Flat Slab Subduction at the Middle American Subduction Zone in Central Mexico

Determined from Receiver Function Analysis

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Abstract

The flat slab subduction of the Cocos plate beneath central Mexico is determined from the receiver functions (RFs) utilizing data from the Mexico America Subduction Experiment (MASE). The RF image shows that the subducting oceanic crust is shallowly dipping to the north at 15° to 85 km from Acapulco, and then horizontally underplates the continental crust for a distance of approximately 300 km from the trench. There is no apparent evidence of crustal compressional features supported by the geotectonic or geodetic data. The migrated image of the RFs shows deep dipping into the mantle at about 50° beneath the TMVB. Both the continental and oceanic Moho are clearly seen in both images. In particular, the RF image from Acapulco to a point 150 km to the north shows the collision of the continental material by the slab. However, there is no apparent evidence of crustal compressional features supported by the geotectonic or geodetic data. The modeling of the RF conversion amplitudes and the dipping of the upper mantle indicates the need for a low-velocity zone between the plate and the continental crust. This may indicate melted upper crust or melted continental lithosphere.

Data

The flat slab subduction of the Cocos plate beneath central Mexico is determined from the receiver functions (RFs) utilizing data from the Mexico America Subduction Experiment (MASE). The RF image shows that the subducting oceanic crust is shallowly dipping to the north at 15° to 85 km from Acapulco, and then horizontally underplates the continental crust for a distance of approximately 300 km from the trench. There is no apparent evidence of crustal compressional features supported by the geotectonic or geodetic data. The migrated image of the RFs shows deep dipping into the mantle at about 50° beneath the TMVB. Both the continental and oceanic Moho are clearly seen in both images. In particular, the RF image from Acapulco to a point 150 km to the north shows the collision of the continental material by the slab. However, there is no apparent evidence of crustal compressional features supported by the geotectonic or geodetic data. The modeling of the RF conversion amplitudes and the dipping of the upper mantle indicates the need for a low-velocity zone between the plate and the continental crust. This may indicate melted upper crust or melted continental lithosphere.

3 Method: RF Stacking Algorithm and RF Migration

Plan view of geometry for several teleseismic wavefields. Incident plane wave is assumed to be P wave coming from a distant source; as hitting the scraper, it converts to S wave to become P0 or other wavefields such as P0Ps, P0Ps, or P0Ps, or P0Ps, or P0Ps. Each wavefield is migrated using a Kirchhoff-style migration, which characterizes the model input as a grid of point scatterers.

4 RF Results

(1) Anisotropic layers present in the crust.

Stacked RFs using events from all directions (top), RF migration image from the surface to a depth of 130 km (middle), and migrated image of the upper mantle structure including 410 and 660 discontinuities (bottom). In the top panel, the blue interpretation segment shows the top of the subducting slab, red segment the top of the oceanic and continental Moho, and the orange segment partial melting features from the TMVB. In the middle panel, the blue interpretation lines the bottom of the subducting slab; the dotted red line the continental Moho shallowing towards the north, and the dotted brown line mid-crustal interface. In the bottom panel, note the upward-moving trend of the 660 discontinuity underneath the TMVB suggesting an upwelling.

(2) Stacked RF and migration results

The subducted Cocos plate as imaged with RFs underplates the continental crust for a distance of approximately 300 km from the trench. Different velocity models for the flat slab are constructed by considering the azimuthal dependence of the RF images (bottom panel). In the top panel, we show stacked RFs generated from the SE direction (left) and the NW direction (right). We clearly see that the image of the top of the slab appears to be strong from the RFs using events from the SE direction, and the image of the oceanic Moho appears to be strong from the RFs using events from the NW direction. In generating realistic synthetic RFs (middle panel), we match impedance changes of the interface between the crust and the slab by measuring RF amplitudes and positioning of the RF peak amplitudes underneath the Moho and the slab. We ignore complicated structures within the crust (e.g., mid-crustal and upper crustal thin layer under the Moho and slab) and outlying data. The velocity model for the flat slab sitting on oceanic plate (lower normal oceanic crustal velocities) might be necessary to reproduce impedance contrasts that we are not resolving at the moment.

5 Modeling Result

P-wave velocity model for a steeply dipping slab.

The migrated image using synthetic RFs includes primary and secondary conversions from the Moho and the slab. Especially for events coming from the top of the slab, the continental Moho with the mid-crust, and the depolarizing slab are well captured. To note, the migrated image using real RFs includes more complicated features such as mid-crustal interfaces and a low-velocity zone on the TMVB, which we did not incorporate for the synthetic RFs using the crustal model.

6 Preliminary Result on Velocity Models for the Flat Slab

RFs using earthquakes from SE dir (left) and from NW dir (right).

Synthetic RFs using sources from LHS (left) and from RHS (right).

Two velocity models constructed to generate synthetic RFs.

Discussion / Conclusions / Future Work

1. We have obtained RF images of crustal structures associated with tectonic history of subducted Cocos plate beneath central Mexico for the first MASE line.

2. Flat slab subduction from the Pacific coast to the southern extent of TMVB

- The subducting oceanic crust is shallow, dipping to the north at 15° from 80 km from Acapulco.
- There is no compressional feature on surface due to the underplating according to geologic or geodetic data.
- There is a single low velocity zone (lower than normal oceanic Moho) beneath the TMVB suggesting an upwelling.
- The continental Moho is about 40 km deep beneath the TMVB and shallows towards the north.
- There is no apparent maximum attenuation at the top of the dipping slab.
- Deeply dipping slab is likely to be flat slab subduction.
- The slab geometry supports the idea of slab roll-back.

3. For the future work, we process seismograms recorded from the second MASE line (VECO) to generate the RFs.