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Origin of silicic magmas along the Central American volcanic front: Genetic relationship to mafic melts

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Abstract

Silicic pyroclastic flows and related deposits are abundant along the Central American volcanic front. These silicic magmas erupted through both the non-continental Chorotega block to the southeast and the Paleozoic continental Chortis block to the northwest. The along-arc variations of the silicic deposits with respect to diagnostic trace element ratios (Ba/La, U/Th, Ce/Pb), oxygen isotopes, Nd and Sr isotope ratios mimic the along-arc variation in the basaltic and andesitic lavas. This variation in the lavas has been interpreted to indicate relative contributions from the slab and asthenosphere to the basaltic magmas [Carr, M.J., Feigenson, M.D., Bennett, E.A., 1990. Incompatible element and isotopic evidence for tectonic control of source mixing and melt extraction along the Central American arc. Contributions to Mineralogy and Petrology, 105, 369–380.; Patino, L.C., Carr, M.J. and Feigenson, M.D., 2000. Local and regional variations in Central American arc lavas controlled by variations in subducted sediment input. Contributions to Mineralogy and Petrology, 138 (3), 265–283.]. With respect to along-arc trends in basaltic lavas the largest contribution of slab fluids is in Nicaragua and the smallest input from the slab is in central Costa Rica — similar trends are observed in the silicic pyroclastic deposits. Data from melting experiments of primitive basalts and basaltic andesites demonstrate that it is difficult to produce high K_2O/Na_2O silicic magmas by fractional crystallization or partial melting of low-K_2O/Na_2O sources. However fractional crystallization or partial melting of medium- to high-K basalts can produce these silicic magmas. We interpret that the high-silica magmas associated Central America volcanic front are partial melts of penecontemporaneous, mantle-derived, evolved magmas that have ponded and crystallized in the mid-crust — or are melts extracted from these nearly completely crystallized magmas.

Keywords: silicic magmas; Central America volcanic front; mantle-derived crustal melts

1. Introduction

This paper focuses on the geochemistry and origin of silicic pyroclastic flows and related pyroclastic deposits (>65 wt.% SiO_2), associated with the Central American

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volcanic front (Fig. 1). These deposits occur throughout the Central American volcanic front from Guatemala to Costa Rica and are principally of Miocene to recent age. In Central America, the crust in the south (southeast Nicaragua and Costa Rica) is a modified oceanic plateau (the Caribbean Oceanic Plateau), whereas in the north (northwest Nicaragua to Guatemala) it is continental crust. Geochemical data from modern lavas of the Central American volcanic front show a systematic variation in trace element ratios along the arc and these have been interpreted to indicate relative contributions from the slab and asthenosphere (Carr et al., 1990; Patino et al., 2000). Geochemical data from these lavas show an absence of arc magma interaction with the Paleozoic continental crust (Carr et al., 2003). For this reason, Carr et al. (2003) infer that a post-Paleozoic, arc-type basement underlies the modern Middle America arc and areas extending an unknown distance northeast of the modern volcanic line. This paper evaluates the relationship between the silicic pyroclastic flows and related deposits to basaltic lavas from the modern volcanic front. The compositional variation of these silicic volcanic rocks along the arc places constraints on models of the origin of silicic magmas and continental crust evolution.

Silicic magmas are common in continental convergent zones, but also are abundant in other tectonic environments. Their origin has been attributed to a variety of processes (Cameron et al., 1980; Lipman, 1984; de Silva and Wolff, 1995; Eichelberger et al., 2000; Costa and Singer, 2002). Most models for the origin of silicic magmas in areas with continental crust involve interaction with the crust either by partial melting of crustal rocks (Cobbing and Pitcher, 1983; White and Chappell, 1983; Vielzeuf and Holloway, 1988) or by fractional crystallization along with assimilation of these crustal rocks (MASH) (DePaolo, 1981; Hildreth and Moorbath, 1988). In these models the compositions of the silicic magmas vary according to the relative contribution of evolved continental crust and mantle-derived melts. In contrast, with some exceptions (McBirney, 1969; Gill and Stork, 1979), silicic magmatism has been considered to be minor in oceanic arcs or oceanic extensional areas, where evolved continental crust is absent. However, recent work (Tamura and Tatsumi, 2002; Leat et al., 2003; Smith et al., 2003; Vogel et al., 2004) has shown that silicic magmatism can be abundant in subduction zones without evolved continental crust. These workers propose that the generation of these silicic magmas involves the partial melting, or melt extraction from, recently emplaced, mantle-derived, stalled (crystallized or partially crystallized) calc-alkaline magmas. It is clear that abundant silicic magmas can be produced both with and without the presence

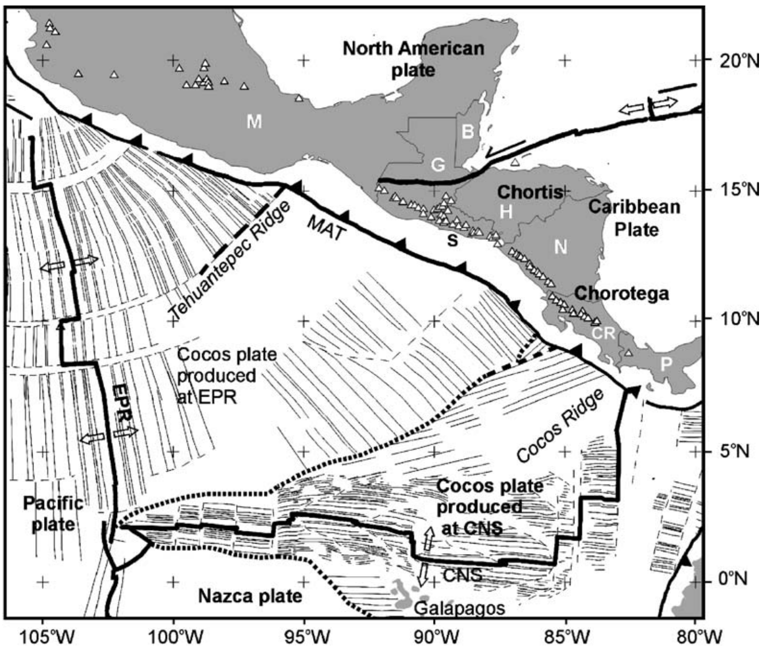

Fig. 1. Tectonic setting of northern Central America showing the Cocos-Nazca spreading center (CNS), East Pacific Rise (EPR), triple junction trace (heavy dots), volcanoes (open triangles), Middle America Trench (MAT) and the Chortis and Chorotega blocks. The boundary between these blocks is not well defined and shown by a dashed line (Rogers et al., 2002). Letters indicate respective countries in Central America.