The magmatic system of the Tepic-Zacoalco Rift revealed by multi-scale magnetotellurics

Castro, C.[1,2], Junge, A.[1], Díaz, M.K.[3], Corbo-Camargo, F.[3], Kiyan, D.[2], Ávila-Vargas, O.[4], Hering, P.[4,1], Ferrari, L. [3], González-Castillo, L.[5], Eysteinsson, H.[6], Hogg, C.[2], Galindo-Zaldivar, J.[5]

[1] Goethe University Frankfurt,
castro@geophysik.uni-frankfurt.de, junge@geophysik.uni-frankfurt.de, phhering@geophysik.uni-frankfurt.de
[2] Dublin Institute for Advanced Studies, duygu@cp.dias.ie, chogg@cp.dias.ie
[3] Institute for Geosciences – National University Autonomous of Mexico (UNAM),
mdiazna@geociencias.unam.mx, fercorbo@geociencias.unam.mx, oavila@geociencias.unam.mx, luca@unam.mx
[4] Institute for Geothermal Resource Management (IGEM), hering@igem-energie.de
[5] University of Granada, lgcastillo@ugr.es, jgalindo@ugr.es
[6] Reykjavik Geothermal, hjalmar@rg.is

SUMMARY

Western Mexico features unique volcanism and complex tectonic evolution due to its geodynamic setting. The steep subduction of the Rivera Plate beneath the North American Plate, and the tear between the Rivera and Cocos plates, has induced slab rollback. This drives a toroidal flow of the asthenosphere into a sub-vertically opening mantle wedge, mixing mantle materials with different isotopic signatures.

High rates of Rivera Plate subduction have reactivated the Jalisco Block, forming extensional corridors known as the Chapala, Colima, and Tepic-Zacoalco rifts. This has caused significant intra-plate deformation and led to multiple volcanic arcs. Despite extensive studies of the Tepic-Zacoalco Rift (TZR), the occurrence of bimodal magmatism within a short period, without evidence of source interaction, remains unclear.

This study presents the first multi-scale 3-D resistivity model of the TZR derived from magnetotellurics (MT). The MT data includes various datasets (AMT, BBMT, LMT) collected at different times with irregular spatial distribution, which are unified into a single database covering periods up to 10,000 s. Tensor ellipses aligned to the TZR strike, consistent phase splits, and negligible induction vectors suggest regional mid-crust electrical anisotropy. Towards longer periods, the phase tensor (PT) ellipses rotate by 90°, and decreasing phases in both PT axes are identified. This transition suggests that the induction effect of the Pacific Ocean, combined with large conductivity contrasts in the deeper structure—between the ocean, the highly resistive lower continental crust, and the magmatic system beneath the TZR—significantly influences the observed transfer functions.

The conductivity model reveals the plumbing system and interconnections beneath the main volcanoes, advancing our understanding of subduction-related magmatic systems in western Mexico. While hints of electrical anisotropy at mid-to-deep crustal and upper mantle levels are observed, its origin and boundaries remain arguable, encouraging future research in a broader regional context.

Keywords: magnetotellurics, electrical resistivity, anisotropy, magmatic systems