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Structures and tectonic setting of a strike-slip plate boundary: the left-lateral Polochic-Motagua transform system in Eastern Guatemala

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The seismically active, left-lateral Motagua and Polochic transform systems represent the western termination of the North America-Caribbean plate boundary. These tectonic lineaments cross broadly E-W Guatemala and are superimposed to a wide suture zone where several slices of ophiolitic assemblages crop out. Historical and instrumental seismicity along the faults is predominantly located in the western part of the Motagua-Polochic systems, and is well documented by a superficial rupture zone of more than one meter of sinistral slip during the Ms=7.5, February 2, 1976 earthquake, and by several geomorphological features. The occurrence of large earthquakes in recent times makes this populated region one of highest priorities for seismic hazard prevention. A structural map of the region, encompassing the entire transform system and surrounding mountain belts has been produced, combining geological information, new field structural data, aerial photographs, and satellite-derived images, to better characterize the morpho-structural setting of the Motagua-Polochic seismogenetic lineaments. Geological data and commercial seismic profiles were used to constrain the shallow geometry and structure of the plate boundary across a 60-km-long, vertical cross-section located to the east of Lago Izabal, the largest pull-apart basin formed within the principal deformation zone of the transform systems, and across the Motagua valley. A 2-D gravity modelling, combined with the geological information, has been produced to determine the deep structural framework of the transform system.

The model fits well with the complete Bouguer anomaly map obtained for the investigated area, and explains most of the observed long-wavelength anomalies, as well the local anomalies related to the intracrustal and shallow crustal geological bodies. The most important features derived from the integrated geophysical-geological approach are the geometry and depth of the sedimentary basins associated to the transform system, and the root of the ophiolitic bodies pertaining to the suture zone, and largely present along the western North American-Caribbean plate boundary segment. Multichannel seismic sections reveal that the Izabal basin is asymmetric both in cross and along-strike directions, the deepest side being to the north, close and parallel to the northern bend of the Polochic fault. Notwithstanding the absence of a direct correlation with drilling results, analysis of the seismostratigraphic and structural features has allowed the recognition of four main stages of evolution since the middle Miocene, and a rough correlation of the sedimentary infilling with the Tertiary and Quaternary formations that crop out around the lake. Structural data analyses and geophysical evidence have shown that the tectonic nature of the Polochic fault is mainly transtensional in its eastern part, whereas is mostly transpressional to the west. This regime is responsible for the development of the rhomboidal pull-apart basins, like the Lago Izabal, and wide depressions, like the Motagua valley in eastern Guatemala. Contractional structures (push-ups) characterize these transform systems in central Guatemala. Locally, restraining- and/or releasing-bend configuration determines the presence of related geological features like pressure ridges and rhombo-shaped basins.