Shear Wave Splitting and Mantle Flow in the Vicinity of the North American-Caribbean Plate Boundary in Central America

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Summary

Azimuthal anisotropy quantified by teleseismic *SKS*, *SKKS*, *PKS* ("*XKS*") and local *S*-wave splitting parameters is used to investigate mantle deformation and flow beneath the boundary of the North American and Caribbean plates and adjacent areas. The observations can be divided into two groups based on the spatial distribution of the resulting fast polarization orientations. Those observed on the Caribbean Plate are mostly WNW-ESE which are mostly trench-parallel. In contrast, the fast orientations observed on the North American Plate are dominantly NNE-SSW which are approximately trench-orthogonal and are consistent with those previously observed in southern Mexico to the north of the area of the current study. At most of the stations at which *XKS* and local *S* wave splitting parameters are available, the splitting parameters from the two types of shear waves are comparable, suggesting that the observed azimuthal anisotropy is mostly from the mantle wedge above the slab. The observations especially those obtained at recently deployed stations in Guatemala provide new insights into the complicated mantle flow system associated with slab subduction and rollback, as well as lithospheric shearing along the southern boundary of the North American Plate.

Data and Method

The dataset used in this study were recorded by 26 broadband seismic stations installed in the area of 13 – 18°N and 85 – 93°W archived at the Incorporated Research Institution for Seismology Data Management Center, over the period of August 2004 to March 2018. 2556 teleseismic and 299 local *S* events were obtained from these stations in 7 different networks. All the individual measurements were computed using the transverse component energy minimization technique *(Silver & Chan, 1991)*.

To provide constraints on the depth of the observed *XKS* anisotropy, we also used data from local events in the *S*-wave window to measure splitting parameters based on the procedure detailed in Liu et al. (2008; https://doi.org/10.1029/2007JB005178).

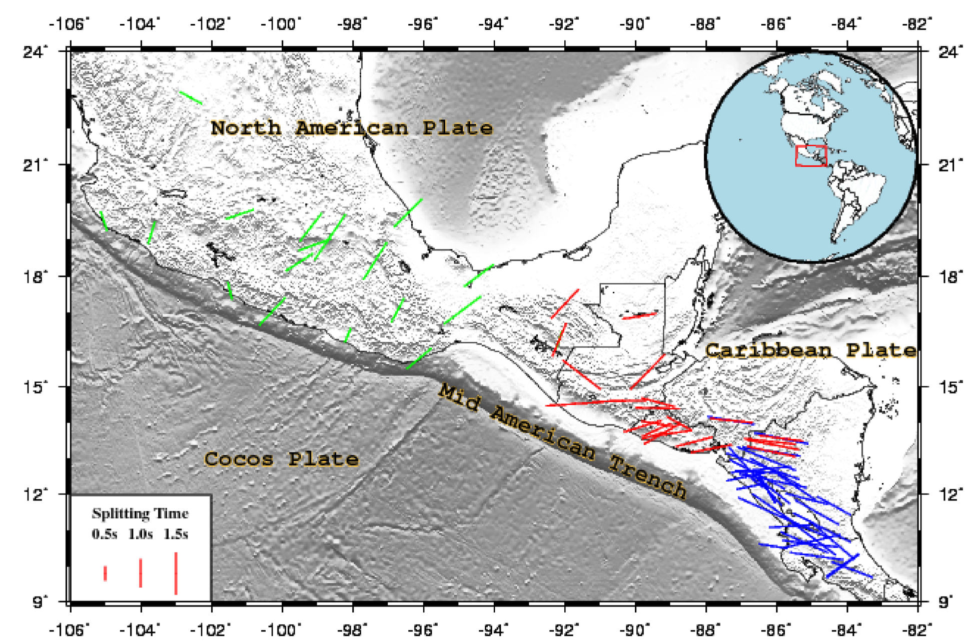

Figure 1. A topographic map showing previous results (green bars for *van Benthem et al., 2013* and blue bars for *Abt et al., 2010*) and this study (red bars). The inset shows the study area.

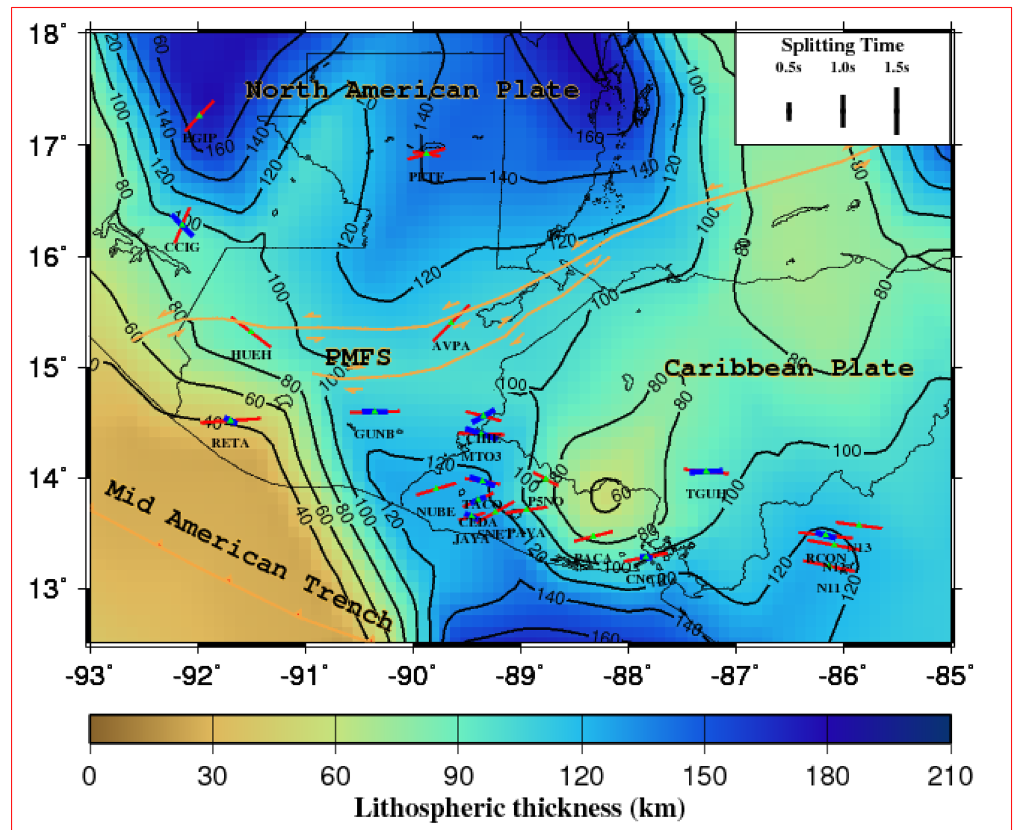

Figure 2. Station averaged results for *XKS* events (red bar) and local *S* events (blue bar). The lithospheric thickness is based on the LITHO 1.0 model (*Pasyanos et al., 2014*).

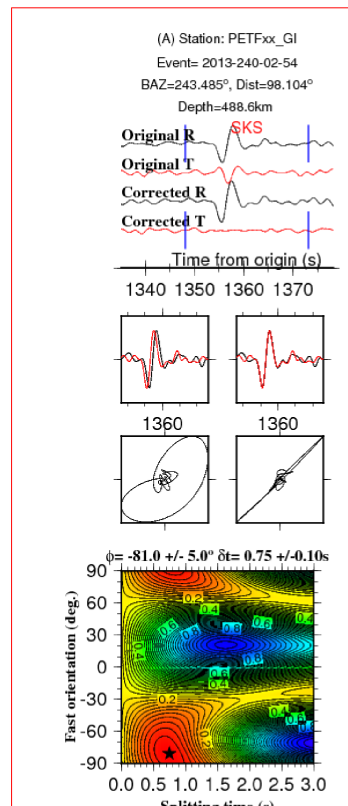

Figure 3. An example *SKS* measurement. (top) Original and corrected radial and transverse components; (middle) Original and corrected particle motion patterns; (bottom) Contour map of corrected transverse energy with the optimal splitting parameter (black star) corresponding to the minimum energy.

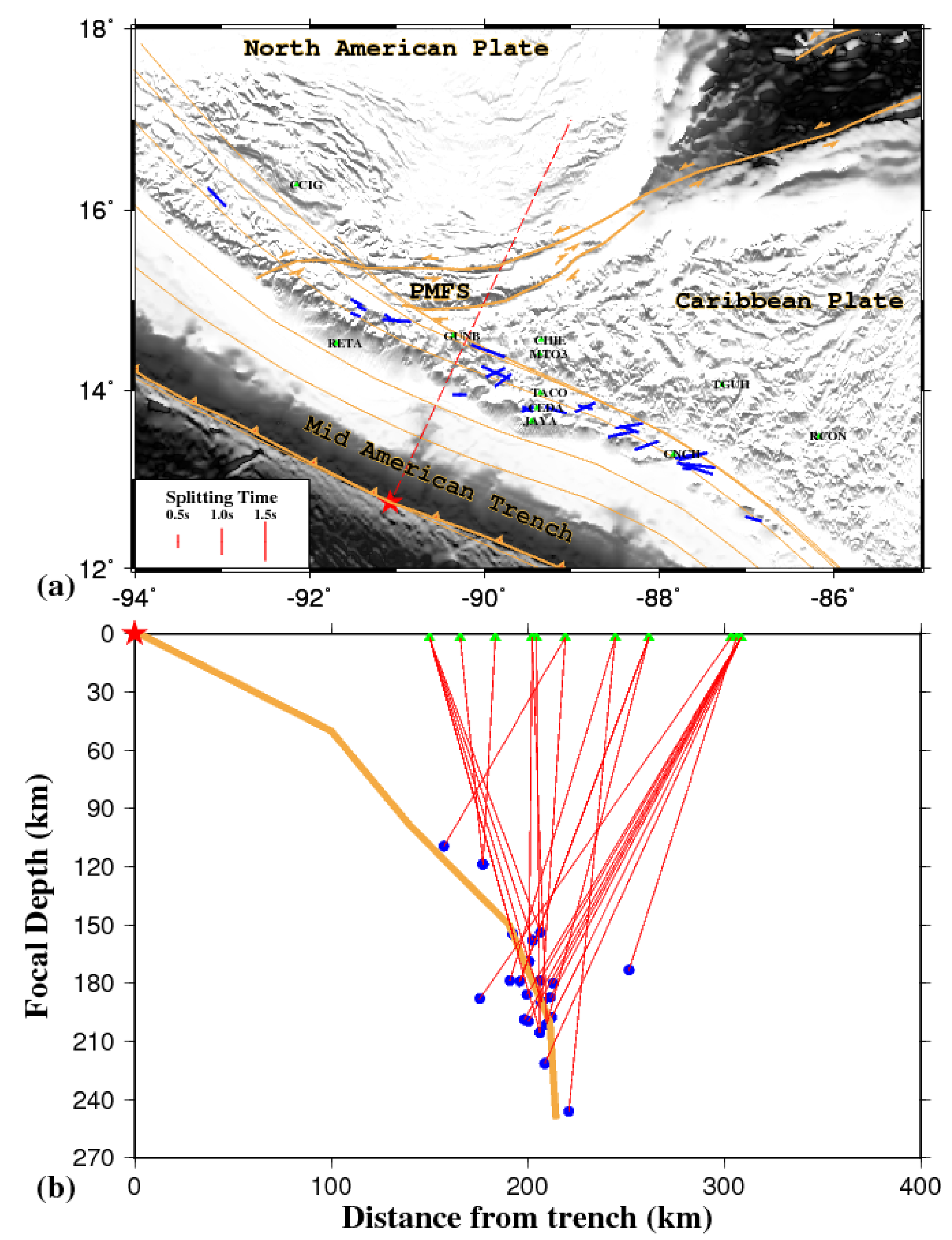

Figure 4. (a). A map view of resulting splitting parameters of local *S* events. Blue bars: individual measurements; Green dots: stations. The light orange lines are depth contours of the Cocos slab. (b). Ray paths of local *S* events projected to the red dashed line in (a). The blue dots represent the foci, and the orange line indicates the top of the Cocos slab. The green triangles are the stations in (a).

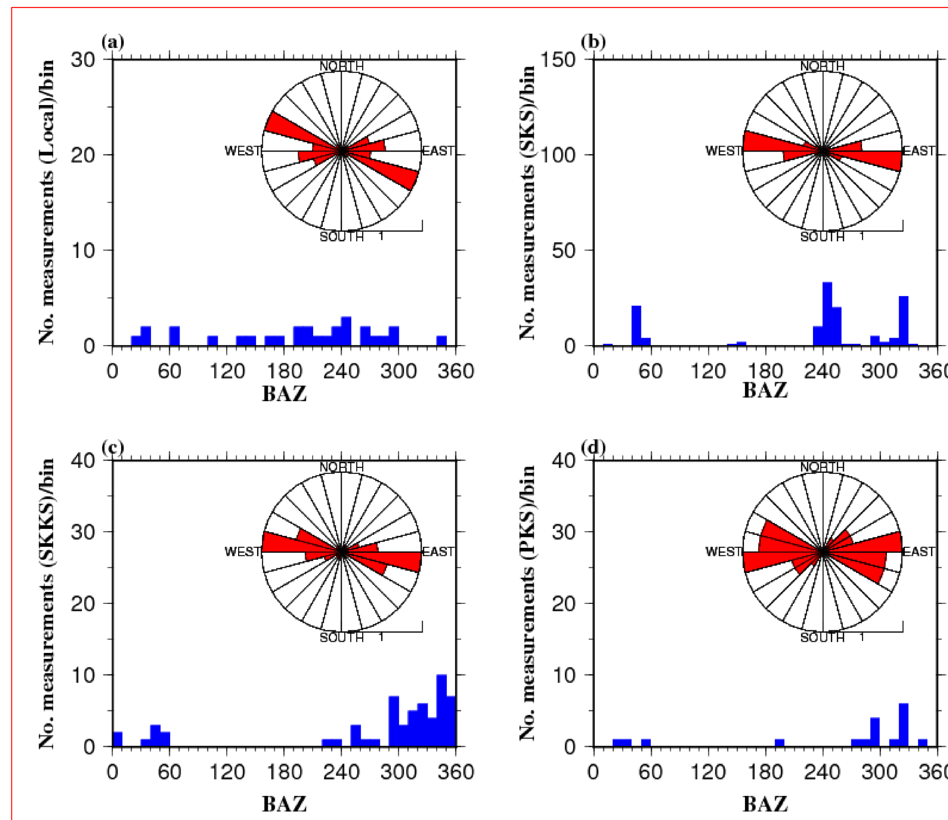

Figure 5. BAZ distribution and observed fast orientations (rose diagrams). (a) Local *S*. (b) SKS. (c) SKKS. (d) PKS.

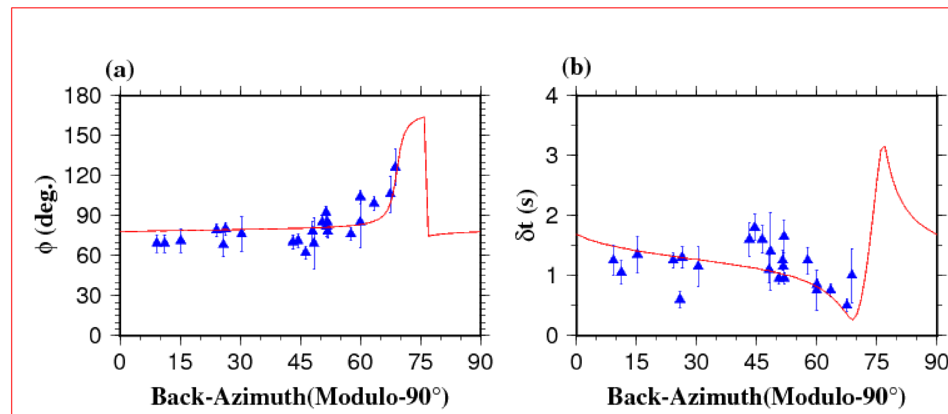

Figure 6. Theoretical splitting parameters calculated using the results of grid searching to fit a two-layer model for station PETF. Lower layer: ϕ_L=68°, δt_L=1.35 s; Upper layer: ϕ_U=-57°, δt_U=0.30 s. (a) Fast orientation. (b) Splitting time.

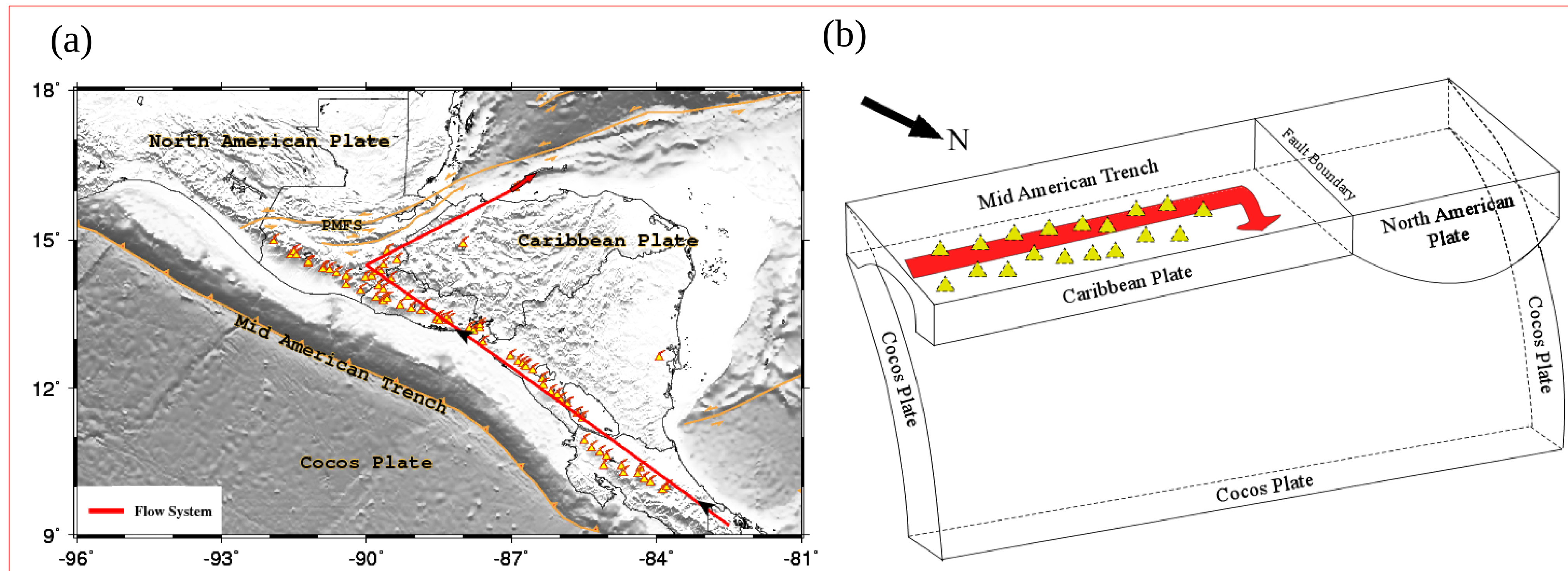

Figure 7. (a). Schematic map showing the mantle flow system beneath the study area. The red solid line represents the mantle flow, and the red arrow shows the direction of this flow system. (b). A schematic 3-D figure showing the anisotropy model beneath the study area. Red line: mantle flow; Yellow triangle: volcanos.

Conclusions

- Similarities between the shear wave splitting parameters observed using *XKS* and local *S* waves suggest that anisotropy mostly resides in the mantle wedge.
- A trench parallel flow probably originated from a slab tear in South America might be responsible for the NW-SE oriented anisotropy observed on the Caribbean plate.
- The flow system is deflected toward the NE by the deep lithospheric root in southern Mexico.
- Lithospheric basal erosion by the trench-parallel flow beneath the Caribbean plate may lead to the numerous Cenozoic volcanoes.

References

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Acknowledgments

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