SILVER, GOLD, AND BASE METALS VEIN SYSTEMS AT SOUTHERN PART OF CORDILLERA DEL VIENTO, NEUQUÉN ARGENTINA

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The Andacollo district, the most important metalliferous mining district of the Neuquén province, extends over 220 km^2 with more than 56 Au, Ag and base metal (Cu, Pb, Zn) veins. This work is focused on cerro Las Minas and San Pedro areas, located at the south periclinal zone of the Cordillera del Viento anticline (CVA). Previous studies (Giacosa 2011, Strazzere *et al.* 2017 and references there in) have proposed that mineralization in this area is the result of at least two hydrothermal events of Carboniferous-Middle Triassic? and upper Cretaceous-Paleogene age. Here, we present new structural, geochronological, mineral chemistry (EDS and microprobe analyses), and textural data of the altered host-rocks and the mineralized structures of the two main vein systems (Buena Vista-San Pedro group, BVSPG, and Sofía-Torreón group, STG) in the district. Based on this data, we define new characteristics of the hydrothermal systems and constrain the mineralization events in the framework of the tectonic evolution of the area.

Volcaniclastic and marine rocks of the lower Carboniferous Arroyo del Torreón Formation (AT) and marine sedimentary rocks of the upper Carboniferous Huaraco Formation (both included in the Andacollo Group) are covered and intruded by ignimbrite and volcanoclastic rocks of the La Premia Formation (LP) and by cogenetic intrusives of the Huingancó Volcanic and Plutonic Complex (Permian-Lower Triassic). Previous units are separated by the regional huarpic unconformity from the overlying volcaniclastics rocks of Cordillera del Viento Formation (CDV, Medium to Upper Triassic in Giacosa 2011 and references there in). Numerous dacitic porphyritic dikes and andesitic-basaltic dikes cut the previous units. During the Gondwanide orogenesis, thrusts and folds structures of the San Rafael compressive phase deformed the Andacollo Group (Giacosa, 2011). Post-orogenic gondwanic structures are normal faults with E-W to NE-SW trend, related to an extensional stage that controlled deposition of a volcaniclastic sequence assigned to LP (Giacosa 2011). At the onset of the Patagonidic orogeny (Late Cretaceous-Paleogene), these faults were reactivated as transtensive and transpressive faults, in the periclinal zone of the CVA.

The BVSPG is hosted in the AT Formation. The San Pedro Norte (SPN) veins are situated in the hangingwall of an inverted N55ºE normal fault named here as El Maicillo fault, meanwhile San Pedro Sur (SPS) veins are located at the footwall of the El Maicillo fault, that shows dextral component of shear. Along this structure is emplaced a dacitic porphyritic dike with numerous mafic enclaves oriented parallel to the contact with wall rock.

In the BVSPG total resources of 63800 Oz AuEq and 1:100 Au/Ag ratios are estimated. Vein lengths vary from 50 to 300 m and 0.3 to 6 m, respectively, with vertical extension of 150-200 m. Underground mapping shows the dacitic porphyry dyke cuts the Buena Vista vein system at Cerro Minas area. The SPN veins are composed by multiple quartz, sericite (adularia) pulses. Quartz veins show coarse banded and crustiform textures typical of extensional and dilatational veins. Most of them are brecciated and cemented by gray quartz and late comb quartz. Main mineralization is hosted in the gray quartz and consist of early pyrite1±arsenopyrite and late pyrite2+iron-bearing sphalerite+chalcopyrite+galena, polybasite-pearceite+argentite±electrum (pyrargyrite, silver) and localized tetrahedrite-tennantite. Traces of enargite and covellite replace Cu-bearing sulfides. Preliminary analyses of fluid inclusions in gray quartz of SPN veins have homogenization temperatures between 225 and 255ºC and low salinities (<3% NaCl eq.). Wall rocks are intensely silicified and sericitized, grading into chloritic alteration 5 to 15 m away from the veins. Similar characteristics have been defining in Buena Vista veins by Pons *et al.* (2019).

The STG is hosted in the Huaraco and LP formations. The most important mineralized structures are Sofía and Julia with total resource of 22900 Oz AuEq., with high Au/Ag ratios (1:5). The veins are thin (<2.5 m thick) and have 150 to 250 m total lengths. The mineralized structures consist of multiple veins and veinlets: (1) scarce early quartz+pyrite+molybdenite+iron poor-sphalerite veinlets, (2) quartz+epidote+calcite±albite (apatite+rutile+titanite+light rare earth elements bearing phosphates) associated to quartz+biotite, epidote (actinolite)+chlorite+calcite, with pyrite+ pyrrhotite±chalcopyrite (iron rich-sphalerite), marcasite veins, that are cut and reopened by (3) polymetallic veins formed by quartz+sericite±carbonates (chlorite), with iron-rich sphalerite+silver rich-galena+chalcopyrite+pyrite, native gold±arsenopyrite (pyrrhotite, bornite, argentite). Pyrite (4) and carbonate+framboidal pyrite (5) veinlets cuts previous ones. Multistage carbonate generation brecciate and cross-cut previous veins. Quartz dominantly shows granular, comb textures and some calcites developed platy textures. Four types of alterations affected the host rock: (1) patches of early potassic alteration; (2) widespread propylitic alteration with disseminated pyrrhotite, chalcopyrite and pyrite; (3) later phyllic alteration; and (4) later supergene alteration. Pervasive intense phyllic and propylitc alteration affected also the dacitic porphyry dikes located along the E-W Sofía-Julia and El Maicillo fault.

New U-Pb zircon ages of two samples from volcaniclastics rocks previously assigned to LP Formation at Cerro Minas and Cerro San Pedro gave an age range between 196.69±1.15 to 191.36±0.85. These new data allow us to reassigned this sequences to the Jurassic CDV Formation. In consequence the E-W and NE-SW faults might have controlled the deposition of CDV during Sinemurian to Pliensbacchian. A U-Pb age of 68.46±0.31Ma was obtained from the altered dacitic porphyritic dike emplaced in the El Maicillo fault. It can be assigned to the Naunaco Late Cretaceous - Paleogene Andesitic Belt defined by Llambías y Aragón (2011).

The STG is controlled by E-W and ENE-WSW strike-slip faults which are the result of re-shearing of Jurassic normal faults, during the Patagonidic and Andean phase. Cross-cutting relationships indicate the strike-slip faults postdate some of the BVSPG veins (*e.g.* Don Fernando, vein). Other veins are located in thrust faults with N-S trend and E vergence that are related to the reactivation of normal fault (Fortuna thrust).

The E-W and NE-SW normal faults seems to have been the main channels for fluid migrations. The reactivation of NE trend structures along with the high competence of volcanoclastic rocks of the AT might have favored hydraulic fracturing and preferential fluid circulation and emplacement of the BVSPG extensional and dilatational veins. The fluids evolved in intermediate to low sulfidation (main silver mineralization) conditions with local variation in sulfur fugacity. The STG might have formed during the Patagonidic and Andean orogenesis, mostly controlled by previous normal faults without significant lithological control. Based on gangue and ore mineralogy, early fluids in STG were mesothermal, (>350ºC), alkaline with relatively high oxygen fugacity. Later epithermal fluids (main base metals and gold mineralization) had lower temperatures (<250ºC) and lower sulfur and oxygen fugacity. The differences in the style of the two vein systems, BVSPG and STG, could be due either to different emplacement levels modified during the Andean orogeny, or to the superposition of two unrelated hydrothermal systems. The new ages, and structural, alteration, paragenetic, and fluid inclusion data, suggest that BVSPG and STG could represent hydrothermal systems developed during the Lower Jurassic to Upper Cretaceous as was previously proposed by Stoll (1957). Mainly based on the age of the altered dacitic porphyritic dyke, ST hydrothermal system at the study area could be part of the Cretaceous-Paleogene Metalogenetic trend defined by Zappetini *et al.* (2021).

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