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Syn-extensional intra-plate trachydacite-rhyolitic dome volcanism of the Mesa Central, southern Sierra Madre Occidental volcanic province, Mexico

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ABSTRACT

Oligocene dome complexes of trachydacitic to rhyolitic composition are common in the southern portion of the Mesa Central physiographic province, which forms part of the southern Basin and Range extensional province as well as of the southern Sierra Madre Occidental volcanic province. Generally, dome complexes occur aligned with regional fault systems, mostly associated with the southern Basin and Range province, and thus suggesting that faults controlled the felsic magmas that formed these domes. Two distribution patterns are evident, one aligned NE–SW and another aligned NNE. The set of domes were emplaced at 33–28 Ma. Emplacement of domes occurred in three continuous phases starting with those of trachydacite affinity at 33–32 Ma, to trachydacite–rhyolitic at 32–31 Ma, and finally to those with rhyolitic composition at 31–28 Ma. Felsic magmas that originated the domes were apparently generated by partial melting at the base of the continental crust. Contrary to previous hypothesis, our evidence suggest that these magmas in these particular areas of the Mesa Central were not accumulated in large magma reservoirs emplaced at shallow levels in the crust, but crossed the continental crust directly. Since continental crust in this region is relatively thin (30–33 km), we propose that an intense extensional episode favored the direct ascension of these magmas through the brittle crust, with little interaction with the country rock during ascent to the surface, to end up forming aligned dome chains or complexes. Geochemical data favors this model, as the felsic rocks show no depletions in Nb and Th but instead relatively enrichment in these elements. REE show flat or concave up patterns, suggesting that the magmas involved enriched (fertile), metasomatized lithospheric fluids that generated partial melting at the base of the continental crust. Based upon these data, we infer an intra-plate tectonic setting for these rocks.

1. Introduction

During Oligocene, felsic volcanism was intense and widespread in the Sierra Madre Occidental (SMO) in western Mexico (McDowell and Clabaugh, 1979; Swanson and McDowell, 1984; Aguirre-Díaz and Labarthe-Hernández, 2003). Felsic rocks of the SMO have been classified within the K-rich calc-alkaline suite (McDowell and Clabaugh, 1979; Cameron et al., 1980; Aranda-Gómez et al., 1983). Most of this volcanism was explosive and has been referred to as the Ignimbrite Flare-up (McDowell et al., 1990; Aguirre-Díaz and McDowell, 1991; Ferrari et al., 2002; Aguirre-Díaz et al., 2008). However, part of this mid-Tertiary volcanism was effusive, particularly, in the southern Mesa Central, where 80 vol.% of middle Oligocene felsic magmatism is represented by lava domes and only 20 vol.% by ignimbrites. Some of these domes are associated with hydrothermal mineralization that formed important precious metal deposits throughout the SMO (Burt et al., 1982; Huspeni et al., 1984; Scheubell et al., 1988; Webster et al., 1996), Sn deposits (Foshag and Fries, 1942; Lee-Moreno, 1972), and topaz-bearing rhyolites (Burt et al., 1982; Burt and Sheridan, 1987).

In general, lava domes can be emplaced at distinct tectono-magmatic regimes (Fink, 1987). Sometimes domes are related to post-collapse activity in calderas (Lipman, 1984; Henry and Price, 1984; Aguirre-Díaz et al., 2007, 2008), and in other cases lava domes are associated with faulting and extensional tectonic settings; these domes commonly bear Sn and topaz, such as those of SW United States (Christiansen et al., 1986). In the southern SMO, near the city of San Luis Potosí, Sn and topaz-bearing lava domes were emplaced during the Oligocene (Tristán-González, 1986; Labarthe-Hernández and Tristán-González, 1988; Aranda-Gómez et al., 1989). These domes have been related with extensional tectonics since they occur aligned with regional fault systems, either along graben or half-graben margins or inside them (Tristán-González, 1986; Nieto-Samaniego et al., 1996; Aranda-Gómez et al., 2000; Tristán-González et al., 2006, 2009a,b). Orozco-Esquivel et al. (2002) have proposed that these

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Table 1
K–Ar isotopic ages.

Volcanic complex	Sample number	Coordinates		Age $\pm 1\sigma$	$^{40}Ar^{a}$ (e^{-7} cm^3)	% $^{40}Ar^{a}$	K_2O (wt.%)	Fraction[a]	Analyzed weight (g)	Ref.[b] analysis
		Latitude N	Longitude W							
SLPVF[1]	SLP00-19			27.4 ± 0.4				fds		
SIC	SLP00-16	21°55′53.5″	101°53′03.3″	28.5 ± 0.5	47.7	74.3	5.15	fds	0.3000	B5578
OC	SLP03-07	21°49′48.5″	101°41′49.5″	28.7 ± 0.7	50.7	75.5	5.45	wr	0.3475	B7078
SLPVF[2]	SLP00-03			28.9 ± 0.5				wr		
AMC	SLP00-13	22°13′51.9″	96°06′32.1″	29.5 ± 0.5	58.8	78.4	6.13	fds	0.2511	B5526
AMC	SLP00-10	23°01′23.4″	101°51″06.8″	30.3 ± 0.5	24.4	82.3	2.48	fds	0.4037	B5555
SLPVF[3]	SLP00-17			30.4 ± 0.5				fds		
SIC	SLP06-07	101°45′23.5″	21°42′26.7″	30.4 ± 0.7	53.6	81.2	5.43	wr	0.3593	B7067
SLPVF[4]	SLP01-22			31.0 ± 0.7				mtx		
AMC	SLP00-09	23°03′37.7″	101°53′41.5″	31.2 ± 0.5	46.8	90.5	4.61	fds	0.2511	B5554
OC	SLP01-07	21°50′49.2″	101°39′05.9″	31.5 ± 0.7	56.1	85.3	5.48	wr	0.3596	B7068
SLPVF[5]	JAG37-03			31.6 ± 0.7				wr		
SLPVF[6]	SLP01-21			31.6 ± 0.8				wr		
AMC	SLP00-15	22°08′48.0″	101°58′01.6″	32.3 ± 0.5	56.1	95.2	5.35	fds	0.3024	B5585
EPC	SLP00-11	21°36′06.3″	101°22′18.1″	32.9 ± 0.6	30.2	59.0	2.82	fds	0.4023	B5556
SIC	SLP00-12	21°28′06.7″	96°00′24.9″	33.3 ± 0.5	53.2	86.8	4.91	fds	0.2615	B5557

All are new ages except for the samples SLPVF reported by Tristán-González et al. (2009a,b).
[1]Trz; El Zapote rhyolite; [2]Trp; Panalillo ignimbrite; [3]Tsm; San Miguelito rhyolite; [4]Tlp; Portezuelo dacite; [5]Toc; Ojo Caliente trachyte; [6]Tdj; Jacavaquero dacite.
[a] Used material; fds — feldspar; wr — whole rock; mtx — matrix.
[b] Laboratory reference of the analyses performed in the Geochronology Laboratory at the Université de Bretagne Occidentale, Brest, France.

felsic lavas result from partial melting of Precambrian continental crust, in a similar way as have been suggested for the topaz rhyolites in the SW United States (Christiansen and Lipman, 1966; Christiansen et al., 1984, 1986). Verma (1984) already has proposed this hypothesis for domes of the southern SMO mentioning that partial melting probably took place at the base of continental crust. Rodríguez-Ríos et al. (2007) in a more recent study agree with the continental crust anatexis model, but include a minor percent of crystal fractionation in the evolution processes.

In order to better understand the origin of this voluminous felsic pulse during Oligocene, we combined geochemical data with well-constrained geological, stratigraphical and geochronological data,

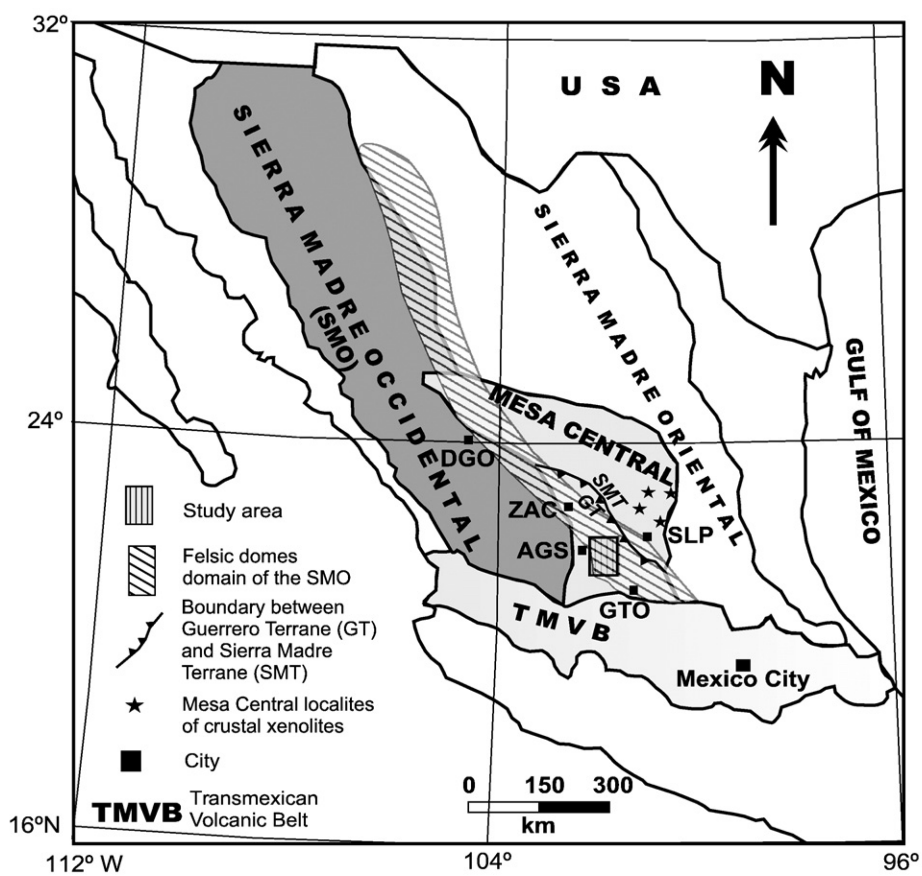

Fig. 1. Index map showing the location of the study area and the geologic provinces of Sierra Madre Occidental, Sierra Madre Oriental, Mesa Central, and Transmexican Volcanic Belt. Also indicated is the extent of the felsic domes domain at the eastern Sierra Madre Occidental. Outlined are the boundaries of Sierra Madre (SMT) and Guerrero (GT) terranes. Towns: AGS — Aguascalientes, DGO — Durango, GTO — Guanajuato, SLP — San Luis Potosí, ZAC — Zacatecas.