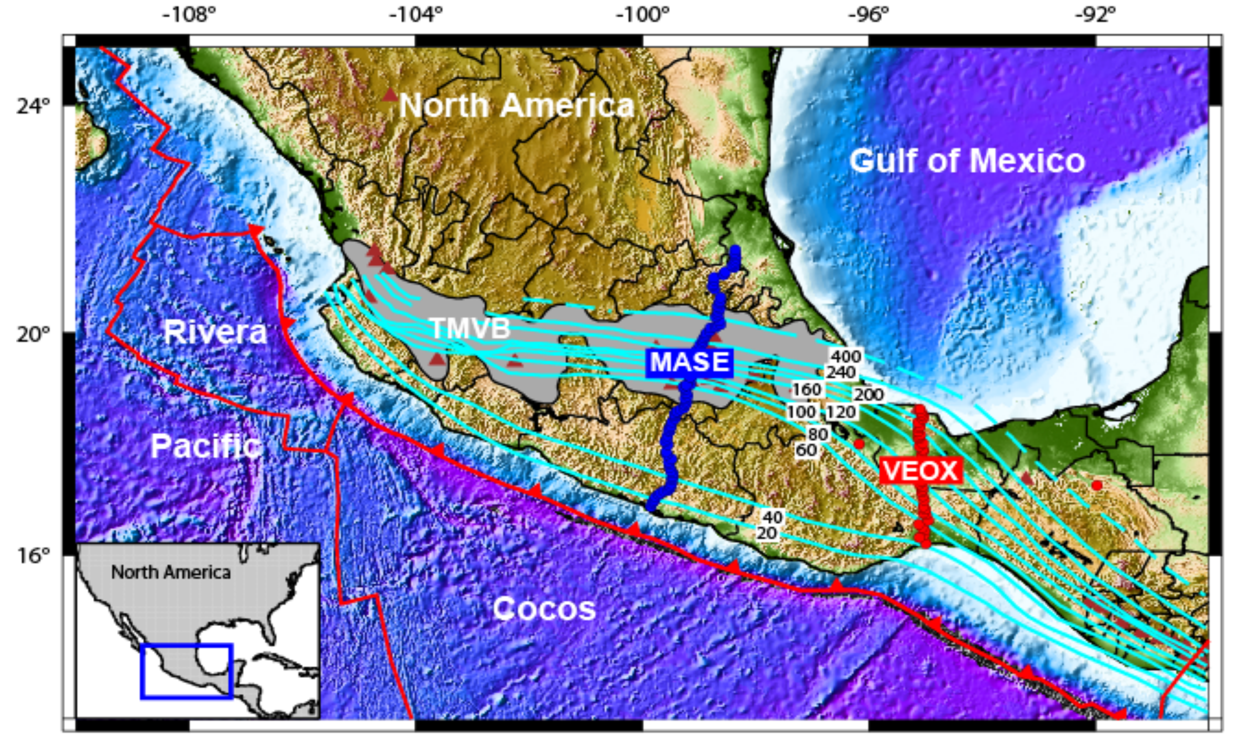

MASE: Subduction in Central Mexico

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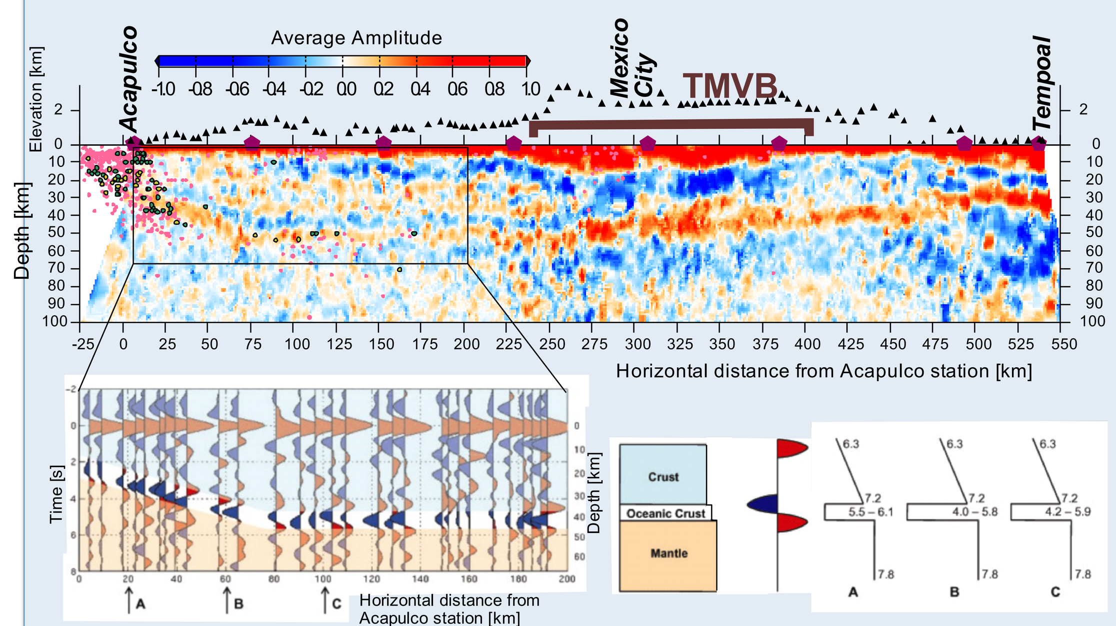
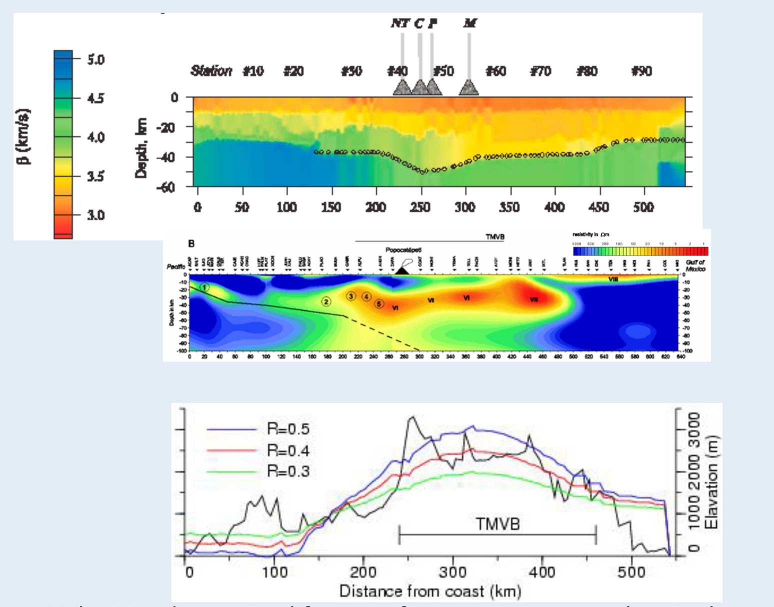
CONACYT (Mexico)

Web Site: http://www.gps.caltech.edu/~clay/MexWeb/MexSubduction.html

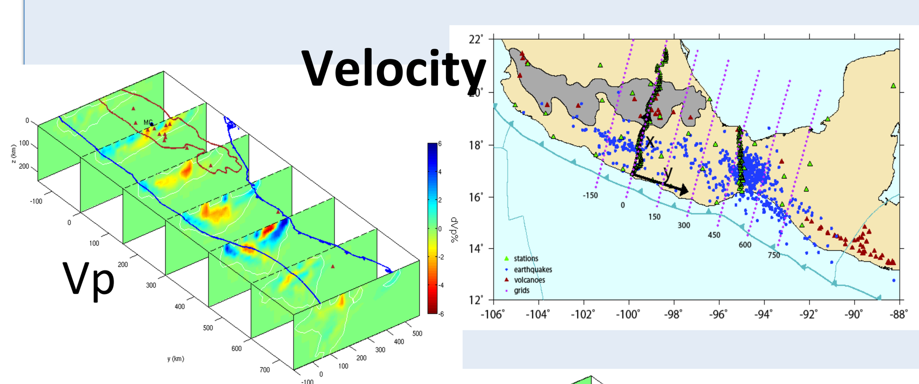
Slab Structure - Central Mexico

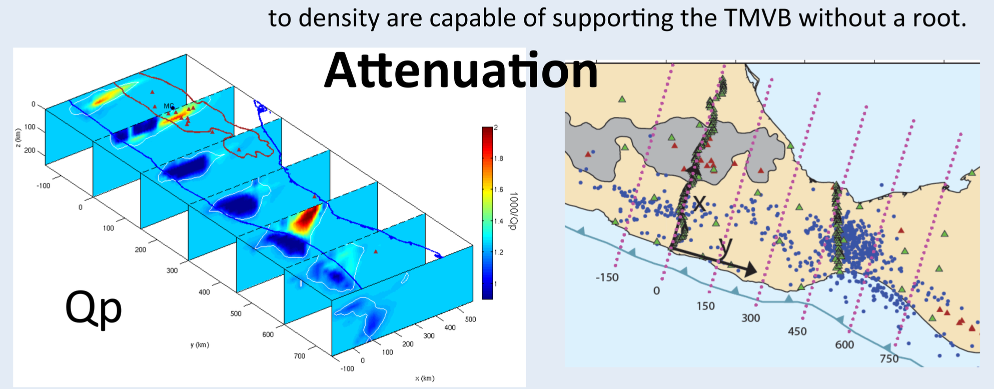


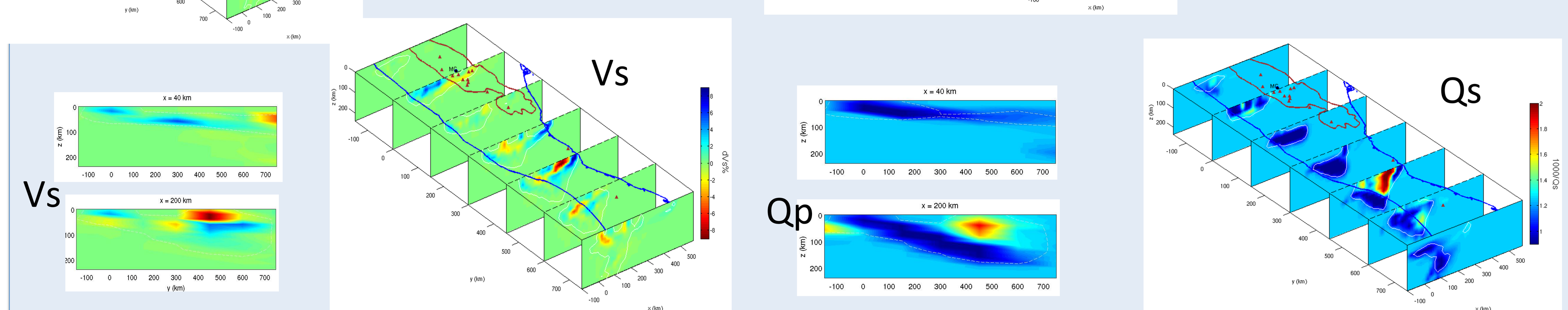
Receiver functions along the MASE line show that the Cocos slab is horizontal for 200 km and is separated from the upper plate by a thin layer with very low shear velocities. Note that Moho does not have an Airy crustal root under the elevated TMVB.



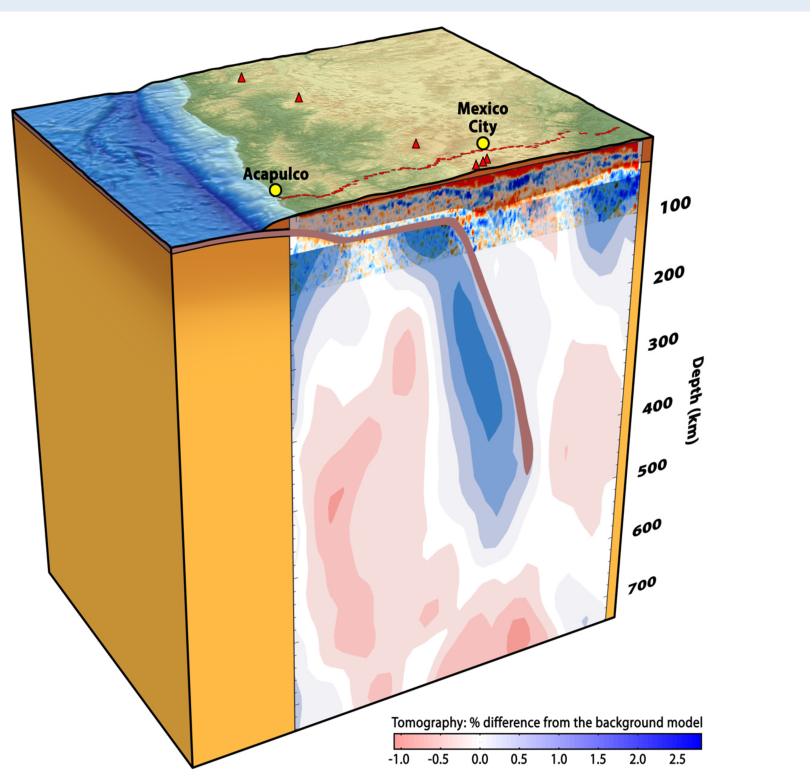
Velocities determined from surface waves are very low in the lower crust beneath the TMVB, probably caused by dehydration of the Cocos slab as it rolled back. These low velocities if scaled to density are capable of supporting the TMVB without a root.



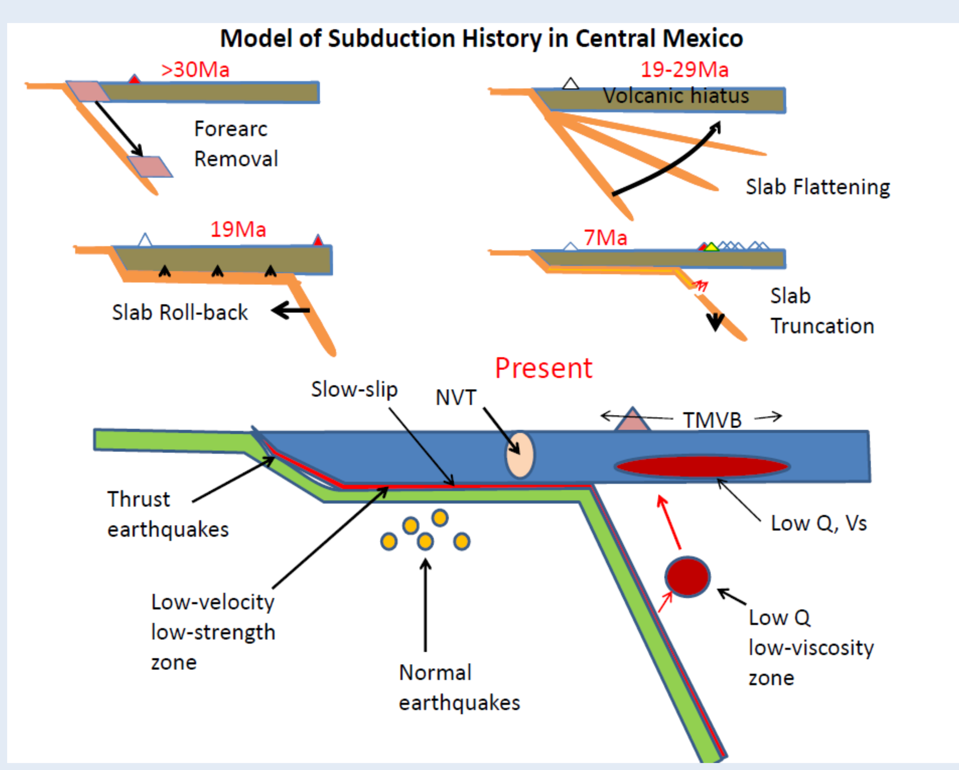




The regional tomography shows the dip progressive steeping to the east. It also shows a south dipping structure on the eastern end of the line. Other features include high attenuation zone associated with tremor located in the continental crust.

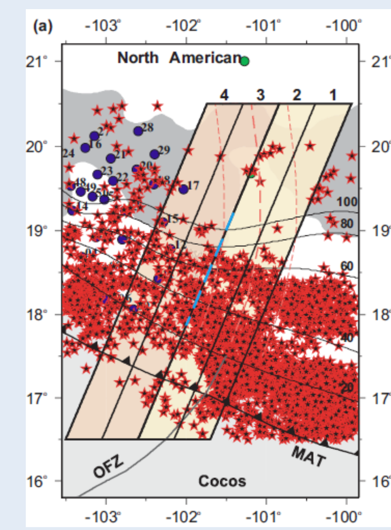


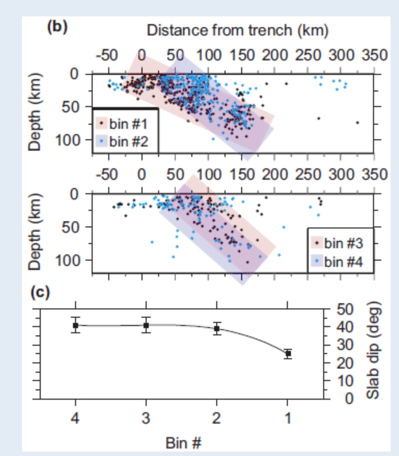
The teleseismic tomography shows that the Cocos slab steeply descends into the mantle to a depth of 500 km.



A model of the evolution of the subduction system. At ~29 Ma the arc presently located near the coast is shut off, and over the next 10 Myrs minimal volcanism migrates north the the north edge of the TMVB. For the past 10 Myrs, it has been rolling back to its present configuration.

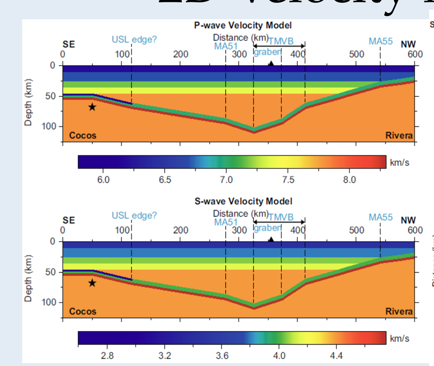
Slab Tearing

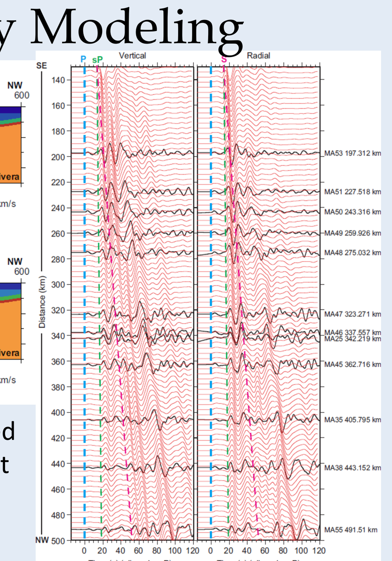




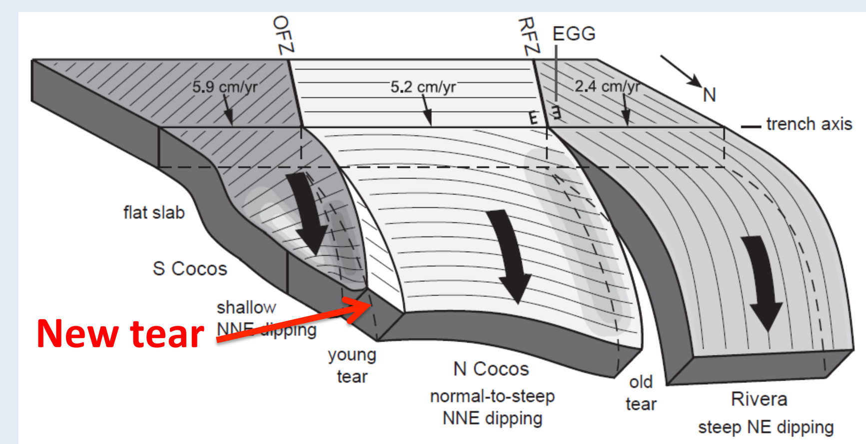
Based on seismicity there is a distinct change in the slab dip along the projection of the Orosco Fracture Zone, indicating a developing tear in the slab.

2D Velocity Modeling



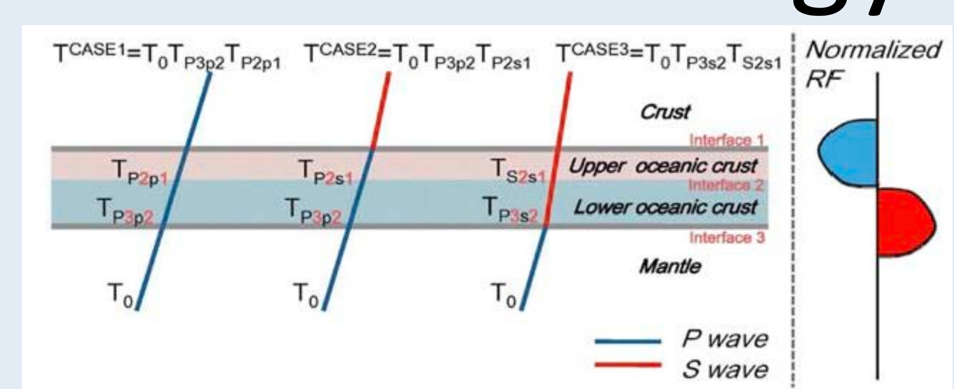


Full waveform modeling is used to determine the lateral extent of the low-velocity layer

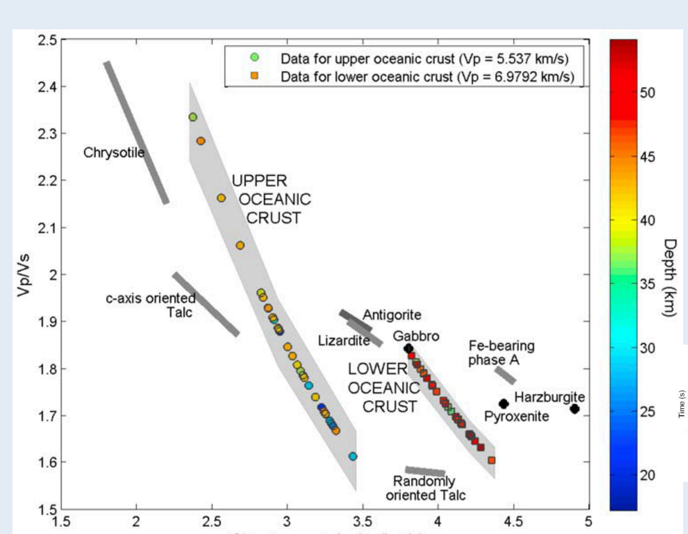


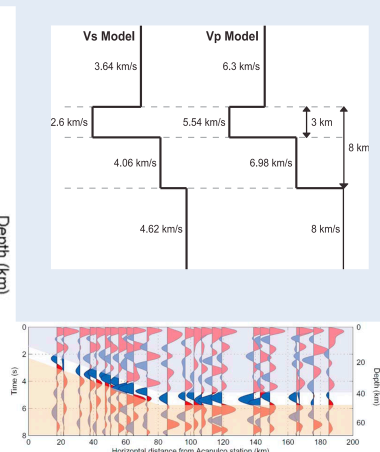
The new tear is likely developing to provide a more efficient path for the return flow while the roll is rolling back. See Southern Mexico poster for more on this story.

Minerology



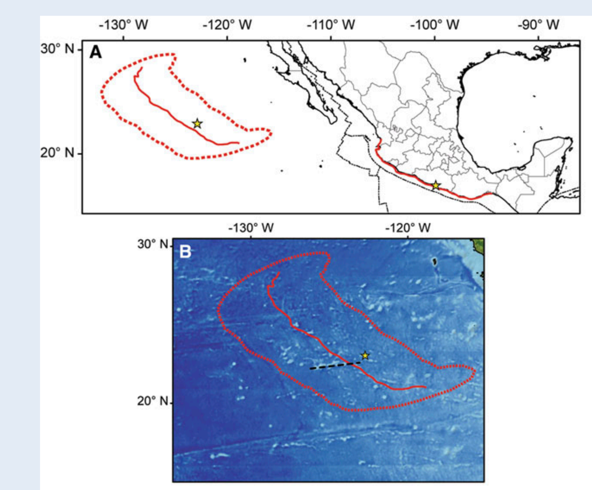
The amplitudes of the receiver functions can be used to determine the changes in shear wave speed across the interfaces. By comparing the positive and negative amplitudes (red and blue), we can determine the relative change in Vs, and by assuming the velocities above and below the thin layer we can convert these to absolute Vs.



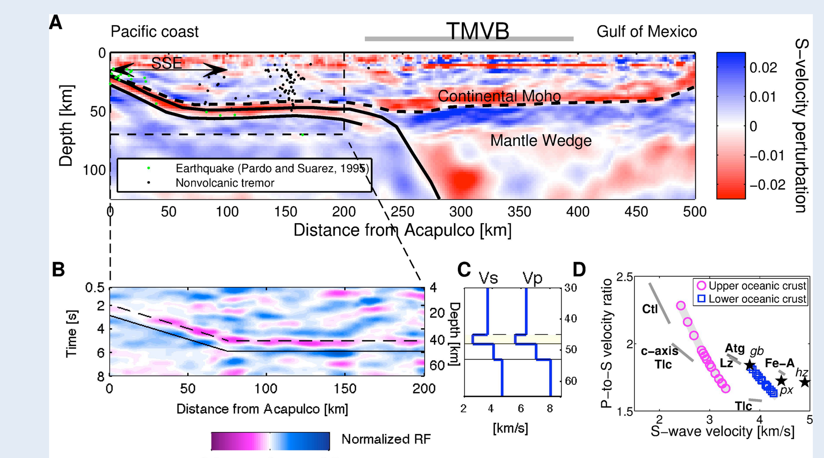


The results show an ultra low-velocity layer between the slab and the overriding continent. The layer is only 3 km thick. When the shear wave velocity is matched to a suite of candidate minerals for the 35-45 km deep section, Talc is the closest. The lower crustal layer the best match is to Gabbro.

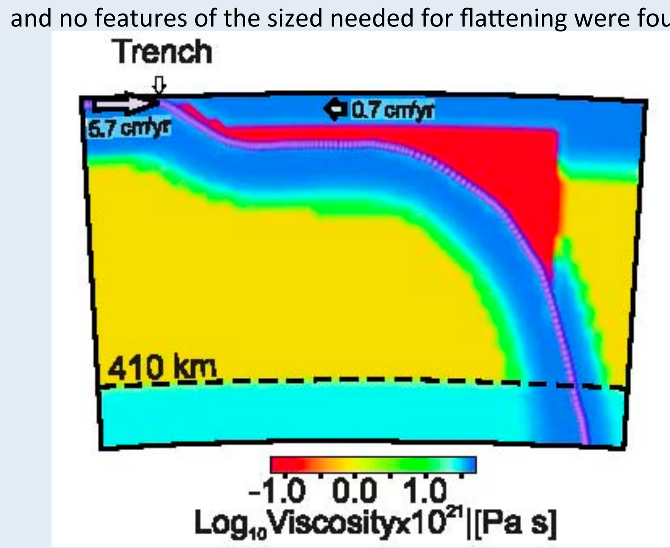
Dynamics



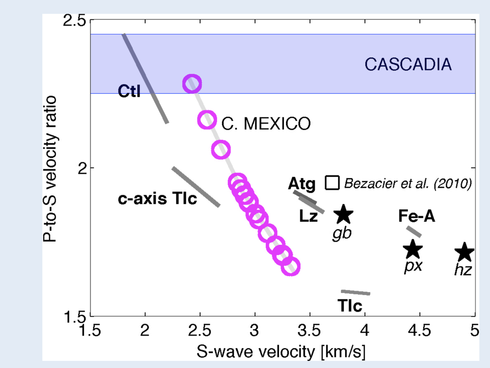
One commonly proposed mechanism for slab flattening is an impactor (ocean ridge or plateau). We search for potential impactors on the conjugate plate but non were found. Here the conjugate of the current trench is overlain on the bathymetry and no features of the sized needed for flattening were found.



The minerology analysis has shown that the only mineral that is capable of producing the ultra-low shear velocities that are found in the layer separating the slab and continent is Talc. Hence, the Talc, S-saturated fluids are required, and these are found in the mantle wedge and not on the trench-side of the system. This implies the flattening process is driven from the mantle wedge, and not by the direct subduction of an impactor.



A model for the initation of flat subduction proposed by Manea and Gurnis (2007) used a low-viscosity zone in the mantle wedge that lifts the slab by increasing the corner flow. The Talc layer mentioned above, may be the low-viscosity zone.



The Mexican flat subduction is sometimes compared to the subduction zone in Cascadia. However, the very low Vp/Vs ratios of the Mexican system is far too low (and too deep) to be explained by free-water, which is the popular model for Cascadia.

Publications

1. Chen, T. and R. Clayton, (2009), Seismic Attenuation Structure in central Mexico: Image of a focused high-attenuation zone in the mantle wedge, (2009), J. Geophys. Res., doi: 10:1029/2008JB005964.
2. Chen, T. and R. Clayton, Structure of central and southern Mexico from velocity and attenuation tomography, (2012), J. Geophys. Res., 117, B09302, doi: 10.1029/2012JB009233
3. Dougherty, S., R. Clayton, and D. Helmberger, (2012), Seismic Structure in central Mexico: Implication for fragmentation of the subducted Cocos Plate, J. Geophys. Res, 117, B09316, doi: 10.1029/2012JB009528.
4. Husker, A., and P. Davis, (2009), Tomography and thermal state of the Cocos plate subduction beneath Mexico City, J. Geophys, Res., 114, B4, pp1978-2012.
5. Iglesias, A., R. Clayton, X. Perez-Campos, S. K. Singh, J. Pacheco, D. Garcia, and C. Valdes-Gonzalez, 2010, S-Wave, Velocity Structure below Central Mexico using High Resolution Surface Wave Tomography, J. Geophys. Res., 115, B06307, doi: 10.1029/2009JB006332
6. Kim, Y., R. Clayton, P. Asimow, and J. Jackson, Generation of Talc in the Mantle Wedge and its Role in Subduction Dynamics in Central Mexico, in revision, EPSL, Aug 2013.
7. Kim, Y., R. Clayton, and J. Jackson, 2010, The Geometry and seismic properties of the subducting Cocos plate in central Mexico, J. Geophys. Res., 115, doi: 10.1029/2009JB006942
8. Kim, Y., R. Clayton, and J. Jackson, Distribution of Hydrous Minerals in the Subduction System Beneath Mexico, (2012), EPSL 341-344, p58-67, doi:10.1016/j.epsl. 2012.06.001.
9. Kim, Y., M. Miller, F. Pearce, and R. Clayton, Seismic imaging of the Cocos subduction zone system in central Mexico, Geochemistry, Geophysics, Geosystems, 13, Q07001, doi: 10.1029/2012GC004033.
10. Kostoglodov, V., A. Husker, N. Shapiro, J. Payero, M. Campillo, N. Cotte, and R. Clayton, (2010), 2006 Slow Slip Event and Nonvolcanic Tremor in the Mexican Subduction Zone, Geophys. Res. Lett., 37, L24301, doi: 10.1029/2010GL045424.
11. Manea, V., and M. Gurnis, (2007), Subduction zone evolution and low viscosity channels, Earth and Planet. Lett., 264, 22-45
12. Payero, J. S., V. Kostoglodov, N. Shapiro, T. Mikumo, A. Iglesias, X. Perez-Campos, and R. W. Clayton (2008), Non-volcanic tremor observed in the Mexican subduction zone, Geophys. Res. Lett., 35, L07305, doi:10.1029/2007GL032877
13. Pérez-Campos, X. (2008), MASE: Undergraduate Research and Outreach as Part of a Large Project, Seismol. Res. Lett. 79 232-236
14. Pérez-Campos, X., and R. Clayton, Interaction of Cocos and Rivera Plates with the Upper Mantle Transition Zone Underneath Central Mexico, submitted to GJI, July 25, 2013
15. Pérez-Campos, X., Y. Kim, A. Husker, P. M. Davis, R. W. Clayton, A. Iglesias, J. F. Pacheco, S. K. Singh, V. C. Manea, and M. Gurnis (2008), Horizontal subduction and truncation of the cocos plate beneath Central Mexico, Geophys. Res. Lett., 35, L18303, doi: 10.1029/2008GL035127 PDF
16. Skinner, S., and R. Clayton, An evaluation of proposed mechansims of slab flat-tening in central Mexico, (2010), Pure Appl. Geophys. (Pageoph), doi: 10.1007/s00024-010-0200-3
17. Song, T. A., D. V. Helmberger, M. R. Brudzinski, R. W. Clayton, P. Davis, X. Perez-Campos, S. K. Singh, (2009), Subducting Slab Ultra-Slow Layer Coincident with Silent Earthquakes in Southern Mexico, Science, 324, 502 (2009), doi:10,1126/science.1167595.
18. Song, T. A.; Kim, Y. (2012),Localized seismic anisotropy associated with long-term slow-slip events beneath southern Mexico, , Geophys Res Lett, Volume 39, Issue L09308, (2012), 10.1029/2012GL051324
19. Stubailo, I., C. Begheim, and P. Davis, (2012),Structure and anisotropy of the Mexico subduction zone based on Rayleigh-wave analysis and implications for the geometry of the Trans-Mexican Volcanic Belt, J. Geophys. Res, 117, B05303, doi:10.1029/2011JB008631

Data Products

MASE (2007): Meso America Subduction Experiment. Caltech. Dataset. doi:10.7909/C3RN35SP