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Epithermal mineralization controlled by synextensional magmatism in the Guazapares Mining District of the Sierra Madre Occidental silicic large igneous province, Mexico

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A B S T R A C T

We show here that epithermal mineralization in the Guazapares Mining District is closely related to extensional deformation and magmatism during the mid-Cenozoic ignimbrite flare-up of the Sierra Madre Occidental silicic large igneous province, Mexico. Three Late Oligocene–Early Miocene synextensional formations are identified by detailed volcanic lithofacies mapping in the study area: (1) ca. 27.5 Ma Parajes formation, composed of silicic outflow ignimbrite sheets; (2) ca. 27–24.5 Ma Témoris formation, consisting primarily of locally erupted mafic-intermediate composition lavas and interbedded fluvial and debris flow deposits; (3) ca. 24.5–23 Ma Sierra Guazapares formation, composed of silicic vent to proximal ignimbrites, lavas, subvolcanic intrusions, and volcaniclastic deposits. Epithermal low- to intermediate-sulfidation, gold–silver–lead–zinc vein and breccia mineralization appears to be associated with emplacement of Sierra Guazapares formation rhyolite plugs and is favored where pre-to-synvolcanic extensional structures are in close association with these hypabyssal intrusions.

Several resource areas in the Guazapares Mining District are located along the easternmost strands of the Guazapares Fault Zone, a NNW-trending normal fault system that hosts most of the epithermal mineralization in the mining district. This study describes the geology that underlies three of these areas, which are, from north to south: (1) The Monte Cristo resource area, which is underlain primarily by Sierra Guazapares formation rhyolite dome collapse breccia, lapilli-tuffs, and fluvially reworked tuffs that interfinger with lacustrine sedimentary rocks in a synvolcanic half-graben bounded by the Sangre de Cristo Fault. Deposition in the hanging wall of this half-graben was concurrent with the development of a rhyolite lava dome-hypabyssal intrusion complex in the footwall; mineralization is concentrated in the high-silica rhyolite intrusions in the footwall and along the syndepositional fault and adjacent hanging wall graben fill. (2) The San Antonio resource area, underlain by interstratified mafic-intermediate lavas and fluvial sandstone of the Témoris formation, faulted and tilted by two en echelon NW-trending normal faults with opposing dip-directions. Mineralization occurs along subvertical structures in the accommodation zone between these faults. There are no silicic intrusions at the surface within the San Antonio resource area, but they outcrop ~0.5 km to the east, where they are intruded along the La Palmera Fault, and are located ~120 m-depth in the subsurface. (3) The La Unión resource area, which is underlain by mineralized andesite lavas and lapilli-tuffs of the Témoris Formation. Adjacent to the La Unión resource area is Cerro Salitrera, one of the largest silicic intrusions in the area. The plug that forms Cerro Salitrera was intruded along the La Palmera Fault, and was not recognized as an intrusion prior to our work.

We show here that epithermal mineralization is Late Oligocene to Miocene-age and hosted in extensional structures, younger than Laramide (Cretaceous-Eocene) ages of mineralization inferred from unpublished mining reports for the region. We further infer that mineralization was directly related to the emplacement of silicic intrusions of the Sierra Guazapares formation, when the mid-Cenozoic ignimbrite flare-up of the Sierra Madre Occidental swept westward into the study area about 24.5–23 Ma ago.

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1. Introduction

The Sierra Madre Occidental of northwestern Mexico is the largest Cenozoic silicic igneous province on Earth (300,000–400,000 km^3; Aguirre-Díaz and Labarthe-Hernández, 2003; Bryan, 2007; Ferrari et al., 2007; Bryan and Ferrari, 2013). The Sierra Madre Occidental also hosts one of the largest (800,000 km^2) and most productive (at least 80 million ounces gold, 4.5 billion ounces silver produced) epithermal precious mineral belt on Earth (Dreier, 1984; Staude and Barton, 2001). As important as these mineral deposits are, there is a limited understanding of the relationships between the timing of epithermal mineralization and the magmatic and tectonic history of the Sierra Madre Occidental, particularly at mining district levels. Regional tectonic controls on the development of epithermal veins in western North America have been proposed (e.g., Dreier, 1984; Price et al., 1988), and Staude and Barton (2001) suggested that Jurassic to Late Cenozoic mineralization is commonly associated with coeval magmatic and tectonic events. In the case of Mexican epithermal deposits, Camprubí et al. (2003) suggest that the age of the volcanic host rock is close to the age of the mineralization. However, the details of the structural setting of the precious mineral deposits, and their relationship to specific magmatic and tectonic events, remain poorly known for most of the Sierra Madre Occidental.

The Guazapares Mining District of western Chihuahua, Mexico is located ~250 km southwest of Chihuahua City in the northern part of the Sierra Madre Occidental (Fig. 1), within the Sierra Madre Occidental Gold–Silver Belt. Previous work in the Guazapares Mining District is restricted to unpublished mining company reports, except for our recently published work (Murray et al., 2013). These unpublished reports (e.g., Roy et al., 2008; Wood and Durgin, 2009; Gustin, 2011, 2012) indicate that mineralization in the Guazapares Mining District is spatially associated with the north-

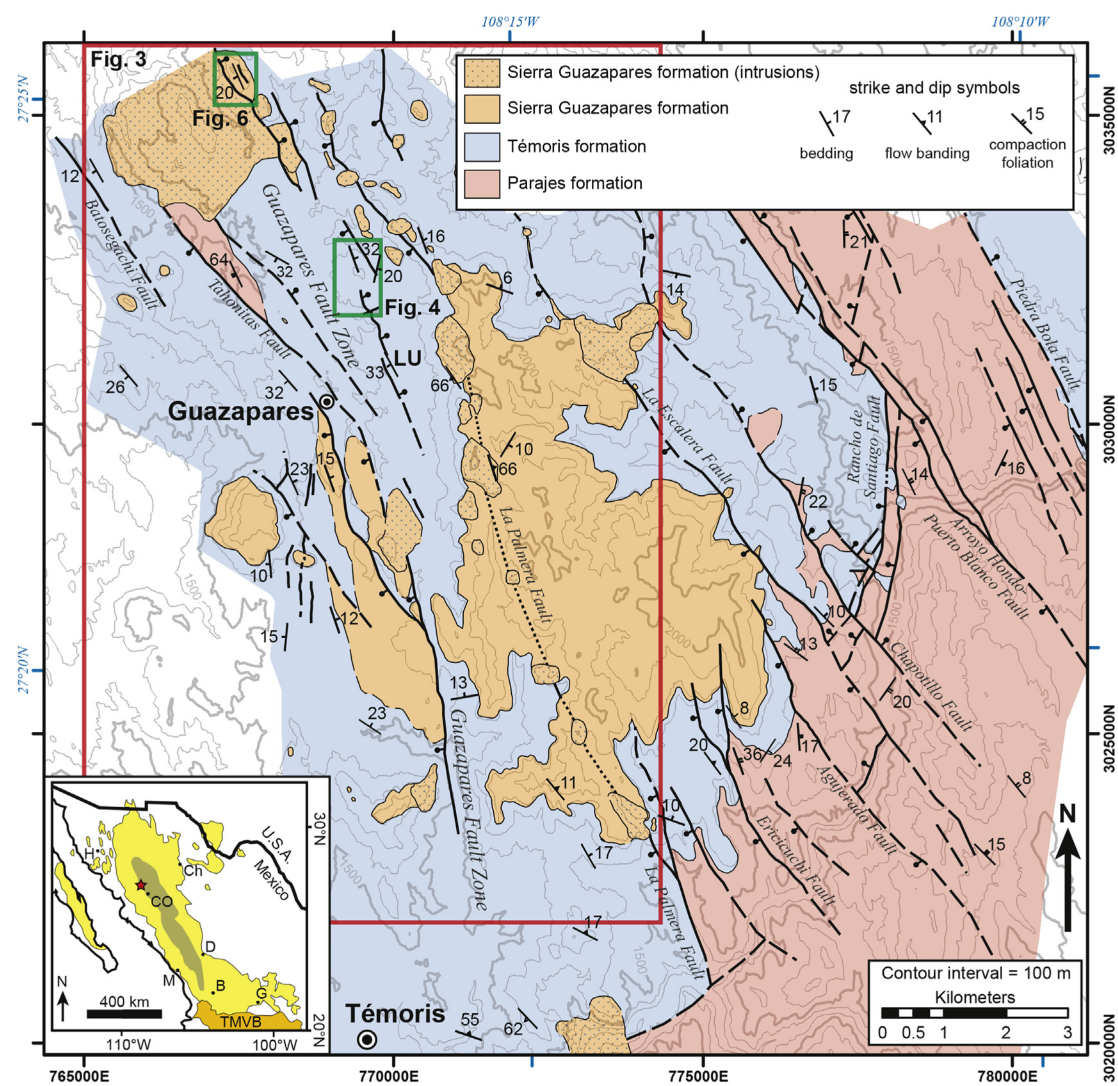

Fig. 1. Simplified geologic map of the Guazapares Mining District region, showing the extent of the three formations (Fig. 2) and the location of major faults (after Murray et al., 2013). The Guazapares Mining District lies north of the town of Témoris, which is a stop on the famous Copper Canyon train. The red box indicates the location of Fig. 3 (shown on two pages below), which focuses on the Guazapares Fault Zone; for detailed discussion of the entire map area, see Murray et al. (2013). The green boxes indicate the locations of the San Antonio (Fig. 4) and Monte Cristo (Fig. 6) resource areas; LU—La Unión resource area. Inset map of western Mexico shows the extent of the Sierra Madre Occidental (SMO) silicic large igneous province (light yellow) and the relatively unextended core (dark gray) of the SMO (after Henry and Aranda-Gómez, 2000; Ferrari et al., 2002; Bryan et al., 2013). The star indicates the location of the Guazapares Mining District (this study). B—San Martín de Bolaños Mining District, CO—Cuenca de Oro basin, Ch—Ciudad Chihuahua, D—Durango, G—Guanajuato Mining District, H—Hermosillo, M—Mazatlán, TMVB—Trans-Mexican Volcanic Belt. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)