Formation ages of the two Phanerozoic IOCG belts in México

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Abstract. In Mexico, two IOCG-bearing belts are disposed roughly parallel to the Pacific Coast: (1) an older, Mesozoic belt located near the Pacific border, constituted by magnetite-rich bodies with Cu-Au anomalies; and (2) a Tertiary belt, located inland Mexico, grossly parallel to the Mesozoic belt,composed mainly by magnetite-hematite-rich deposits. Recently, some new data on the absolute age of these deposits has been obtained.

Keywords. IOCG deposits, Mesozoic belt, Tertiary Belt, Fe deposits, Cu-Au deposits, Mexico

1 Introduction

In North America (US and Mexico), iron-oxide rich deposits are widespread and located mainly in a belt parallel to the Pacific border of the continent. These deposits share an association with saline fluids, voluminous alkaline (Na and/or K -rich) alteration, low sulfur contents and variable enrichments in REE, Cu, Au, Ag, Co and U (Barton et al. 2000).
Although iron deposits with problematic affiliation are known in Mexico for quite a long time (Van Allen 1978; Lyons 1988; Corona-Equivel 2000), the presence of IOCG deposits in Mexico was only very recently formally recognized by Tritlla et al. (2003). The age and geological setting of these deposits are uncertain and this paper provides some new descriptions and geochronological data of some Mexican IOCGs.

2 IOCG deposits in Mexico

In Mexico, two distinctive sub-belts can be recognized (Corona-Esquivel et al. 2007; Fig. 1): (1) an older, Mesozoic belt located near the Pacific border, constituted by magnetite-rich bodies usually with several mineralized bodies within a discrete zone, sometimes related to mesozoic intrusives (Tritlla et al. 2003); (2) a Tertiary belt, located inland Mexico, grossly parallel to the mesozoic belt, made up by magnetite-hematite or hematite-rich deposits of Tertiary age (Corona-Esquivel 2000).

Traditionally, magnetite-dominated mesozoic deposits have been classified mainly as skarns (Peña Colorada, El Encino, El Encino, Aquila, Las Truchas). However, our revision indicates that true skarns (Cerro Nahuatl) coexist with IOCG's (Peña Colorada, Tritlla et al. 2003) in similar geological scenarios.

Tertiary deposits (La Perla, Chihuaha; Cerro de Mercado, Durango), on the contrary, were proposed to form after the upflow of iron rich magmas (Van Allen 1978; Lyons 1988), based mainly on textural evidences and field relationships.

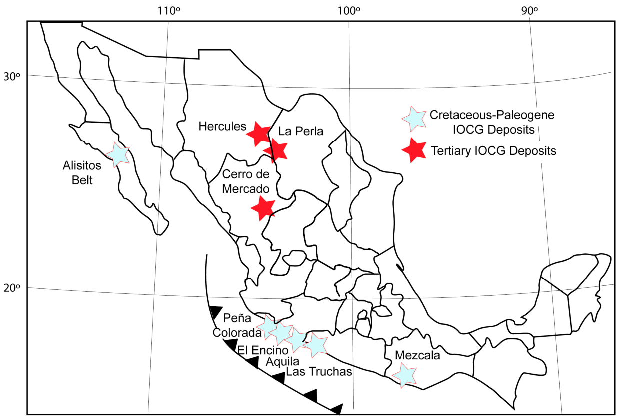

Figure 1. (A) Distribution of IOCG deposits in Mexico

2.1 Pacific Coast (Mesozoic) belt

This IOCG belt is defined by deposits located, from south to north, within the Guerrero (Nukay, Filos, Bermejal), Michoacán (Aquila, Las Truchas), Jalisco (El Encino, Chanquehahuil) and Colima (Peña Colorada, Las Pesadas) States (Corona-Esquivel 2000, 2007b; Tritlla et al. 2003) as well as in the Baja California Peninsula (Alisitos Belt, López et al. 2006). These deposits are mainly composed of magnetite, with minor quantities of sulfides (chalcopyrite, pyrite, pyrrothite) and fluorapatite. They have been mined exclusively for iron ore, and where no real exploration has been performed to look for other substances.

2.1.1 Mezcala (Guerrero State)

The Nukay/Filos/Bermejal gold district, is a Cretaceous to early Paleocene gold-rich IOCG system, closely associated with an adakitic to calco-alcaline magmatic event of ca. 63 Ma (ion-probe U/Pb on zircons; Levresse el al. 2004). Gold abundance in wall rock correlates very well with the composite thickness of the adjacent sills. The fluid inclusion analyses reveal an evolution from boiling magmatic brine to a diluted magmatic brine inferred to have mixed with meteoric water (Gonzalez et al. 2003)

Carbon and oxygen isotope analyses of the inner mineralizing area calcite (-10 to -11.6‰ and +13.2 to +14.6‰, respectively) suggest a magmatic signature of the mineralized fluid. Carbon and oxygen isotopes from the outer mineralizing area calcite (-8.8 to +3.4‰ and +12.9 to +22.8‰, respectively) suggest a complex mechanism of degassing and subsequent cooling/dilution of the resulting magmatic brine with the meteoric water (Levresse el al. 2004). Gold transport is related to the outflow of highly oxidized magmatic brines from the intrusion. The gold precipitation was triggered by cooling/dilution of the degassed magmatic brine by the meteoric fluids.

2.1.2 Peña Colorada (Colima State)

The iron ore bodies are hosted by the middle Cretaceous Tepalcatepec formation, with an overlying volcaniclastic unit, both of Albian age, and an upper conglomerate formation of Cenomanian age (Corona-Esquivel 2000). The lower clay and marl unit is locally intruded in the mine area by a granodiorite apofisis of the Manzanillo batholith (70-63 Ma, K-Ar, Schaaf et al. 1990) and by a Tertiary aplite dike complex.

The Peña Colorada iron deposit is made up of three different mineralized bodies: (1) an upper massive magnetite body, up to 20 meters thick, sub-concordant with the regional stratification, that contains decimetric to metric fragments of an older garnetite (grossular-andradite?) completely replaced by plumose K-feldspar; (2) a sub-horizontal, lower disseminated magnetite body, with a maximum thickness of 150 meters and made up by an alternating pyrite-magnetite-pyroxene-K-feldspar rock and (3) a mineralized diatreme, crosscutting the whole sequence (Tritlla et al. 2003), including some "pegmatitic" magnetite-apatite-pyroxene-bearing decimetric angular blocks.

Geochronology suggests two main mineralizing phases in Pena Colorada. The lower disseminated body appears to be the older, with an approximate age of 65.3 ±1.5 (2σ; K-Ar, Tritlla et al. 2003) to 63.3 ±0.8 (Ar-Ar, A. Iriondo, pers. comm.). The overlying main massive body is younger, with an age of 57.3±2.1 Ma (2σ; K-Ar, Tritlla et al. 2003) to 55.5±08 (2σ; Ar-Ar, A. Iriondo, pers. comm.). This data suggest that the deposits formed after recurrent mineralizing events during a 10 Ma time span.

2.2 Meseta (Tertiary) belt

This IOCG belt is defined by deposits located in the states of Durango (Cerro de Mercado; Lyons 1988; Corona-Esquivel et al. 2007a), Coahuila (Hércules; Corona-Esquivel 2000) and Chihuahua (La Perla; Van Allen 1978; Corona-Esquivel et al. 2007c). Theses ore deposits are located at the contact between the Sierra Madre Occidental volcanic province and the Laramide thrust and fold belt.

These deposits are mainly composed of magnetite, martite and hematite, with minor quantities of fluorapatite; no traces of Au or Cu have been reported so far. The presence of abundant martite after magnetite, coupled with episodes of argillic alteration, suggest that they formed in more surficial conditions than their older (Mesozoic) counterparts.

2.2.1 Cerro de Mercado (Durango State)

Cerro de Mercado ore deposit is located in the City of Durango (Durango State, Mexico). Lyons (1998) and Labarthe et al. (1990) indicate that this deposit is located within the Chupaderos Caldera, a large rhyolitic volcanic center of Oligocene age (30.8-30.1 Ma, Swanson et al. 1978).

The iron masses appear as massive lenses and breccias within the upper Members of the Cacaria Formation (Lyons 1988). At the present time, the mine workings allow to see that the emplacement of the deposit was controlled by the intersection of two faults of N-S and NE-SW directions that also host part of the breccia ore bodies. The massive bodies are conformable with the surrounding rhyolitic rocks, even though in some places they clearly cut and are cut by silicate-altered rocks. The different ore bodies present a fairly simple mineralogy, made up of magnetite, hematite, martite after magnetite, pyroxene and coarse apatite crystals with minor quartz and clays, and is surrounded by an aureole of argillic alteration. The age of the massive ore has been recently re-calculated by the (U-Th)/He method on the apatites to be 31.02 ± 0.22 Ma (McDowell et al. 2005).

2.2.2 LA Perla (Chihuahua State)

La Perla iron deposit is located in the Chihuahua State, in northern Mexico. It is composed mainly of hematite, with minor magnetite and apatite. The overall shape of the original deposit can be described as an elongated lens with down-dipping marginal parts, resembling a mushroom cap in cross-section. In detail, the unexploited deposit was composed of many individual lensoidal bodies, the largest being more than 400 m long and 50 m thick (Corona-Esquivel et al. 2010).

The iron deposit is hosted by a ca. 250 m thick pile of rhyodacitic lavas that is overlain by a lithic arkose. No radiometric data has been reported for the mineralization. The rhyodacite has been dated to between 31.5 ± 0.7 and 31.8 ± 0.5 Ma with the K/Ar method (Campbell 1977). A close relationship between ore and host rock suggests they are coeval and that therefore this age also is valid for the ore. Recently (Corona-Esquivel et al. 2010) well preserved palynomorphs and fungal spores were found intermingled with the unconsolidated, highly laminated powdery ore. The assemblage clearly indicates an Upper Oligocene-Lower Miocene age, in clear concordance with the rhyodacite radiometric ages. Moreover, the exines of the pollen grains are well preserved indicating that temperatures during the powdery ore accumulation did not exceed 150ºC. No signs of replacement have been found involving any kind of previous rock that could contain the spores. The whole suggests that pollen was scavenged in an ash-fall environment, perhaps in close relationship with some lacustrine environment, accounting for the primary kaolinite.

6 Discussions and conclusion

The deposits located within the Pacific Belt present characteristics of a deeper system with clear metasomatic bodies, no extrusive textures and, in Peña Colorada, episodes of reworking due to the formation of late explosive diatremes. Although more thorough work must be done on dating the different iron-rich bodies, these deposits seem to be associated with the Pacific coast batholith development, sharing similar ages.

The deposits scattered within the inland Meseta Belt are more surficial, distal and much younger equivalents of the Pacific Belt. Indeed, these Tertiary deposits present characteristics that suggest their formation in or near the surface, in close relationship with the latest magmatic pulses of the Sierra Madre Occidental Volcanic Province. At La Perla, for instance, Upper Oligocene-Miocene pollen was trapped by a relatively cold, martite-rich ash fall in a possible lacustrine environment.

So, at least two IOCG metallogenic epochs can be envisaged to occur in Mexico. Unraveling such a question is of great importance for future IOCG mining developments for IOCG deposits in Mexico, specially when some of the classic districts, as Mezcala, merit a deep revision in the light of new genetic ideas.

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