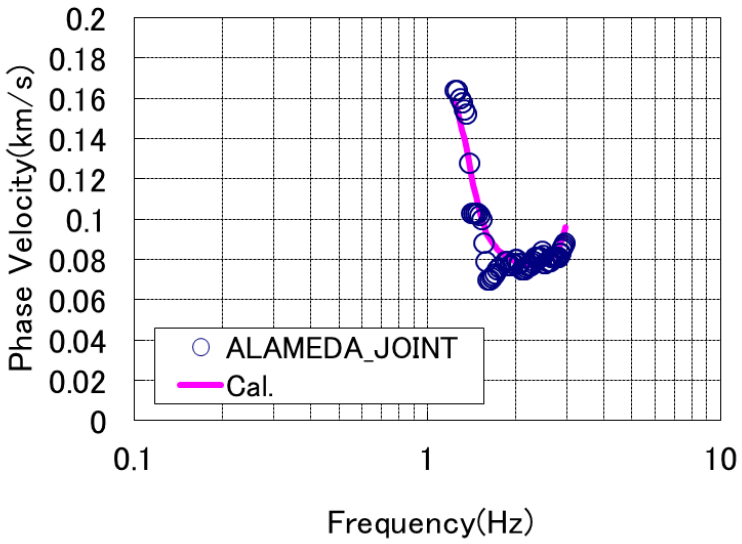


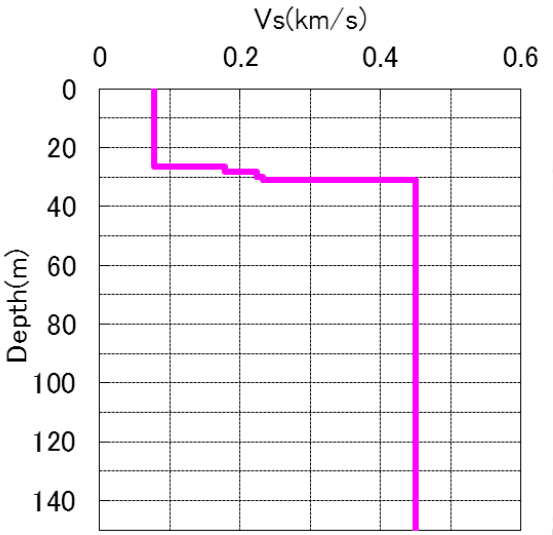


S-wave Velocity Model（West）

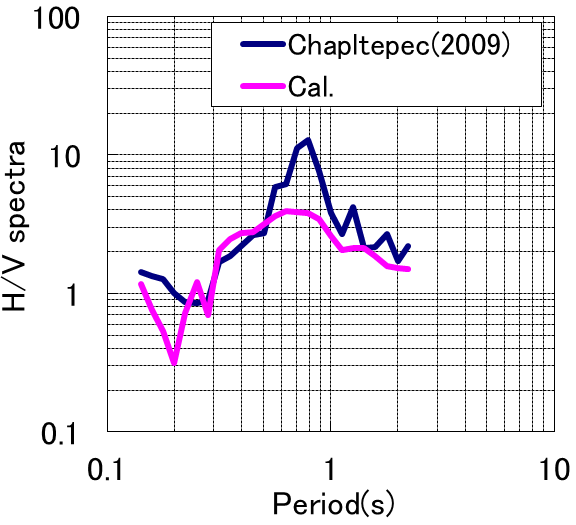
Almeda

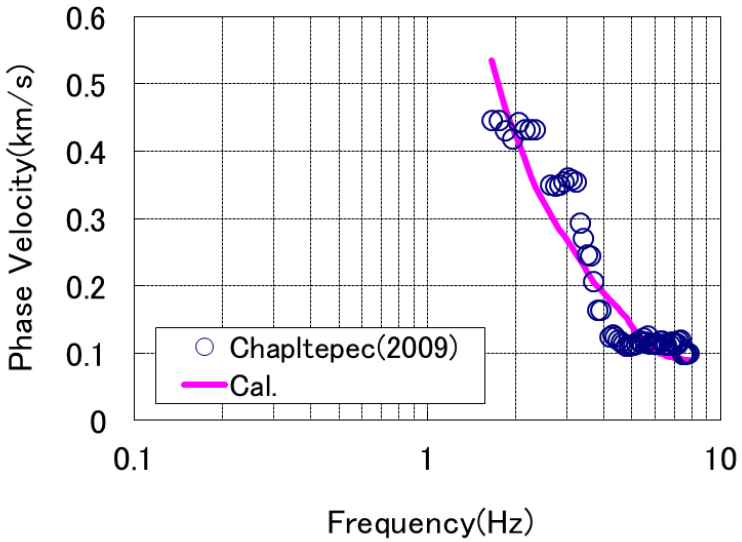


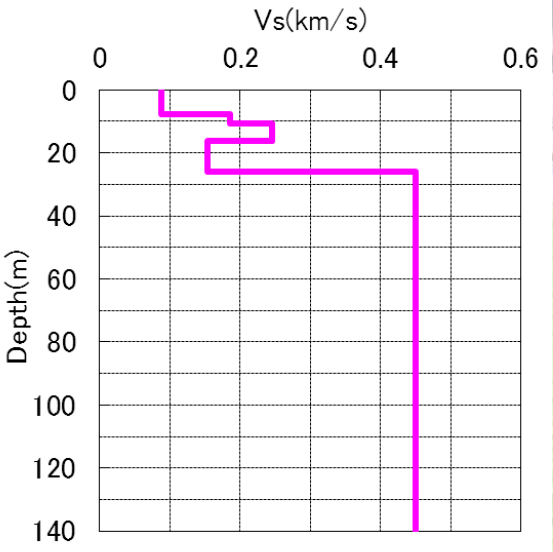




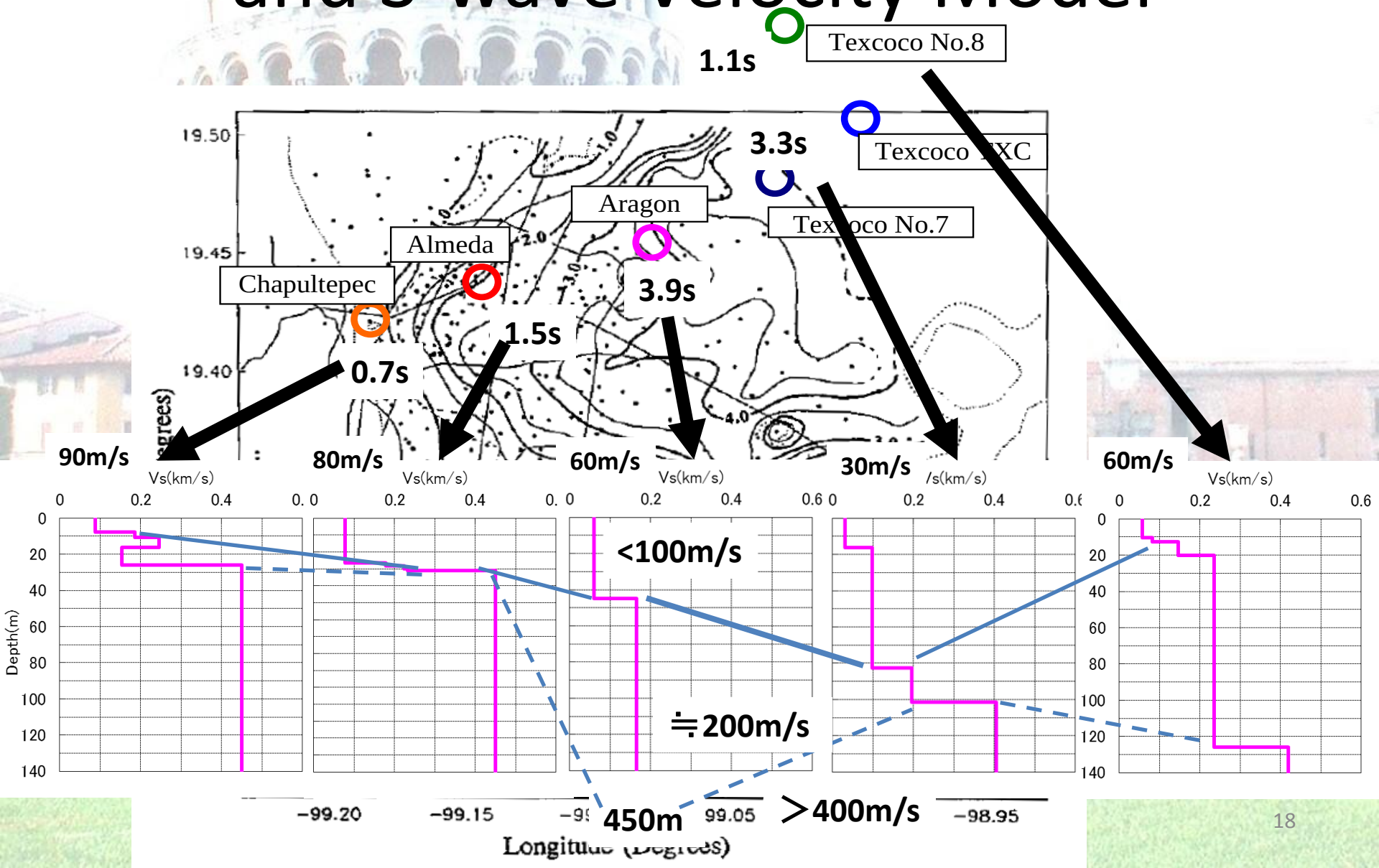
Chapultepec





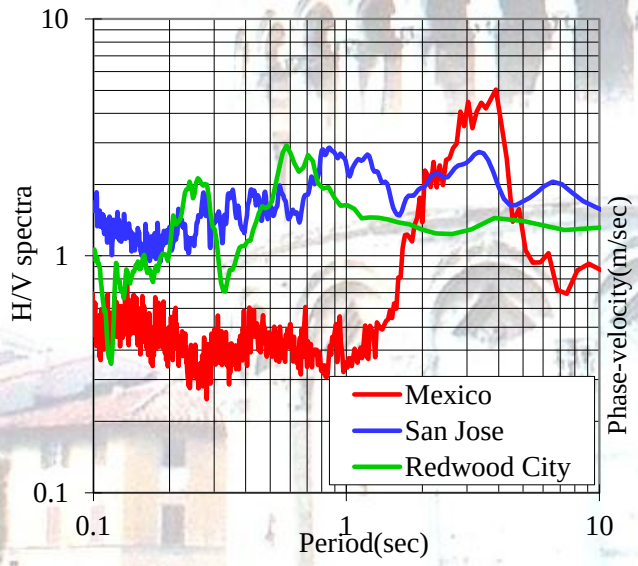


Peak Frequency of H/V and S-wave Velocity Model

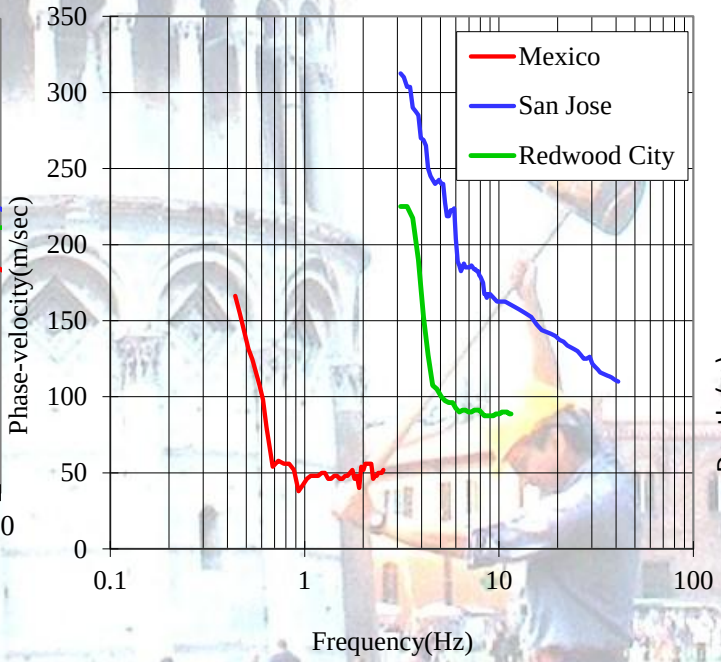


Comparison with United States

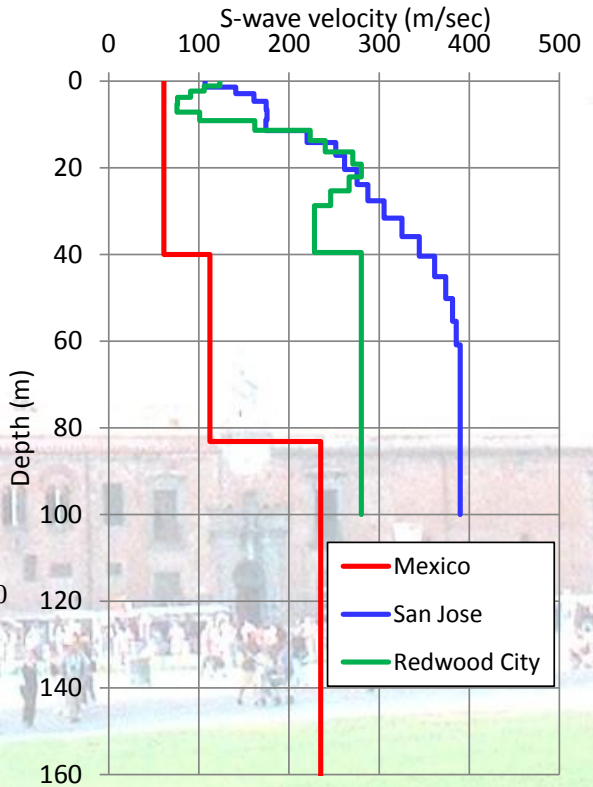
H/V Spectra



Dispersion Curve



S-wave Velocity Model



Mexico City

San Jose (William St. Park), CA

Redwood City, CA

S-wave velocity of Mexico is extremely low compare with San Jose and Redwood City.

Conclusions

- We have performed the three-component microtremor measurements and microtremor array measurements in the Mexico basin and estimated the S-wave velocity models down to a depth of 200m.
- S-wave velocity in the middle of the Mexico basin is lower than 150m/s to a depth of 70m and much lower than typical alluvial plains in Japan and United States.
- Peak frequencies of the H/V spectra in Mexico City vary from 0.25 to 1Hz and it seems that these peak frequencies are mainly due to the low-velocity layer shallower than a depth of 100m.