Simple Sb deposits in Mexico

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Abstract. Simple Sb deposits consist on veins formed mainly with stibnite, quartz with traces of Au and Hg. These deposits occur in shear zones usually in syn/post-orogenic geotectonic environments. Our study is an overview of the features and distribution of this kind of deposits in Mexico. Besides the classical simple-Sb veins, in central and southern Mexico, some stratabound ore deposits were found. They are generated by the intersection of these simple-Sb veins with diagenetic evaporites. All the deposits recognized during this study have a similar geological setting and a very simple paragenesis. In addition, the major districts studied seem to be contemporaneous and none of them present a clear correlation with magmatic events.

Keywords. simple-Sb, Mexico, diagenesis, TSR, magmatic arc, post-orogenic ore.

1 Simple Sb deposits

Simple Sb deposits occur in shear zones related to the fold dynamic of the host orogen developing in non-metamorphosed country rocks at low temperatures (Dill et al. 1998). Their mineralogy is rather simple and made up of stibnite and arsenopyrite with small amounts of Pb–Cu–Zn minerals in a quartz-rich matrix and with a low Au content. Mineralizing fluids are generated by metamorphic dehydration, and zones of structural weakness channeled the hydrothermal fluids during regional deformation (Boiron et al. 2001; Neiva et al. 2008). The source of metals is thought to be the orogenic crust (Marcoux et al. 1988; Neiva et al. 2008).

2 Simple Sb deposits in Mexico

As can be seen in Figure 1, Simple Sb deposits in Mexico are distributed in a linear zone along the eastern limit of the Sierra Madre Occidental (SMOc). This alignment is not related to the distribution of the SMOc (Oligocene to Miocene) and the Trans Mexican Volcanic Belt (FVTM; Miocene in age) volcanic cover (Fig. 1A). All deposits are located in Oaxaquia continental crust and in the Mixteco terrain to the south. There are no direct correlations between deposits distribution and crustal thickness (Fig. 1B). Despite of their wide regional distribution, most of these deposits share similar geological features. They are located in stratigraphic and structural traps in Triassic to upper Jurassic rocks. The primary paragenetic sequence is restricted to stibnite, chalcedony and calcite. Very large euhedral crystals of stibnite are commonly found, some being as much as 50 cm long, 10 cm wide, and 8 cm thick. Some brown, yellow and more rarely white antimony oxides, are formed by oxidation of the hypogene sulphide phase.

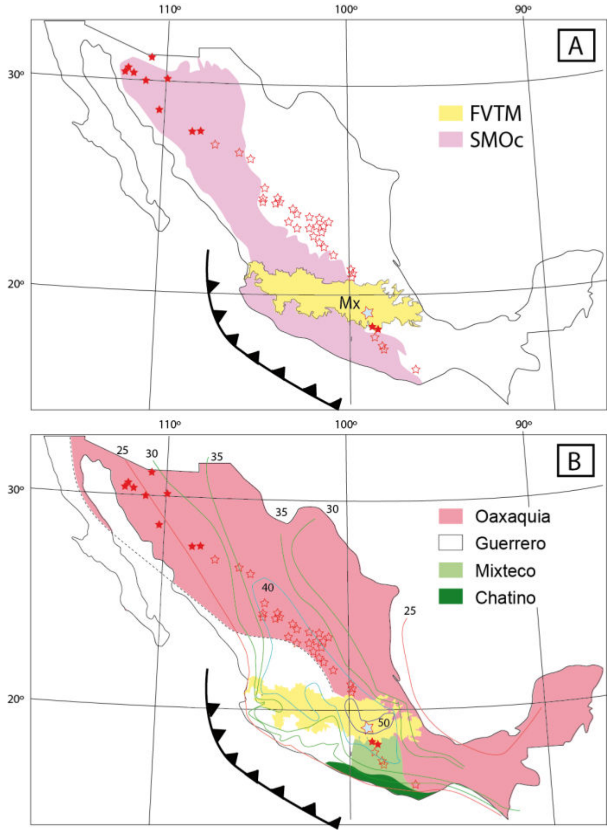

Figure 1. Simple Sb deposits distribution in Mexico (A) FVTM: Faja Volcánica Trans Mexicana; SMOc: Sierra Madre Occidental; (B) Terrane distribution; Lines: present day crustal thickness isopachs (in km) and trench position (Molina-Garza et al. 1993). Filled stars are deposits hosted in silicoclastic formations. Open stars are deposits hosted in limestones.

2.1 Northern veins deposits

In northern Mexico (El Antimonio District, Sonora), the antimony deposits are hosted in Triassic siliciclastic, Lower Jurassic carbonate rocks and granodioritic intrusives (Paleocene in age). The ore is found in veins of various orientations. The veins are larger within the siltstones formation. The stibnite veins apparently avoid the limestone even where it is abundant. No mineralization is known within the Permian limestone. Most of the veins in the sedimentary rocks are parallel or nearly parallel to the stratification. The veins are generally emplaced in transcurrent inverted fault (Fig. 2A). The paragenesis consists predominantly of coarse-grained milky-white quartz, stibnite and minor chalcedony and Sb-oxides. Silver and native gold are found in some veins, but it seems to be related to a late hydrothermal event (El Palo Verde; White and Guiza 1949).

2.2 Central and southern stratabound deposits

Most central and southern, simple Sb deposits (Wadley, San Luis Potosi; Soyatal, Queretaro; Tejocotes, Oaxaca) are hosted by Middle and Upper Jurassic limestone in anticlines and shear faults particularly where limestone is overlain by shale, which acted as an impermeable cap for ascending fluids. However, some small Mexican deposits in limestone that have been examined by the authors are not overlain by shales. In Los Tejocotes (Oaxaca, White and Guiza 1945) and Wadley (San Luis Potosi) the Sb mineralization emplacement is controlled not only by these structural traps, but also is associated with a diagenetic event and is chemically controlled by sulphate reduction in anhydrite horizons. The simple mineralization paragenesis is formed by stibnite in chalcedony and calcite gangue. Minor pyrite is disseminated in the chalcedony. It is common to find the stibnite altered to stibiconite and other antimony hydroxides.

The few post orogenic magmatic intrusions in the area are mineralized (i.e. Ag-Pb-Zn-veins), but this event seems to post-date the Sb mineralization.

3 Age of simple Sb deposits in central Mexico

The lack of minerals suitable for traditional radiometric dating in the paragenetic sequence complicates the determination of depositional ages. So far none of the simple-Sb Mexican deposits have been dated, but at least in the Wadley deposit (Central Mexico), the magmatic and structural regional evolution allows to constrain the timing of mineralization. The mineralized mantos are folded but not the antimony crystals. The folding event is dated in the area at ca. 65 Ma (Fitz-Díaz 2011). The transcurrent faults, which are the feeder channels of mineralizing fluids, are developed during the transition between the compressive to extensional regimes. This fact is evidenced by the non-symetrical folding development in the two sides of each fault. Both mantos and transcurrent faults are crosscut by normal faulting which was intruded by magmatism dated at ca. 42 Ma. So we suggest that the mineralizing episode occurred between 62 and 42 Ma during the transition from compression to post orogenic extension.

4 Genetic model

All Mexican antimony deposits recognized in this study present common features. They are hosted in the continental crust, particularly in Jurassic sedimentary units, the mineralizing fluids flowed along reverse or transcurrent faults, no direct relationship with magmatism could be established and they present simple paragenesis based on stibnite and quartz with or without calcite. The timing of mineralization seems to be always during the transition between orogen compression and post orogenic extension. All these deposits form a well-defined curved linear zone, (parallel to the subduction trench) that is narrow compared to the width of the orogen, particularly in Central Mexico.

In Mexico the propagation of the Laramide orogenic front is directly related to the subduction evolution and more specifically to the flat subduction episode in central Mexico. Subduction zones act as an element recycling mechanism at crustal scale. There is a relation between the thermal structure of the subduction zone and the efficiency of the volatile elements transport (Abbott and Lyle 1984; Staudigel and King 1992). Cold oceanic plates are subducted faster than the hot ones, and the volatile elements are retained longer in the subducting cold slab, being easier delivered to a deeper mantle zones or at great distances from the trench. Bebout et al. (1999), show that antimony is not released from the subducting sediments and basaltic materials until the plate reaches the amphibolitic metamorphic grade. When that happens, the rock suffers a depletion of Sb of about 90%. This is even more drastic in a subduction front prograde context, where the displacement is fast enough to not allow plate dehydratation and or melting (Humpreys et al. 2003).

This should be reflected on a selective enrichment of antimony in a restricted parts of the metasomatized mantle wedge, which will vary depending on the thermal regime or the subduction angle. The flat subduction slabs reach the temperature needed for the Sb expulsion farther than no flat ones, so the Sb is released at greater distances from the trench.

Sb presents calcophile affinity, is moderately-volatile and is considered one of the most mobile metals after the Hg (Laznicka 1999). This suggests that Sb should have a low assimilation degree in the mantle wedge or in the crustal rocks. So, high Sb percentage should be released during the last orogenic magmatic phase and drive to the surface, if there are the channels needed for it.

5 Conclusions

Most Sb deposits in Mexico are simple Sb type, and share common features. All the studied deposits are developed over the same geologic and paragenetic framework, and are independent of crustal thickness. The more important districts apparently have similar mineralization ages (Paleocene to Eocene), and are all emplaced in post-orogenic geotectonic environment. The distribution of these deposits is restricted to a thin regional antimoniferous belt (antimoniferous Mexican belt). These facts suggest a common origin of the major part of Sb-deposits in Mexico. The formation mechanism may include two factors; i) a very restricted crustal or mantel wedge Sb-enrichment by the fluids derived from the subducting slab metamorphism, and ii) the presence of crustal discontinuities acting as channels for these fluids. The curvature of the lineation of these Sb deposits in Central Mexico is consistent with the flat subduction described for this zone. With these insights, the authors conclude that these deposits were formed after the last Laramide compression event, in the early extensional stages (post-orogenic context), possibly favoured by roll-back or rupture of the subduction slab.

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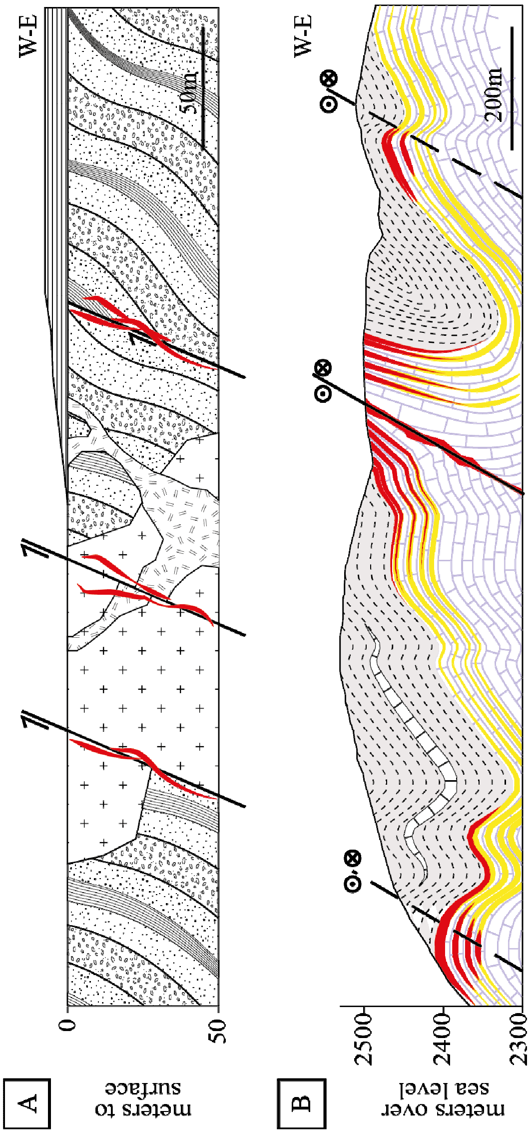

Figure 2. Schematic cross sections of selected deposits. Economic mineralizations in red: (a) Cross section of El Antimonio district, Sonora, North Mexico. Ore is hosted by stibnite-quartz veins, within Triassic siliciclastic sequences, that are intruded by Paleocene and Eocene granodioritic intrusions; (b) Cross section of Wadley mines, San Luis Potosí, Central Mexico. Ore is accumulated both in stibnite-quartz veins and diagenetic evaporite levels (now calcite with variable H_2S contents) in yellow, within an Oxfordian aged limestone overlain by a Tithonian shale.