Body Wave Attenuation Structure in Central Mexico

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Abstract

Velocity spectra from moderate-sized earthquakes are used to investigate the P-wave attenuation structure in central Mexico. In particular, we include regional events with magnitudes in the range 4.5 < M < 6.1 recorded from February 2005 to July 2007 on the Meso American Subduction Experiment (MASE) array, which consists of 100 broadband sensors from Acapulco to Tampico in central Mexico. Using a spectral-decay method, we obtain a path attenuation operator t* for each seismogram in the frequency band 2 to 30 Hz, depending on the signal quality. These measurements are then inverted for spatial variations in attenuation. The 2-D inversion shows a low-Q zone directly beneath the volcanic belt between the depth of 80 km and 100 km. The location of the low-Q region provides some constraints on the geometry of the subducting slab, or with the structure provided by other methods such as receiver functions, the Q estimates will be used to estimate variations in viscosity. We also find that there are some attenuation variations in the crust.

Introduction

The Meso American Subduction Experiment (MASE) provides us a good opportunity to study the attenuation of central Mexico carefully.

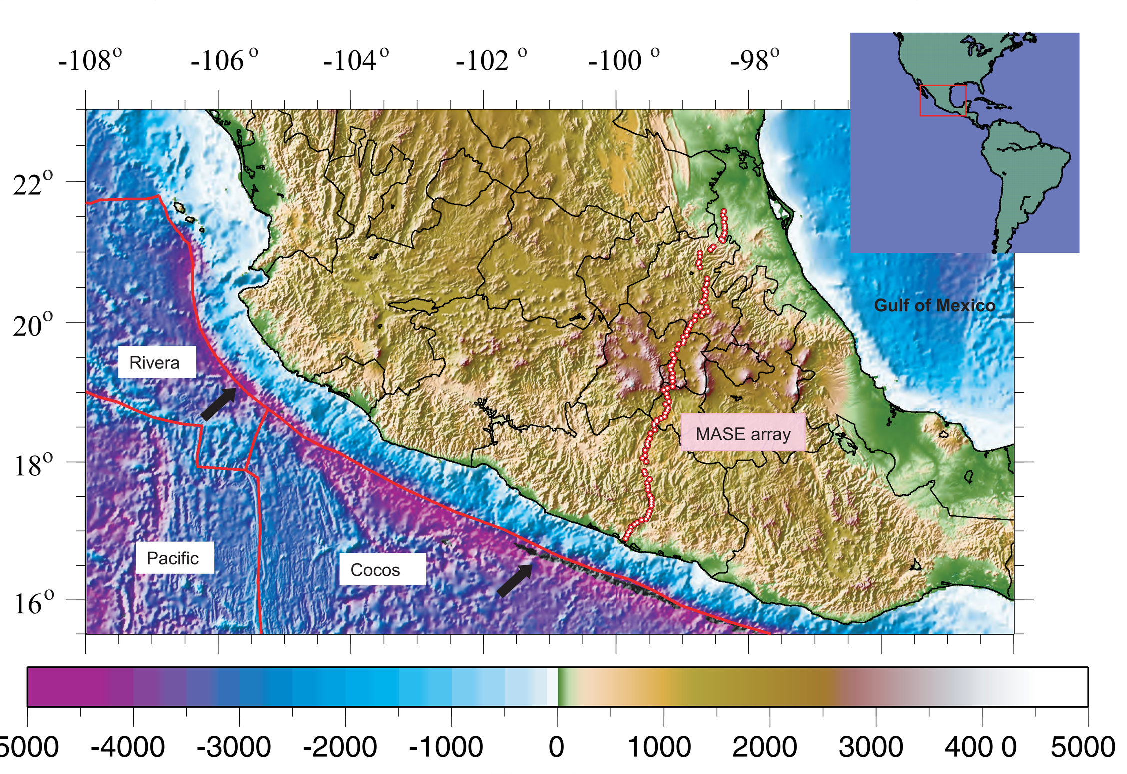


fig. 1

Spectral Analysis Method

The Fourier velocity spectral amplitude of a body wave from event *j*, recorded at station *i*, can be written as [e.g. Garcia *et al.*, 2004]

$$A_{ij}(f) = C S_j(f) I_i(f) \exp(-\pi f t^*_{ij}) \quad (1)$$

where *S(f)* is the source spectra, *I(f)* is the instrument response, *C* is the frequency-independent amplitude term. The exponential term describes the attenuation effect. $t^* = t/Q$, where *t* is the travel time, and *Q* is the quality factor.

Assuming a Brune-type source [Brune,1970], the source velocity spectrum of event *j*, can be written as

$$S_j(f) = \frac{f M_{0j}}{1+(f/f_c)^2} \quad (2)$$

where M_{0j} is the signal moment, and f_c is the corner frequency.

*t** for each seismogram and a common corner frequency for each event are obtained applying the techniques from *Eberhart-Phillips* and *Chadwick* (2002).

Data and Analysis

We used 93 events in total as showed in fig. 2. Here we show an example of attenuation difference between the P wave going to forearc region and the P wave to backarc region. The two waves are from the same event, and have about equal raypath length. It is clear from the spectra that the wave going to backarc regioin attenuates more than the other one.

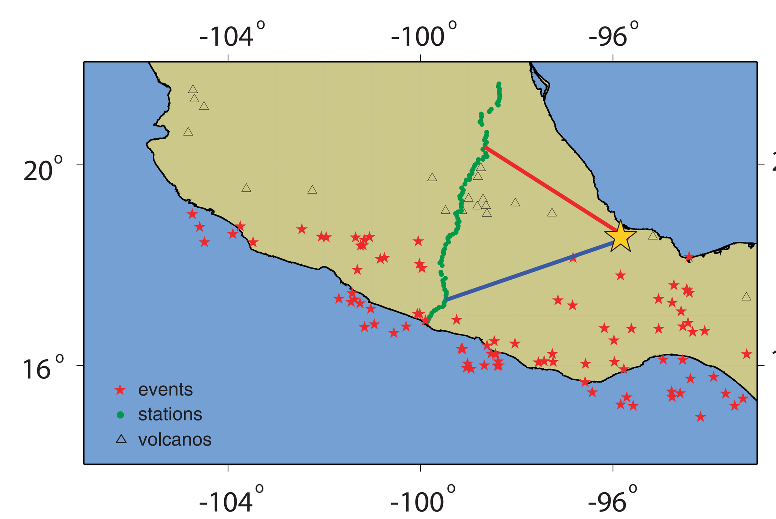
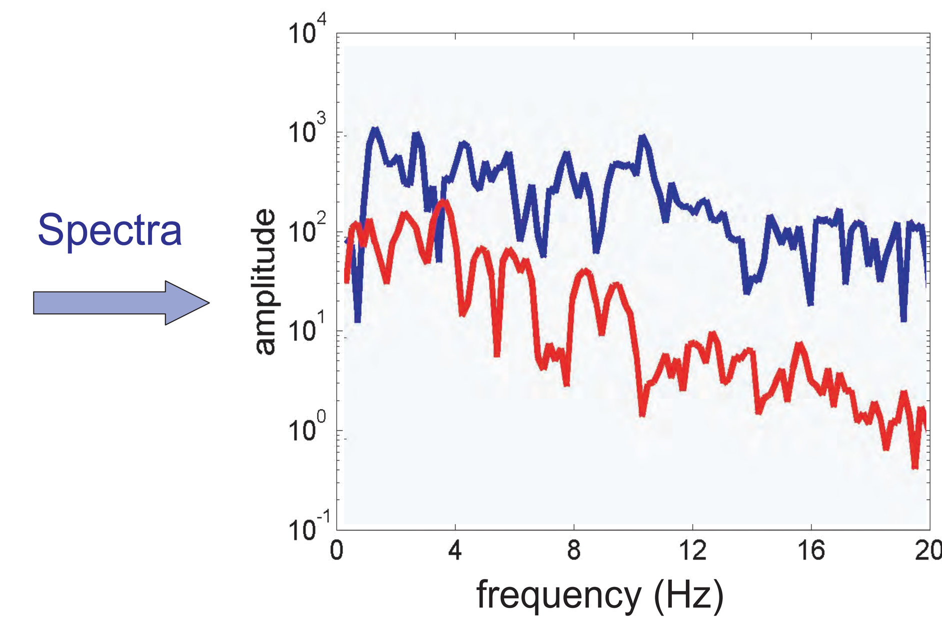


fig. 2



Example of signals, noises, and fittings for some seismograms.

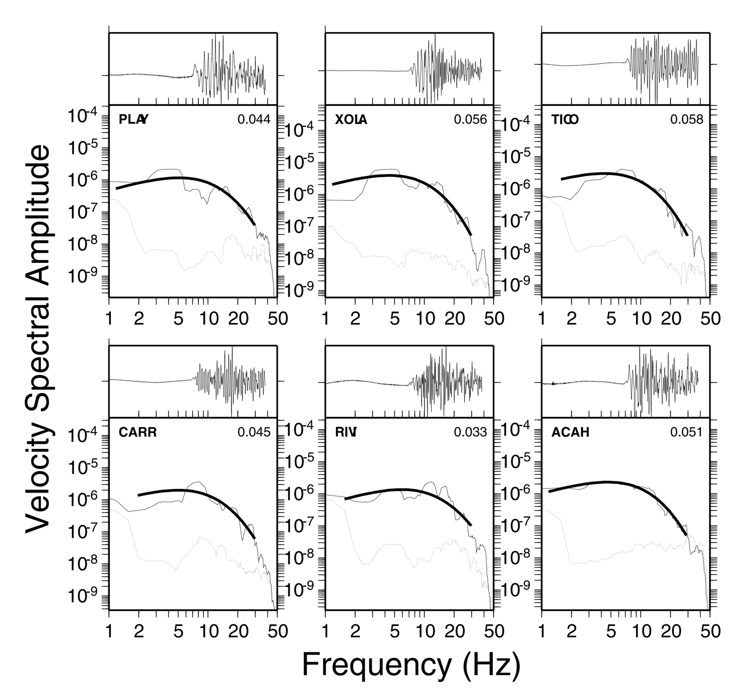


fig. 3

Example of path-averaged attenuation result (1000t*/d) for some event.

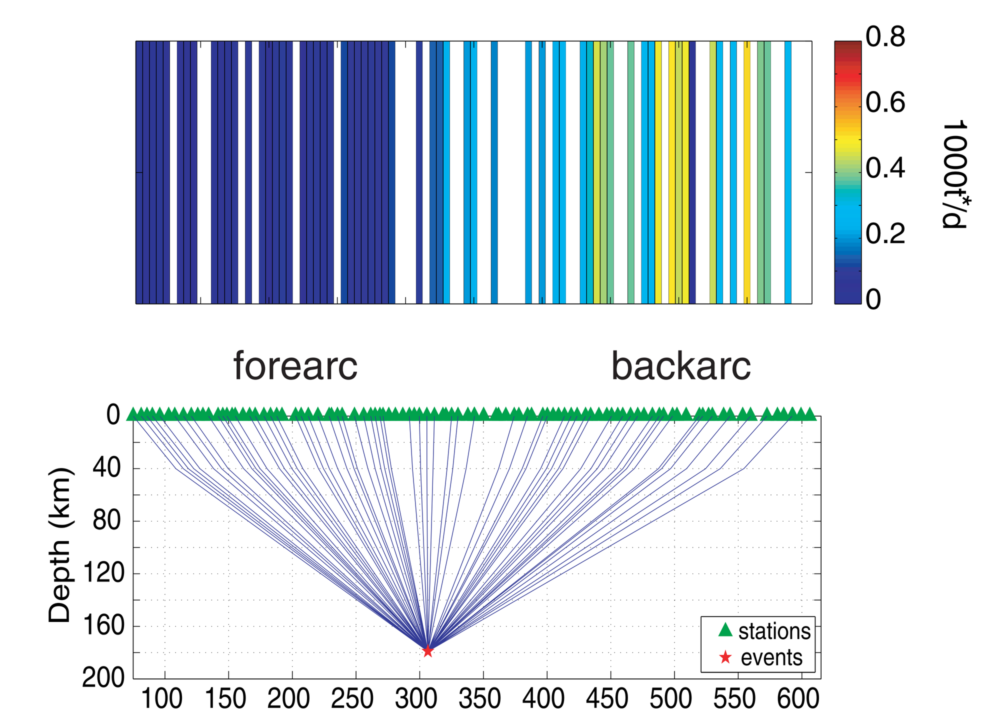


fig.4

Tomographic Geometry

We attemp to obtain a 2-D attenuation structure for the cross section along the array line. Fig. 5 shows the projection of events to this cross section and the 50 km x 20 km blocks we used. Assuming a simple 1-D velocity model with crust velocity be 6.3 km/s and mantle velocity be 8 km/s, we applied the ray tracing (fig. 6).

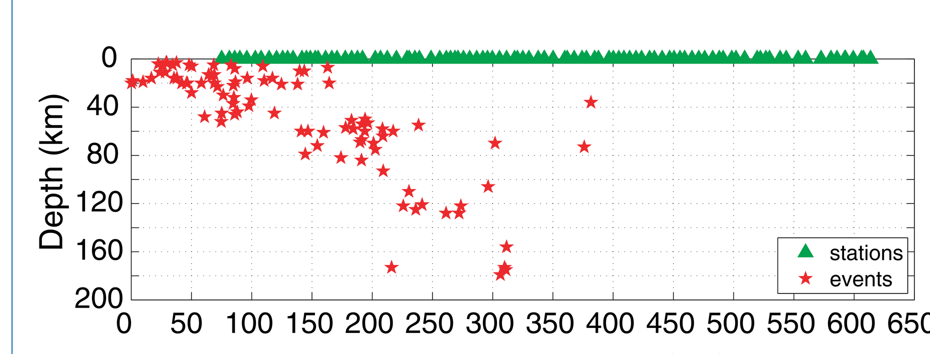


fig. 5

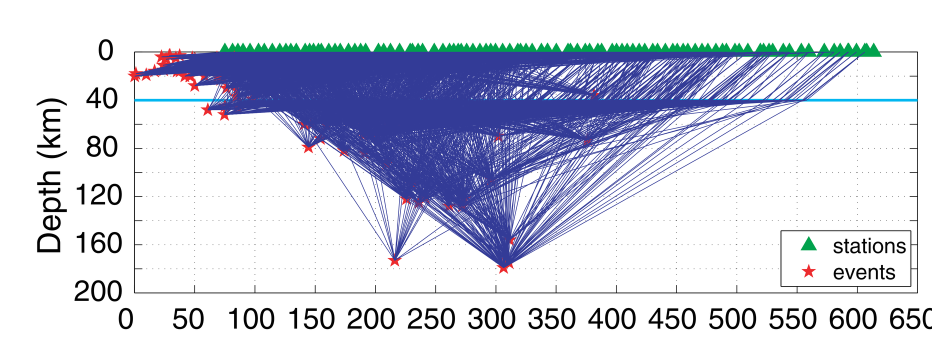


fig. 6

Inversion Result

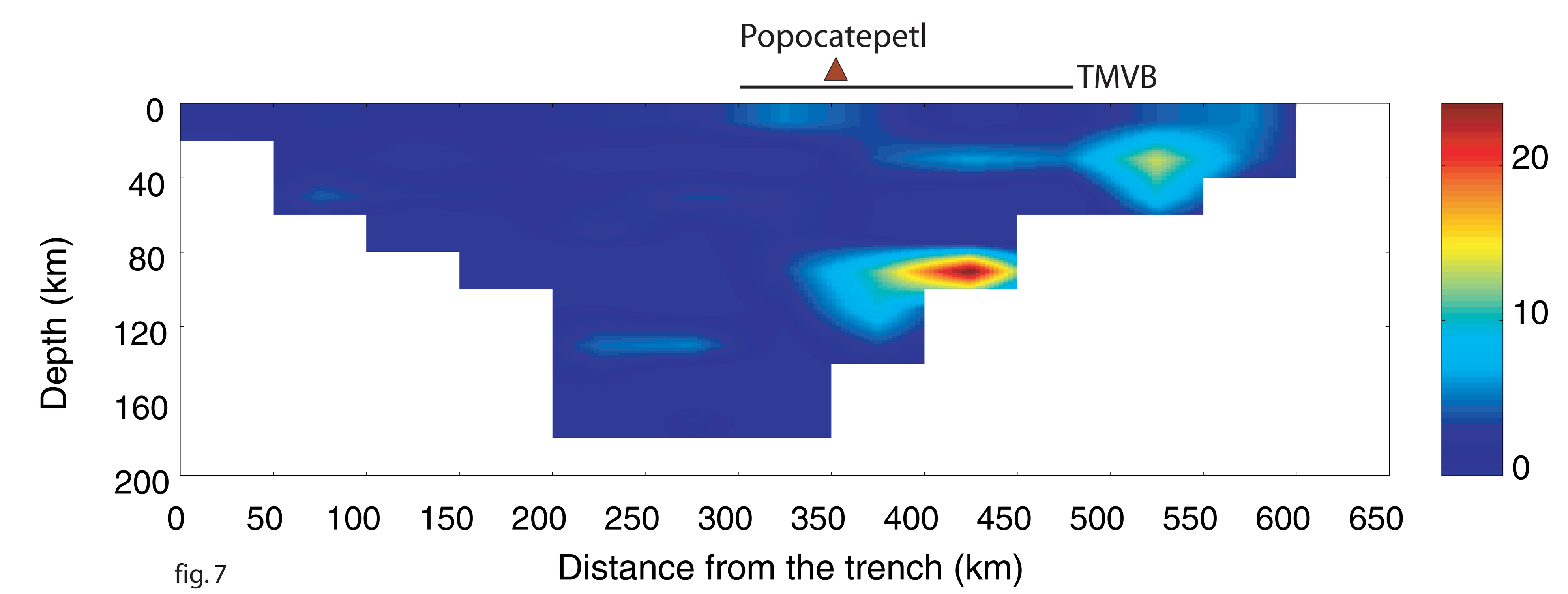


fig. 7

The 2-D tomographic inversion result shows that there is a high attenuation region with a Q of about 50 between the depth of 80 km and 100 km, and directly beneath the volcanic belt (fig. 8). This is where the mantle wedge is expected to be.

The relative high attenuation region in crust is consitent with the resistivity result from Jodicke et al [2006] (fig. 9).

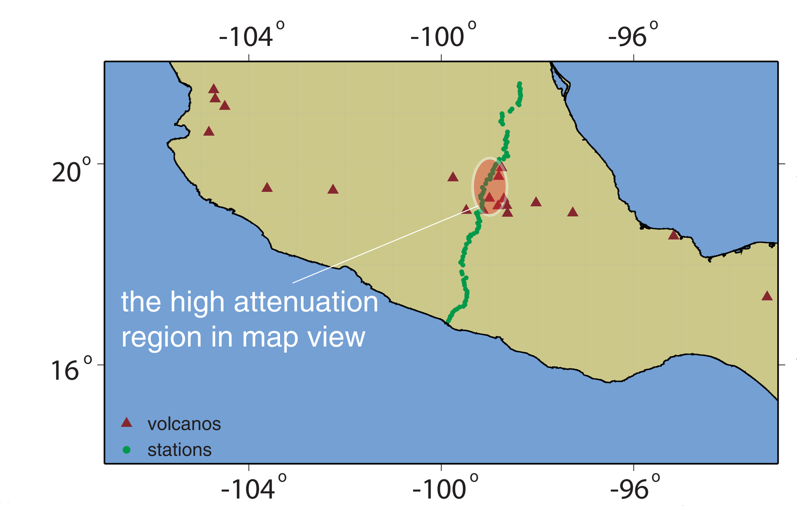


fig. 8

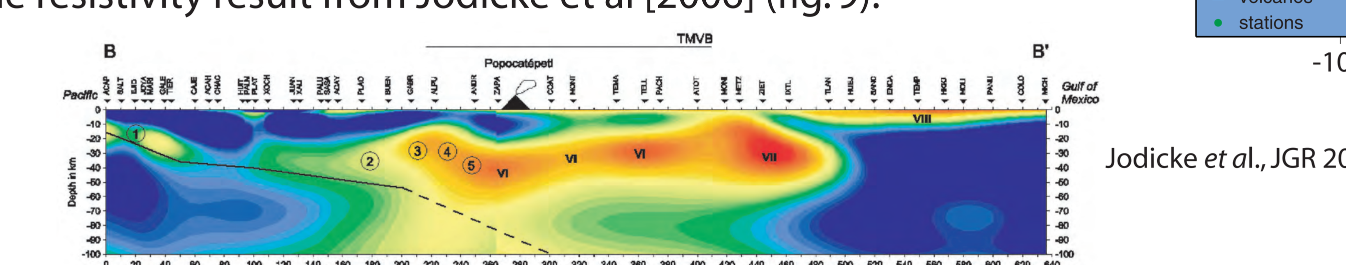


fig. 9

lined up

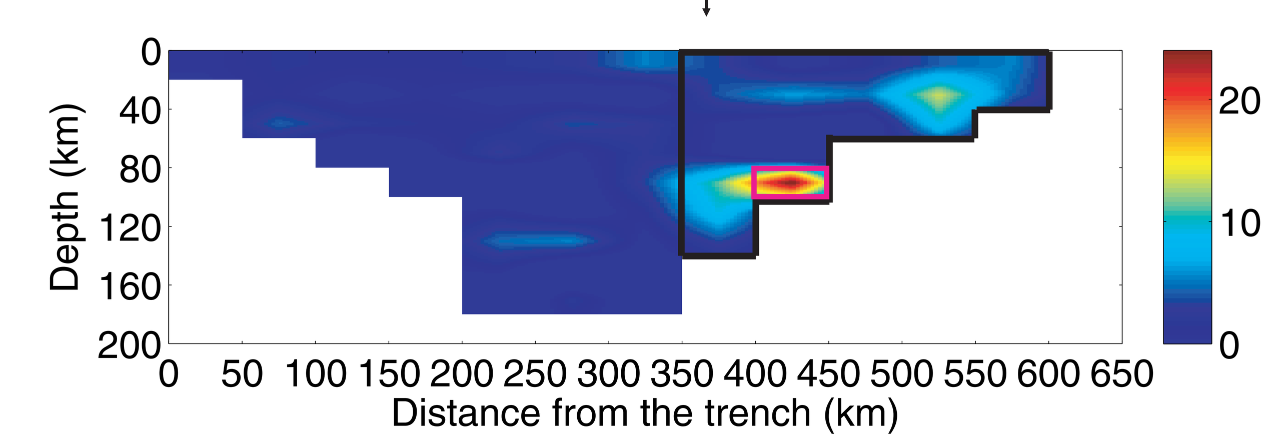


fig. 10

During inversion, we only considered the blocks with hit count larger than 15 to ensure reliable result. Here we also checked the average attenuation (1000t*/d) for the rays passing through the pink block region and black block region respectively (fig. 10), and found that the average 1000t*/d for pink region is about 0.1 larger than that for black region. So we think this high attenuation result is real and not an artifact.

Summary

We have studied the P wave attenuation structure in central Mexico using the spectral decay method. The results show a low-Q zone beneath the Trans-Mexico-Volcanic-Belt between the depth of 80km and 100 km, which we interpret to correspond to the mantle wedge. We suggest that the mantle wedge lies about 300 km far from the coast, and has a low Q value about 50. The attenuation structure obtained in this study is similar to that of other subduction zones. The attenuation model could be converted into viscosity model, and help us to conduct a more realistic geodynamic modeling in central Mexico.