Ore Geology Reviews 81 (2017) 1158–1171

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Geology and geochemistry of the Suaqui Verde deposit: A contribution to the knowledge of the Laramide porphyry copper mineralization in south central Sonora, Mexico

L.H. Ochoa-Landín [a,*], M. Valencia-Moreno [b], T. Calmus [b], R. Del Rio-Salas [b], H. Mendívil-Quijada [c], D. Meza-Figueroa [a], I. Flores-Vásquez [a], L.G. Zúñiga-Hernández [a]

[a] Departamento de Geología, División de Ciencias Exactas y Naturales, Universidad de Sonora, Blvd. Rosales y L. Encinas, Hermosillo, Sonora 83000, México
[b] Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México. L.D. Colosio S/N y Madrid, Col. Los Arcos, Hermosillo, Sonora 83240, México
[c] GEO Digital Imaging de México, S.A. de C.V., Hermosillo, Sonora, México

ARTICLE INFO

Article history:
Received 28 November 2015
Received in revised form 4 August 2016
Accepted 14 October 2016
Available online 18 October 2016

Keywords:
Suaqui Verde
Porphyry copper deposit
Sonora
Laramide magmatic arc

ABSTRACT

The Suaqui Verde porphyry copper deposit is a small ore body of about 20 million tons of oxide ore grading 0.29% copper, located ~8 km E-NE of the town of Suaqui Grande in east-central Sonora, northwestern Mexico. The largest and better-known deposits occur in northern Sonora, whereas those from central and southern Sonora are smaller and poorly studied. This paper contributes with new geological and geochemical data to characterize the Suaqui Verde porphyry copper prospect, which may help to understand the porphyry copper mineralization in central Sonora. The Cu mineralization is centered on a 57 ± 0.3 Ma old quartz-feldspar porphyry stock, intruding co-magmatic Laramide volcanic and plutonic rocks. The Suaqui Verde porphyry copper system is characterized by widespread phyllic alteration dominated by quartz-sericite, propylitic and local potassic alteration, with Cu, Mo, and Fe sulfide mineralization emplaced in quartz veinlets filling stockwork zones. Quartz-tourmaline breccias, presumably pre-dating the copper sulfide mineralization, occur in the southern part of the deposit, apparently forming the apical parts of the equigranular plutons. Geochemical data of plutonic and volcanic rocks indicate derivation from subduction related calc-alkaline and metaluminous to slightly peraluminous magmas. Light REE enriched normalized patterns, with negative Eu anomalies resemble typical composition of Laramide magmatic rocks in northwestern Mexico. However, positive Eu anomalies in three of the samples indicate that some magmatic stages underwent a process that increased the Eu^{+2}/Eu^{+3} ratios in the liquid, possibly associated with changes in the oxidation-reduction conditions. Chondrite-normalized multi-elemental diagrams show negative Nb-Ta, P and Ti anomalies, coupled with positive Rb, Th, U, Sr and Pb anomalies, strongly suggesting a subduction-related magmatic arc affinity. The mineralized system was segmented and tilted during the Cenozoic Basin and Range extension, which exhumed the hypogene sulfide zone, promoting supergene enrichment processes and subsequent transport of copper solutions that developed weak exotic copper mineralization.

1. Introduction

Northwestern Mexico includes around 35 porphyry copper deposits (Fig. 1), mainly located in Sonora and Sinaloa (Staude and Barton, 2001; Valencia-Moreno et al., 2006b, 2007). In northern Sonora there are about a dozen occurrences, among which the Buenavista del Cobre (formerly the Cananea mine), La Caridad, Mariquita, and Milpillas deposits account for >40 Mt contained Cu. In contrast, the porphyry copper deposits in south-central Sonora comprise ~2 Mt of contained Cu, as a whole (Barton et al., 1995; Singer et al., 2005; Valencia-Moreno et al., 2006b, 2007). Resources for the Suaqui Verde prospect are estimated at 87.2 Mt of oxide ore grading 0.43% copper (Singer et al., 2008).

The porphyry copper prospects of south-central Sonora display a near E-W alignment, in contrast to the regional NNW-SSE trend of the main porphyry copper deposit belt (Fig. 1), which is parallel to the trench during Cretaceous time. This alignment may reflect the inherited E-W structural pattern associated with thrusting of Paleozoic oceanic sediments onto the continental platform of Laurentia continent during the Ouachita-Marathon-Sonora Late Permian orogeny (Poole et al., 2005). Thus, the central Sonora porphyry copper deposits were emplaced in a crust characterized by a southwards thinning of the Proterozoic basement of North America (Valencia-Moreno et al., 2001).

* Corresponding author.
E-mail address: lucaso.geologia@gmail.com (L.H. Ochoa-Landín).

http://dx.doi.org/10.1016/j.oregeorev.2016.10.011
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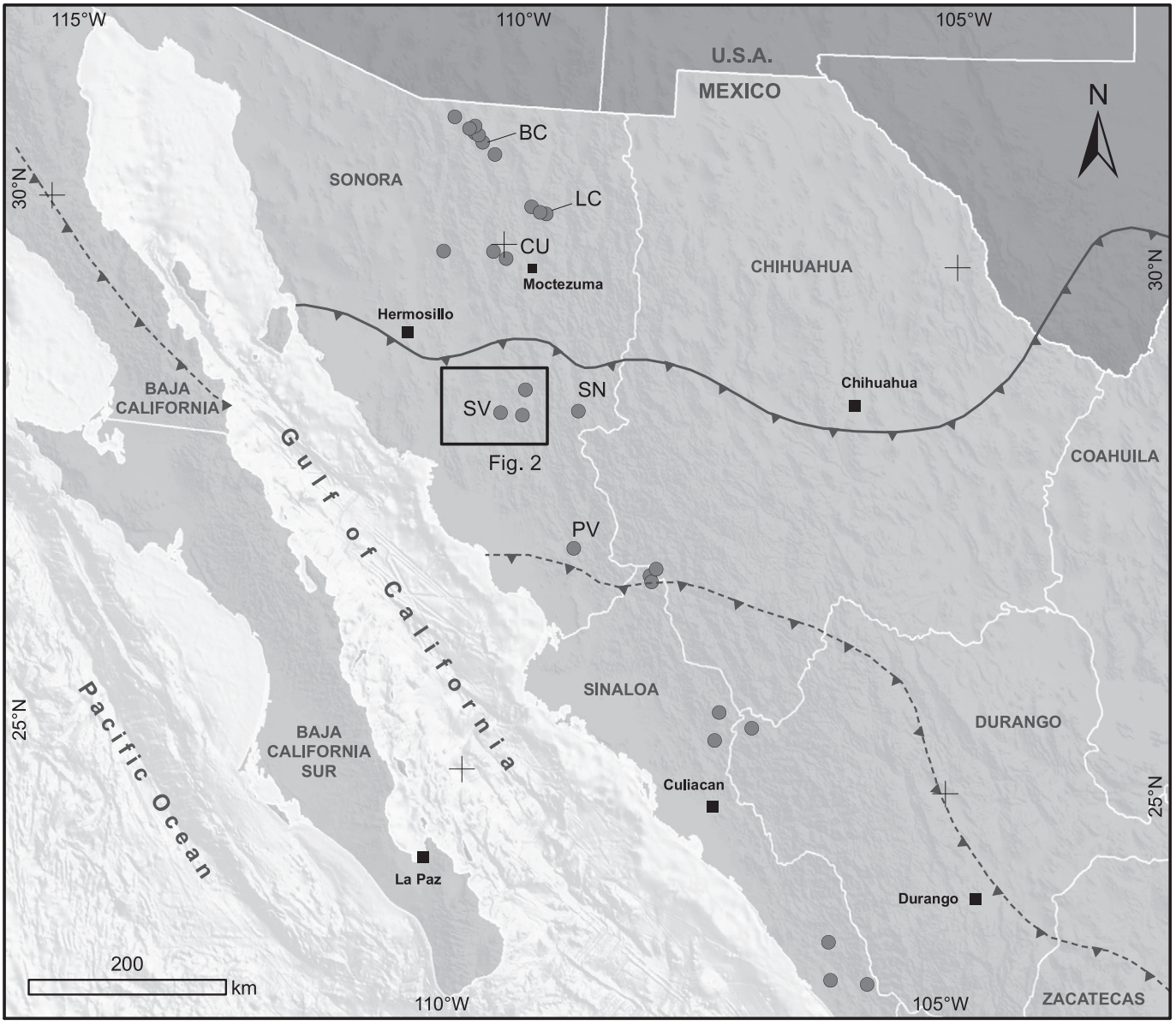

Fig. 1. Map showing the location of the study area, and the distribution of the Laramide porphyry copper deposits in northwestern Mexico. BC: Buenavista del Cobre; LC: La Caridad; SV: Suaqui Verde; CU: Cumobabi; SN: San Nicolás; PV: Piedras Verdes. The solid line corresponds to the southern edge of the Ouachita-Marathon-Sonora orogenic belt (modified from Poole et al., 2005). The dashed line represents the accretionary thrust front of the Guerrero-Alisitos island arc terranes.
(Modified from Dickinson and Lawton, 2001).

Porphyry copper deposits of central Sonora are characterized by a weak supergene enrichment, in contrast to the deposits of northern Sonora, where supergene enriched blankets have been well-developed and preserved, as in Cananea where a supergene enrichment blanket is 150 to 300 m thick (Virtue, 1996). These supergenic blankets were probably exhumed and eroded during the Basin and Range extension, which has been well documented in this region (e.g. Stewart and Roldán-Quintana, 1994; Gans, 1997). In eastern Sonora, at the latitude of Suaqui Verde, the rate of extension has been estimated in 90% (Gans, 1997). About 40 km to the east of Suaqui Verde, apatite fission track studies in the Potrero de Galindo Laramide pluton yielded cooling ages between 23.9 ± 0.7 Ma and 18.4 ± 0.7 Ma (Calmus et al., 2015), suggesting this pluton was exhumed during the Late-Oligocene-Miocene Basin and Range extensional event.

The present paper provides new geological and geochemical information of the Suaqui Verde porphyry copper magmatic system, as an effort to understand the emplacement environment, geochemical composition, and the petrogenetic and metallogenic aspects of the porphyry copper deposits of south-central Sonora. Also, this study brings to light new information to compare this part of the porphyry copper belt of Sonora with the world-class deposits emplaced in the northern part, in terms of the nature of magmatic sources and mineralization.

1.1. Geological setting

The study area is located in south-central Sonora, near the town of Suaqui Grande (Fig. 2). The oldest rocks correspond to a sequence of sediments deposited in both shelf and deep-water marine environments during Late Ordovician to Permian. The deep-water facies consist of alternating layers of black shale, chert, siltstone, quartzite, and conglomerate, and few horizons of limestone and stratiform barite bodies (Poole et al., 1991, 2005). These rocks were thrust onto the southwestern margin of Laurentia during the Permian Sonoran orogeny (Poole et al., 2005). After this compressional event, E-W oriented rift-related basins were formed south of the thrust front in central and southern