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Evaluation of the ongoing rifting and subduction processes in the geochemistry of magmas from the western part of the Mexican Volcanic Belt

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A B S T R A C T

A compilation of new and published geochemical data for 1512 samples of volcanic rocks from the western part of the Mexican Volcanic Belt was first subdivided according to the age group (136 samples of Miocene and 1376 samples of Pliocene-Holocene). Rocks of the younger group were then subdivided as Rift (1014 samples from the triple-rift system) and No Rift (362 samples outside of the triple-rift system) or Near Trench (937 samples) and Far Trench (439 samples) magmas. These subdivisions were considered separately as basic, intermediate, and acid magmatic rocks. The application of the conventional and multidimensional techniques confirmed the great tectonic and geochemical complexity of this region. The presence of oceanic-type basalts suggested to result from a mantle plume was not confirmed from the tectonomagmatic multidimensional diagrams. The Miocene rocks, which are present at the surface far from the Middle-America Trench, showed a likely continental rift setting in most diagrams for basic rocks and a continental arc setting for intermediate rocks. These differences can be explained in terms of the petrogenetic origin of the magmas. Unlike the current thinking, the triple-rift system seems to have influenced the chemistry of Pliocene-Holocene basic rocks, which indicated a continental rift setting. The Pliocene-Holocene intermediate and acid rocks, however, did not show such an influence. The Pliocene-Holocene basic rocks indicated a continental rift setting, irrespective of the Near Trench and Far Trench subdivision because numerous Near Trench rocks also lie in the triple-rift and graben systems. However, the intermediate rocks having a crustal component in their genesis indicated a continental arc (Near Trench) or a transitional arc to within-plate setting (Far Trench). The acid rocks having a crustal component also suggested a continental arc (Near Trench) or a transitional setting (Far Trench). The application of the tectonomagmatic multidimensional diagrams to the data from the three rifts (Tepic-Zacoalco Rift, Colima Rift, and Chapala Rift) also revealed similarities and differences among them. The application of significance tests to log-transformed ratios further clarified the similarities and differences among the chemical characteristics of the Rift – No Rift and Near Trench – Far Trench subdivisions.

1. Introduction

In the western (W) part of the Mexican Volcanic Belt (MVB; also called the Trans-Mexican Volcanic Belt – TMVB), the Rivera plate and northern part of the Cocos plate are subducting beneath western Mexico along the Middle America Trench (MAT; Fig. 1; Bandy et al., 1995; Yang et al., 2009), and a triple rift system (TZR-CR-ChR) on land is simultaneously active. The Rivera and Cocos plates are kinematically different. The deformation in southwestern Mexico and the opening along the Colima rift is related to oblique subduction of the Cocos plate along the northern part of the MAT (DeMets and Stein, 1990). Based on the data on hypocenters of earthquakes recorded along western Mexico, Pardo and Suárez

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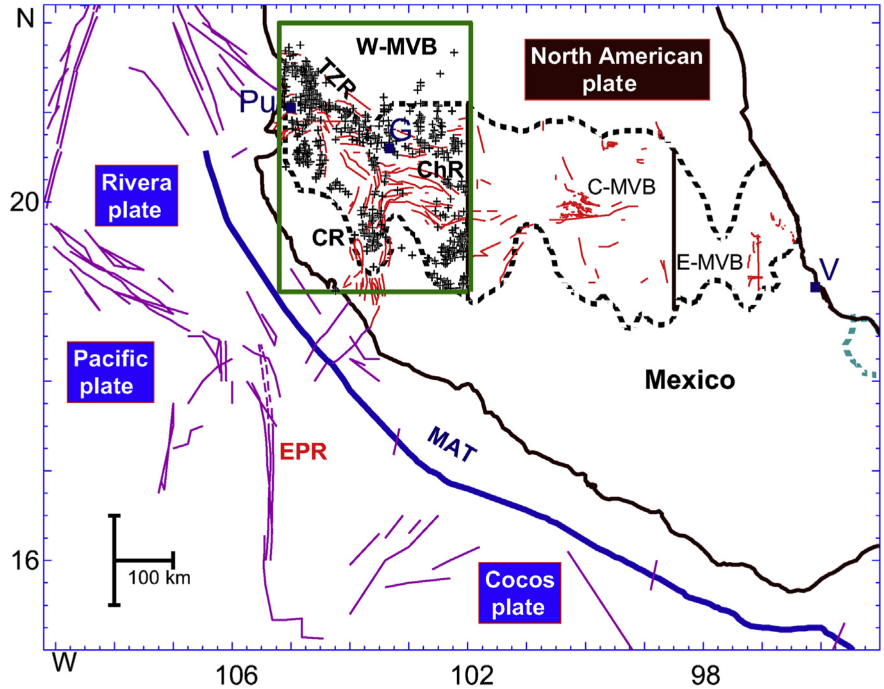

Fig. 1. Location of the study area of the western (W) part of the Mexican Volcanic Belt (MVB). The traces of the central and eastern parts of the MVB (C-MVB and E-MVB) as well as the approximate location of the Rivera, Cocos, Pacific and North American plates are also shown. An approximate scale is also included for reference. The abbreviations are as follows: Pu–Puerto Vallarta; G–Guadalajara; V–Veracruz; EPR–East Pacific Rise; MAT–Middle American Trench (thick curve); CR–Colima Rift; ChR–Chapala Rift; TZR–Tepic Zacoalco Rift. Fractures and faults are shown schematically as thin solid curves. The box shows approximate boundary of the W-MVB and represents the study area. Thick vertical line represents the approximate boundary between C-MVB and E-MVB. Similarly, the dashed line indicates the schematic limits of the Mexican Volcanic Belt. The small crosses indicate approximate sample locations from the W-MVB.

(1995) indicated a difference in the Rivera and Cocos subduction systems. According to them, the subduction of the Rivera plate is steep (similar to the geometry of the subduction of the Cocos plate beneath Central America), whereas the subduction of the Cocos plate in southern Mexico is shallower and subhorizontal. According to Pardo and Suárez (1995) the presence of Colima and other Quaternary volcanoes parallel to the MAT might have resulted from the subduction of Rivera plate below the Jalisco block in western Mexico. Based on aeromagnetic data from the western part of the MVB, Campos-Enriquez et al. (1990) have reported that the basal Miocene-Early Pliocene volcanic products become thinner, whereas the overlying Plio-Quaternary volcanism becomes thicker from west to east.

Bandy et al. (2000) interpreted marine geophysical and geological data to infer the presence of three distinct morphotectonic zones (an eastern extensional zone located adjacent to the MAT, a central zone which lacks discrete deformation, and a western zone which exhibits a complex morphology related to ridge propagation) in the vicinity of the boundary of the Rivera and Cocos plates. Another concept that may affect the interpretation of the geoscientific data from the MVB was put forth by the presence of a southern Mexico block that is uncoupled from the North American plate and has a southeast motion with respect to North America, accommodated by extension through the central part of the MVB. From offshore and inland gravimetric data, Alvarez and Yutsis (2015) proposed that the diffuse boundary between the Rivera and Cocos plates can be considered well-defined at least from the MAT to the region of the Colima Volcanic Complex. Suhardja et al. (2015) opined that southwestern Mexico is a region of complex active tectonics with subduction of the Rivera and Cocos plates and widespread magmatism and rifting in the continental interior. These authors also stated that the crustal thickness varies from about 20 km near the coast to about 42 km in the continental interior. The Rivera plate has steeper dip than the Cocos plate and is also about 10 km deeper along the coast than previously estimated by Pardo and Suárez (1995).

At the same time, a well-defined triple rift system (Tepic-Zacoalco Rift, Colima Rift, and Chapala Rift; Fig. 1; e.g. Luhr et al., 1985; Allan, 1986; Wallace et al., 1992; Garduño-Monroy et al., 1993; Campos-Enríquez and Alatorre-Zamora, 1998; Pacheco et al., 1999; Frey et al., 2007) has been causing the Jalisco block to drift westward towards the Pacific Ocean. From GPS data, Selvans et al. (2011) inferred the extension across both the Colima and Tepic-Zacoalco rifts at about 8 mm/year or less, which is less than the relative rates of motion at nearby plate boundaries.

Righter et al. (1995) noted that the junction of the W-MVB and the Gulf of California represents a superposition of subduction and continental rifting tectonic regimes in the late Cenozoic and documented that the extension at the edge of the Jalisco Block has occurred since ca. 4.2 Ma. Frey et al. (2007) suggested that the voluminous ignimbrite flare-up in the Tepic-Zacoalco rift at 5–3 Ma may reflect the initial stages of rifting of the Jalisco block away from North America, analogous to what occurred in the proto-gulf region at 12–6 Ma prior to the transfer of Baja California from North America to the Pacific plate.

The Neogene tectonic picture of southern Mexico is even more complicated from the presence of Southern Mexico block (Andreani et al., 2008), which is considered to be in motion with respect to the North American plate. According to these authors, the motion of