Distribution of hydrous minerals in the Cocos oceanic crust inferred from receiver function analysis

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1 Abstract

Receiver functions (RFs) are used to estimate the mineralogy as a function of depth along the Cocos slab in central and southern Mexico. The RF image includes a thin low-velocity layer (lower than normal oceanic crustal velocities) on the top of the subducting oceanic lithosphere beneath Mexico. By inverting the amplitudes of the converted phases for the shear-wave velocity (Vs) and density, we can produce detailed maps of the seismic properties (Vs, density, Vp/Vs ratio, and Poissons ratios) of the upper and lower oceanic crust. We first compared the increasing trends in Vs and density as a function of depth in two regions, and found that the Vs and density values for the downgoing oceanic crust in southen Mexico from 40 to 120 km are increasing faster than the ones in central Mexico from 40 to 200 km. This suggests that the downgoing oceanic crust in central Mexico contains a hydrous mineral assemblage. The release of H_2O via dehydration could be in the form of a fluid phase or could lower the melting temperature of surrounding phases, where either scenario correlates well with the arc volcanism directly above the slab. The region under southern Mexico is less hydrous than under central Mexico, and this difference may provide a clue as to why the slab in central Mexico is flat and in southern Mexico it is not.

2 Data

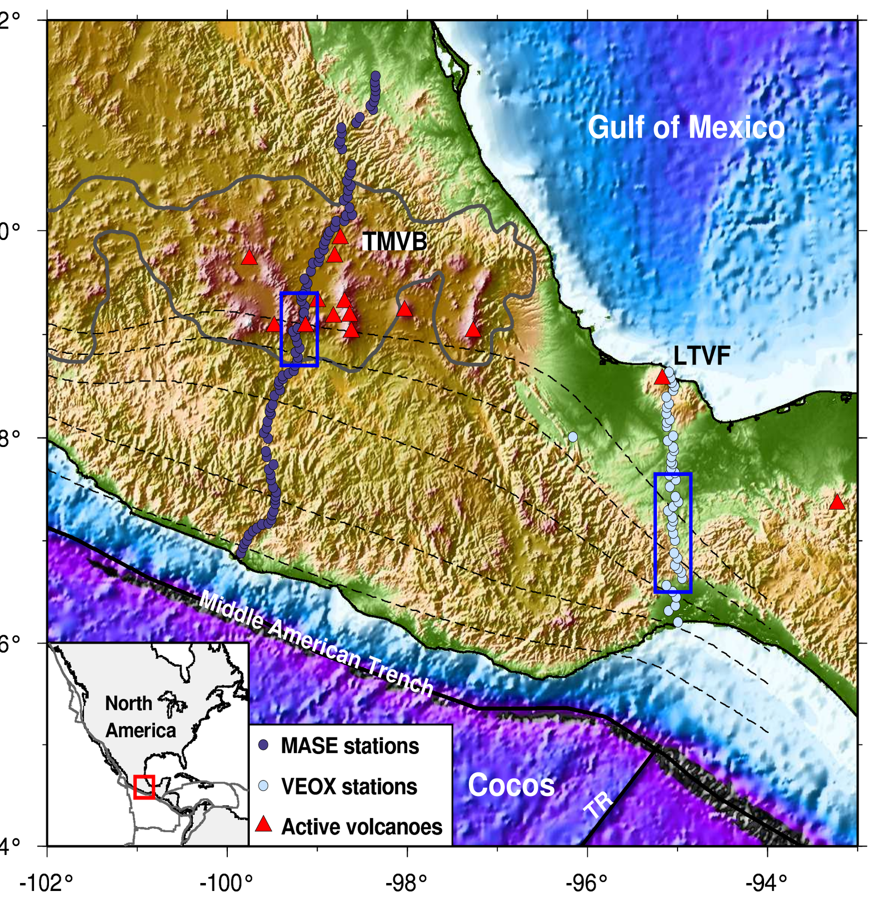


Figure 1: **Topographic-bathymetric map showing the region of the study and stations.** Isodepth contours of the Cocos Plate beneath the North American (NA) Plate (*Pardo and Suárez*, 1995) are shown as cyan lines in the map. The abbreviations shown in the map are TMVB, Trans Mexican Volcanic Belt; LTVF, Los Tuxtlas Volcanic Field; TR, Tehuantepec Ridge. The regions of the focus are included in blue boxes.

3 Inversion of RF Amplitudes

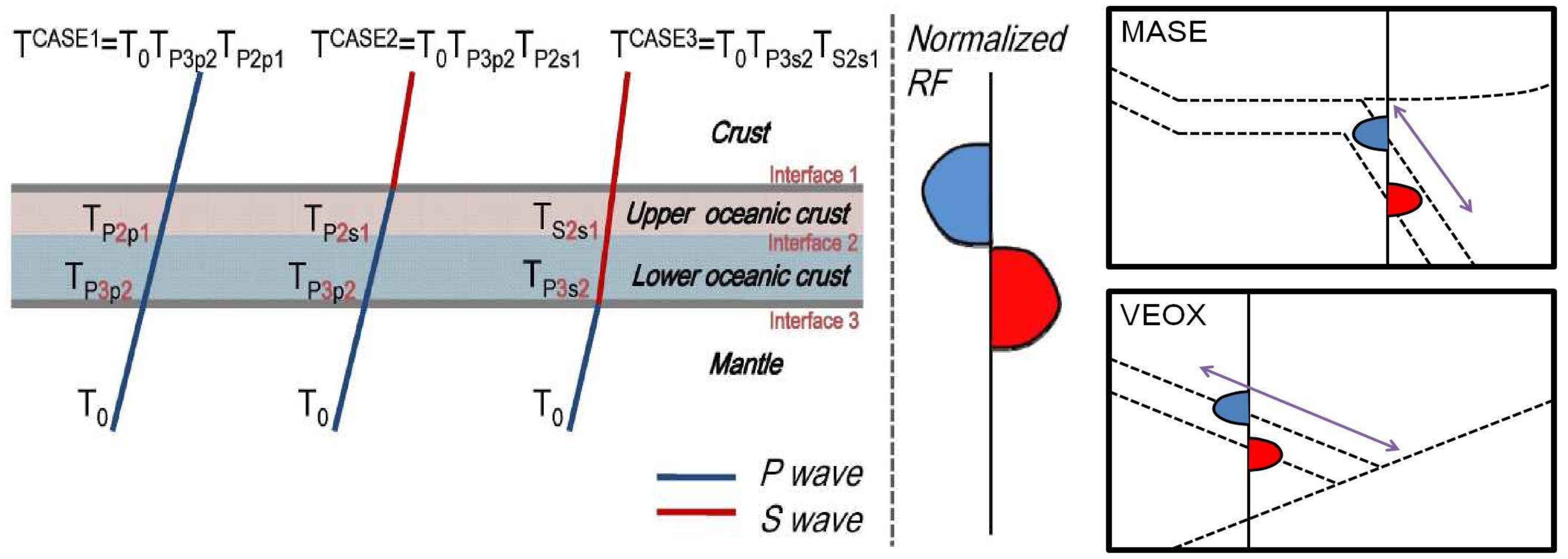
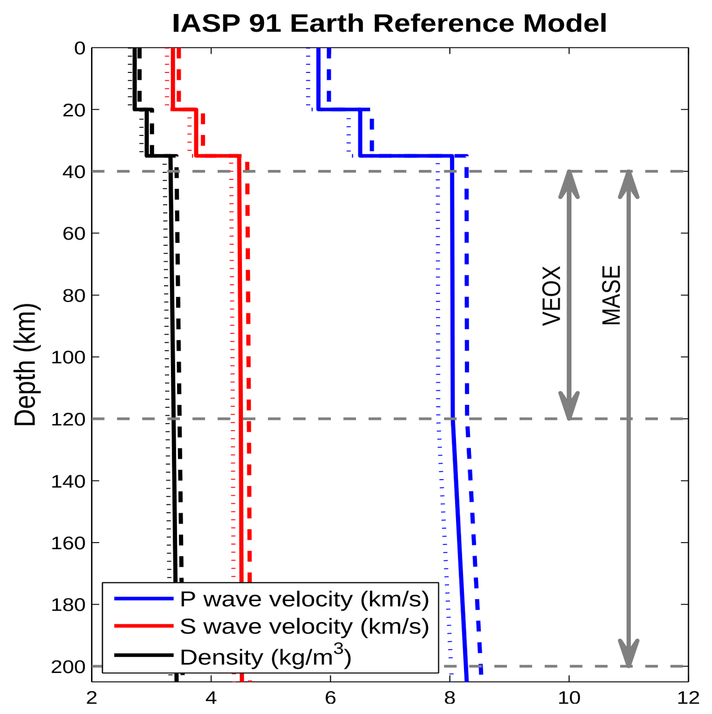


Figure 2: **Inversion scheme.** [left] Schematic showing transmitted responses at top and bottom interfaces of the oceanic crust. The RF responses are normalized by the P arrival. The peak of the negative RF pulse is obtained at the interface 1 between the crust and the upper oceanic crust; the peak of the positive RF pulse at the interface 3 between the lower oceanic crust and the mantle. The detailed analysis is described in *Kim et al.* (2010). [right] Schematic showing two RF pulses from the depth of 40 km to ~120 km for VEOX and 40 km to ~200 km for MASE.

4 Results



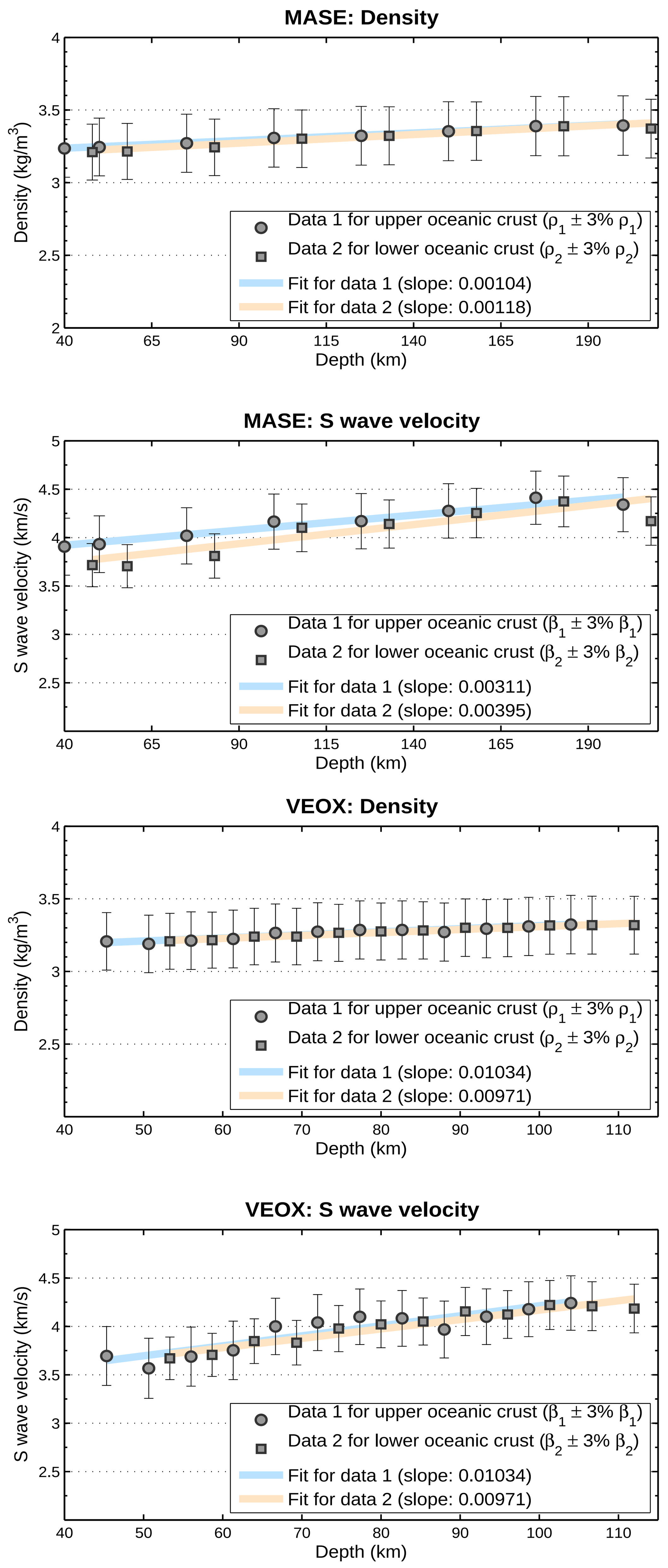


Figure 3: **Input velocity model, and inverted density and S wave velocity for MASE and VEOX.** [left] IASP91 Earth reference model (*Kennet and Engdahl*, 1991) provides Vp, Vs, and density of the layer above the upper oceanic crust and the layer below the lower oceanic crust. The dotted line indicates the three percent less than the Vp, Vs, and density shown as a solid line, and the dashed line the three percent greater. [right] Top two panels show the inverted density and S wave velocity for MASE. Bottom two panels show the inverted density and S wave velocity for VEOX. The three percent perterbuation in Vp, Vs, and density of the crust gives rise to errors in the inverted values for the upper oceanic crust. The three percent perterbuation in Vp, Vs, and density of the mantle gives rise to errors in the inverted valules for the lower oceanic crust. The slope of each trend line is indicated in the legend of each panel. The increasing trend for VEOX (southen Mexico) is slightly faster than the one for MASE (central Mexico).

5 Discussion

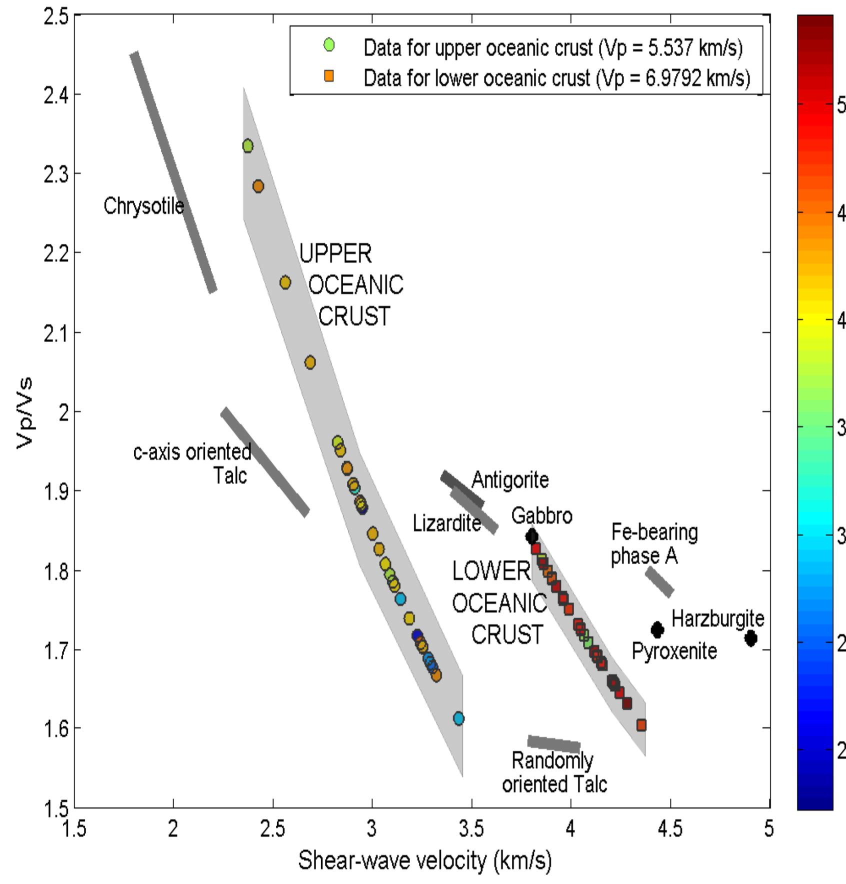


Figure 4: **Calculated Vp/Vs ratio versus S wave velocity (Vs) at a depth of 35 km and a range of likely temperatures (500−800°C) for candidate hydrated phases and rock types in central Mexico.** Calculated Vp/Vs ratio versus Vs are plotted with candidate hydrated phases (gray lines) and rock types (black diamonds). The points for randomly oriented talc and c axis oriented talc are from *Mainprice et al.* (2008), and those for different rock types from *Christensen and Salisbury* (1975). The data points for the upper oceanic crust are highly varying in Vp/Vs and Vs domain (average Vp/Vs of 1.85) and lie close to talc phases, whereas those for the lower oceanic crust are tightly bounded (average of 1.72). The light-gray shaded regions denote uncertainties due to the choice of Vp. Note that the inverted values are obtained at the shallowly-dipping segment near the Pacific coast and flat slab segment in central Mexico.

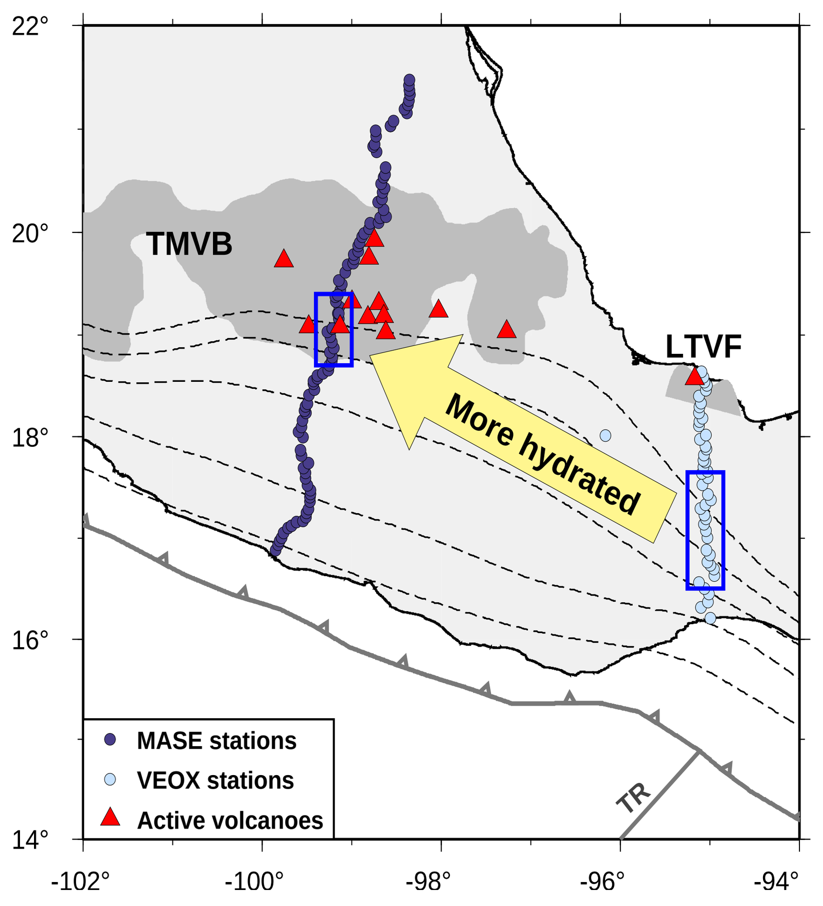


Figure 5: **Plot showing that MASE is more hydrated than VEOX.**

- We have obtained anomalously low S wave veolcity at the upper oceanic crust in the flat slab region (*Kim et al.*, 2010). As Figure 4 shows, the upper oceanic crust contains highly heterogeneous, weak, and hydrous minerals (talc) on top of lower oceanic crust.
- Based on the inverted Vs and density at the dipping oceanic crusts in central and southen Mexico (Figure 5), seismic and mineral physics analysis suggests MASE is more hydrated than VEOX, and observed volcanic arc (TMVB) is fully consistent with our observations.
- Inverted Vs and density are highly sensitive to the Vp, Vs, and density values of the layer above/below the oceanic crust, so more careful analysis in selecting the model is necessary.

6 Acknowledgments

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