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Delamination of sub-crustal lithosphere beneath the Isthmus of Tehuantepec, Mexico

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Recent seismic data from a dense seismic array (VEOX), as well as from the permanent broadband network of the Mexican National Seismological Service (SSN), revealed several anomalous structures in the Isthmus of Tehuantepec. Seismic tomography imaged a high velocity body dipping $\sim$30° from the Gulf of Mexico southward. Analysis of seismic noise detected a large well-defined low-velocity anomaly on top of this structure in the vicinity of the Late Miocene-Quaternary Los Tuxtlas volcanic field. The current interpretation of these observations propose the presence of a southward dipping slab resulting from the subduction of oceanic lithosphere prior to the collision of the Yucatán Block with Mexico $\sim$12 Ma ago. However this interpretation contradicts many aspects of well-established models of Caribbean tectonics. Additionally such model does not explain how the southward dipping structure remained at a relatively low dipping angle ($\sim$30°) over the last 12 Ma, and why it is not seismically active. We propose an alternative model that reconciles the seismic observations with the tectonic evolution of the region. The south dipping seismic structure is the result of lithospheric delamination produced by a thermal anomaly that migrated upwards through a slab gap in the Cocos slab located at $\sim$200 km depth. Using high-resolution two-dimensional coupled petrological-thermomechanical numerical simulations of subduction, we show that hot and buoyant asthenospheric material flowing through a slab gap in the Cocos plate may have produced a rapid delamination of the lithosphere once it reached its base. The model geometry of the delaminated lithosphere is similar to the observed seismic anomaly, and the hot material from the plume impact is consistent with the low-velocity anomaly located at the north of the Isthmus of Tehuantepec, which feeds the Los Tuxtla volcanic field. Additionally our simulations show that the temperature of the delaminated lithosphere is above 700°C explaining why the slab-like structure is not seismically active.