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Evolution of Flat Subduction in the Central Trans-Mexican Volcanic Belt

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Flat slabs have been commonly attributed to buoyant features, such as an oceanic plateau or aseismic ridge. Yet, flat slabs segments are also detected in regions without evidences of present or past subduction of thickened oceanic lithosphere. One such a place is the central Trans-Mexican Volcanic Belt (TMVB), where recent geophysical studies confirmed that the western Cocos plate is subducting horizontally at ∼50 km of depth up to 250 km from the trench. Unlike regions like the Andes, in Central Mexico flat subduction is not associated with crustal shortening because the continental crust is decoupled from the flat slab by a <5 km thick ultra low velocity layer, interpreted as a remnant of the paleo mantle wedge. The onset of slab subduction can be inferred indirectly using the space-time evolution of arc magmatism and its geochemical variations. South of Mexico City, a last pulse of silicic magmatism correlative with the Sierra Madre Occidental occurred between ∼23 and ∼21 Ma in a WNW-ESE trending belt. This was followed since 19 Ma by the formation of an almost E-W oriented arc, dominated by basaltic andesitic to andesitic (56–63 % SiO2) central volcanoes and domes. During the following 10 Ma the volcanic front of this early TMVB migrated 180 km to the north, away from the trench. The southernmost and oldest rocks originated by melting of mantle fluxed by fluids derived from the subducting plate. More to the north, rocks show evidence of reduced slab fluid contribution and of melting of subducted sediments. Some of the northernmost and youngest stratovolcanoes (∼11-9 Ma) show an adakitic signature, signaling the initiation of slab melting. The migration of the volcanic front away from the trench and the emplacement of adakitic lavas at the end of this period are consistent with a shallowing of the subducted slab, which would have reached a flat geometry by about 10 Ma.
Since no obvious buoyant oceanic lithosphere have subducted in Central Mexico in the Neogene, two other, non-exclusive, mechanisms can be envisaged to explain the flattening of the slab. The first is the active overriding of the North America plate over the Cocos plate. No detailed estimation of Cocos-North America convergence rate is available for the Miocene. However, plate tectonic reconstructions indicate that North America has been moving obliquely toward the trench. It is permissible to think that the relatively young Cocos plate (<20 Ma) may have not retreated at the same rate, leading to a decrease in slab dip. On the other hand, the change from fluid-fluxed melting, to sediment, and then slab melting between 19 and 9 Ma is indicative of a progressive decrease in the amount of fluids released to the mantle wedge. This would produce an increase in the mantle wedge viscosity and a larger degree of coupling between subducted and overriding plates, which eventually produced the flattening of the slab. At ∼8 Ma a trench-parallel slab tear, started at 13 Ma in the southern Gulf of California, reached the central TMVB. This allowed infiltration of low viscosity asthenosphere that decoupled the slab from the continental plate. Since then the leading edge of the slab rolled back and the volcanic front started to move trenchward.