

Ordovician mineralizations in the Sistema de Famatina and Sierra de Velasco, northwestern Argentina

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Key words: Mineralization. Sierra de Velasco. Sistema de Famatina. Ordovician. NW Argentina.

Introduction

The Sistema de Famatina is located mainly in La Rioja province in the northwestern sector of Argentina. The Sistema de Famatina display N-S orientation being represented by metamorphites (Negro Peinado/La Aguadita Formations) of the Pampean Cycle (Aceñolaza and Toselli, 1981). The marine clastic and volcanoclastic sedimentary rocks, the volcanic-subvolcanic bodies of basic and acid composition and the widespread outcrops of granitoids belong to the Famatinian Cycle (Aceñolaza and Toselli, 1981).

The Sierra de Velasco is located eastwards of the Sistema de Famatina in La Rioja province. This is the largest orographic unit of the Sierras Pampeanas, nearly totally represented by Famatinian granitoids with porphyric and equigranular textures.

Epigenic mineralizations (Cu, Mo, W, Be) are recorded in the region related to the different magmatic units. These igneous manifestations are formed by a volcano-sedimentary sequences of El Chuschin Formation and the Ñuñorco and Paimán Granites in the Sistema de Famatina, and the Huaco Granite in the Sierra de Velasco (Figure1).

Deposits related to subvolcanic bodies

Two hydrothermal deposits have been recorded in the Sistema de Famatina. They were originated from subvolcanic activity of the El Chuschin Formation. These deposits are characterized by the shallow level of magma intrusion, fact that turns out to be an important condition to hydrothermal alteration development and base metals precipitation. Acid subvolcanic bodies are classified as calc-alkaline, peraluminous, and they are pertain to volcanic arc lavas originated by continental crust materials (Mannheim and Miller, 1996).

1. Miranda Sur

According to Peralta (1981), in the southern extreme of the Sierra de Famatina up to the Bordo Atravesado, a subvolcanic hydrothermal type occurrence of Ordovician-Devonian age mineralization is present. Two types of alteration can be distinguished: sericitic, with the highest values of Mo, and propylitic, where Cu and Pb sulphide, fluorite and barite exist and seem to respond to a hypogenic zonation. This mineralization type is related to shallow acid magmatism of the El Chuschin Formation that probably correspond to a volcanic arc.

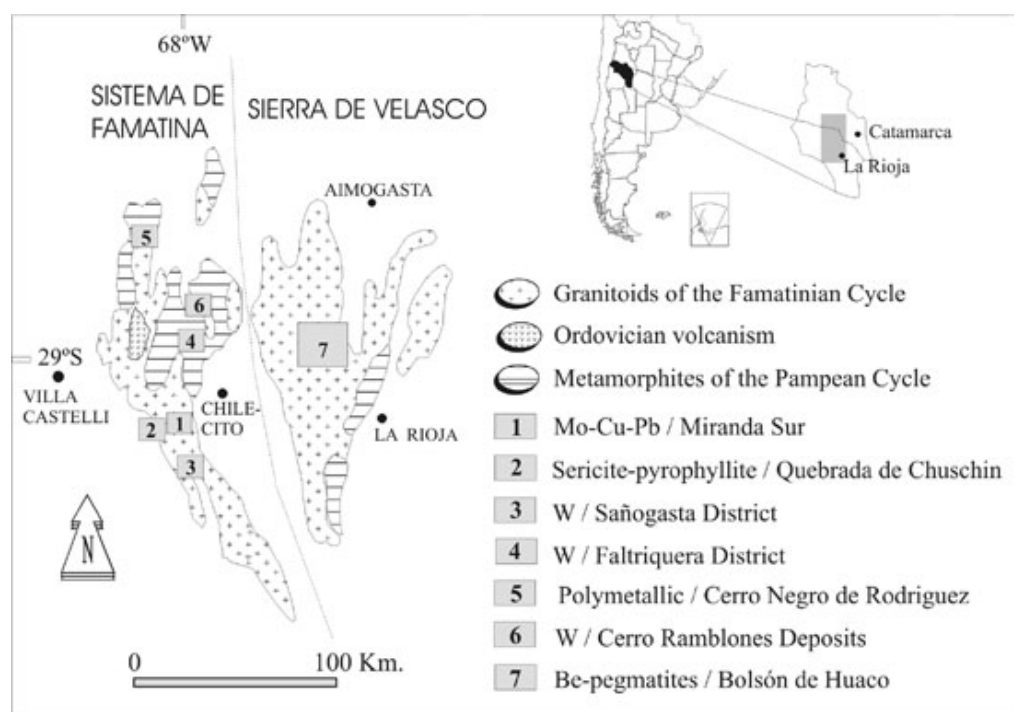


Figure 1. Simplified geological map of the area and location of mineralized deposits.

2. Quebrada de Chuschin

Between the Cosme and Chuschin creeks, in the southwestern sector of the Sierra de Famatina, a large elongated area of sericite-pyrophyllite is developed, as a result of hydrothermal alteration. This area is composed of a central zone with pyrophyllite, dickite, kaolinite and quartz, marginated by side to side rich sericite and quartz zones (Schalamuk *et al.*, 1981). According to Maiza *et al.* (1981) the host rock of the "Juanita del Puerto" deposit belong to this altered belt consist in a porphyritic rhyolite emplaced in the slates of the Negro Peinado Formation. The mineralization and geological setting of the deposit, are a strong evidence of the genetic interpretation related to subvolcanic hydrothermal phenomena produced by El Chuschin Formation.

Deposits related to granitoids

The Ñuñorco and Paimán Granites in the eastern sector of the Sistema de Famatina have generated essentially W-bearing deposits, with small amounts of Mo and Bi minerals. These deposits are vein-like type and are contained in the same granites or sometimes in their metamorphic host rocks. Granitoids show shallow crustal emplacements, related to convergent tectonic setting, displaying calc-alkaline trends and meta to peraluminous character. These units shown affinity with the magnetite-granite series of Ishihara (1977). Tungsten content in the original granitic magma may have increased by assimilation of the shaly host rock, with high amount of this element.

The U/Pb-zircon (SHRIMP) age obtained in a sample of the Ñuñorco granite in Cuesta de Miranda is 484.2 ± 4.7 Ma (Pankhurst *et al.*, 2000), while for the Paimán Granite the presence of Carboniferous sediments without deformation over mylonitized granites in the homonymous range indicates an older age for the deformative event, with famatinian age magmatism (Toselli *et al.*, 1996).

On the other hand, in Sierra de Velasco, the Huaco Granite is an S-type granite. It is leucocratic, with muscovite and biotite accessories, and geochemically are calc-alkaline and peraluminous (Chappell and White, 1974). However this granitoids corresponds to ilmenite-granite series (Ishihara, 1977) which developed an important amount of pegmatite bodies that beryl contains. Nevertheless, Pankhurst *et al.* (2000) indicate that the porphyritic facies (Huaco granite) of the Sierra de Velasco would have a Lower Ordovician crystallization age, and probably are originated in a continent-continent collision setting (Toselli *et al.*, 2000).

3. Sañogasta tungsten-bearing district

This area is located in the southern sector of the Sierra de Sañogasta and is formed by quartz veins filled fissures with tungsten-bearing minerals contained in the Ñuñorco Granite. The main mineral in the veins is wolframite, which appears in tabular crystals, sometimes grouped together, or forming radial aggregates; scheelite appears isolated, in smaller sizes than wolframite, or replacing it; molybdenite, pyrite, chalcopyrite and bismuthine are also present (Brodtkorb *et al.*, 1996).

4. Faltriquera tungsten-bearing district

This area consists of quartz-wolframite veins in low to very low grade metamorphites of the Negro Peinado Formation, eastwards of the Sierra de Famatina (Sardi, 1999). The Faltriquera deposit consists of parallel and subparallel veins concordant with the structure of host metamorphic rock. The hypogenic mineralogy is simple and scarce: tabular wolframite, very rarely acicular; yellow scheelite, pyrite, arsenopyrite and pyrrhotite (Sardi, 1999).

These last two tungsten-bearing areas (3 y 4) would have been originated by Ñuñorco Granite.

5. Cerro Negro de Rodríguez

This orographic unit is located north of the Sistema de Famatina, SW of Catamarca province. According to Avila (1981), the polymetallic occurrences in the western slope are associated genetically with the Ñuñorco Granite. These mineralizations consist of fine veins-like with Cu sulphides, galena, sphalerite, pyrite and supergene sulphides, which are in fault breccias of the Negro Peinado Formation. In addition, small veins of quartz with wolframite and molybdenite are present in the granite (Brodtkorb *et al.*, 1996). Distributed as setted, W and Mo minerals in quartz veins within the borders of granite and mineralizations of the Cu-Pb-Zn in the metamorphites, far away of the intrusive, may be interpreted as a mineral zonation produced by the Ñuñorco Granite.

6. Cerro Ramblones Deposits

This area consists mainly of quartz veins with magnetite, hematite, wolframite, pyrite and scheelite (Sardi, 1999) and are located in S and SW of the Cerro Ramblones (Sistema de Famatina). The quartz veins are contained either in the Paimán Granite or in their metamorphic (Negro Peinado/La Aguadita Formations) host rocks. Genetically, the deposits of Cerro Ramblones are related to Paimán Granite.

7. Bolsón de Huaco

The pegmatites from north of the Bolson de Huaco in the Sierra de Velasco, are known as the Velasco Pegmatitic District. The origin of these pegmatites is attributed to the Huaco Granite. The pegmatitic bodies are related to fluid rich granitoids that favored the concentration of minerals in the early referred bodies. Granite and pegmatites have coincidence with the features of the LCT (Li-Cs-Ta) family of rare-element pegmatites classification of Cerný (1991). According to many authors and own observations, these pegmatites have irregular shapes and most are zoned, displaying quartz-microcline, quartz-plagioclase and quartz zones. Minerals of these deposits, besides the already named, are: muscovite, biotite, beryl, garnet, columbite-tantalite, wolframite, tourmaline, spodumene, apatite, triplite and zircon.

Conclusions

The carried out observations allow to conclude that the deposits, metallic occurrences and zones of alteration are related to the Ordovician acid magmatism, which has different compositional characteristics and levels of intrusion.

The metallic deposits of the Sistema de Famatina are of hydrothermal origin. These deposits would be related to granites and volcanites intruding low grade metamorphic rocks of La Aguadita/Negro Peinado Formation, and would belong to the magnetite-granite series. Mineralizations of the Mo, Cu and Pb, and intense hydrothermal alteration were originated by subvolcanic bodies related to El Chuschin Formation, while the Ñuñorco and Paimán Granites generated W-bearing deposits.

On the other hand, in the Sierra de Velasco the beryl-bearing mineralization is of pegmatitic origin and it is developed in the Huaco Granite with characteristics of ilmenite-granite series.

Aknowledgements

Authors thank F. Aceñolaza, J. Avila, J. Rossi, S. Esteban, G. Aceñolaza and P. Grosse for the critical reading of this contribution. Line drawing were done by D. Ruiz Holgado who is kindly thanked.

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Received: February 15, 2003

Accepted: June 15, 2003