GEOCHEMISTRY OF PATRICIA Zn-Pb-Ag DEPOSIT (PAGUANTA, NE CHILE)

Darío Chinchilla[1,2], Raúl Merinero[1], Rubén Piña[1], Lorena Ortega[1], Rosario Lunar[1,2], Cecilio Quesada[3], Antonio Valverde[4]

1-Departamento de Cristalografía y Mineralogía, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Spain
2-Instituto de Geociencias (CSIC, UCM), Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Spain
3-Instituto Geológico y Minero de España (IGME), Madrid, Spain
4-Herencia Resources Plc. Compañia Minera Paguanta, Santiago de Chile, Chile

dchinchilla@geo.ucm.es

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GEOLOGICAL SETTING

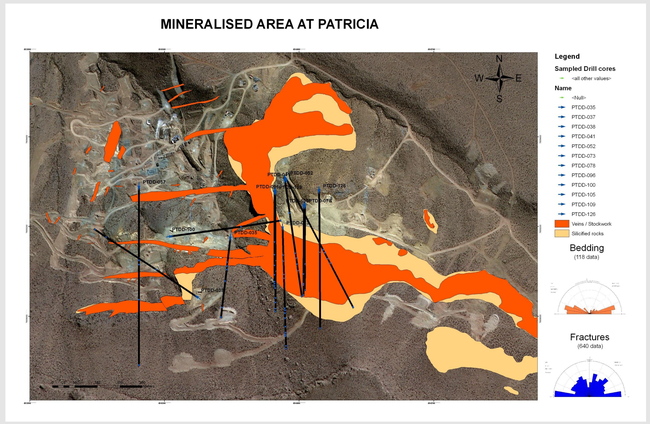
The Patricia Zn-Pb-Ag ore deposit (Paguanta mining project) is located at the northern end of the Andean Oligocene Porphyry Copper Belt of Chile, in the Tarapacá region (~ 150 km NE from Iquique and ~ 30 km from the border). This metallogenic belt is structurally controlled by the N-S-oriented Domeyko fault system and by the arc magmatic position, the obliquity of the plate convergence and the position and inclination of the subduction zone. These faults systems permits the ascent of magmas and the hydrothermal fluids circulation, enabling the formation of metal deposit.

The ore mineralization forms part of the Paguanta mining project that also includes other two prospects called, La Rosa and Doris. The Patricia Zn-Pb-Ag ore deposit represents economic mineralization (4.53 Mt with average grades of 3.7 % Zn, 1.3 % Pb, 83 g/t Ag and 0.2 g/t Au, www.herenciaresources.com) discovered by Herencia Resources Plc in 2006 during exploration over mine workings dating back to the nineteenth century.
Major mineralized structures occurs as subvertical E-W oriented veins comprising a well-developed stockwork. They are hosted by Upper Cretaceous to Middle Tertiary volcanic and volcaniclastic andesitic breccias with variable-sized clasts.

Schematic map showing the position of Paguanta in the Oligocene Porphyry Copper belt of Chile. Modified from Camus (2003).

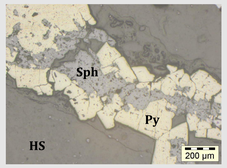
SAMPLING

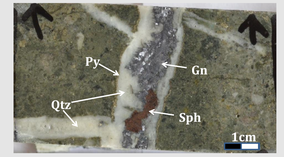
Samples examined in this study were collected from outcrops in the Patricia deposit. Several drill cores that cut the mineralized veins were also studied. Samples were studied by transmitted and reflected optical microscopy, as well as environmental scanning electron microscopy (ESEM) operated in backscattered electron mode. These microscopy analyses were followed by electron microprobe (EMP) studies. We carried out analyses of the whole rock of selected samples and drill cores by ICP/MS and XRF. Contents of major and trace elements were obtained. Least squares linear regression was applied to each pair of element showing linearity, normality and homoscedasticity.



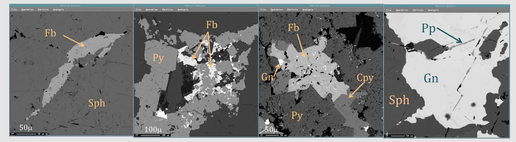
ORE MINERALOGY

The ore minerals in the veins comprise in order of abundance; (py) pyrite, (sph) sphalerite (5.5 - 10.89 wt % Fe, 9.8-19 % mol FeS and 0.52 wt % Cd), (gn) galena, arsenopyrite, (cpy) chalcopyrite and Ag-bearing sulfosalts. The veins show a zoned and banded internal structure with pyrite at the edges and sphalerite in the center or quartz at the edges and ore minerals in the center.





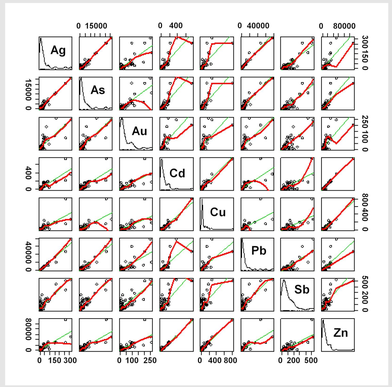
The Ag occurs mostly as Ag-Cu-Sb sulfosalts, in order of abundance: series freibergite – argentotennantite (Fb) , polybasite (Pp) and stephanite. Other minor Ag phases such as argentite, pyrargirite and diaphorite were also identified. These Ag phases are typically associated with the base-metal sulfides. Freibergite occurs filling voids within sphalerite, chalcopyrite and at the contact between sphalerite and galena. Polybasite, stephanite, pyrargirite and argentite are mostly in close association with freibergite. In the case of diaphorite, it commonly occurs filling voids between galena crystals or as inclusions within galena. Some minor Ag-bearing sulfosalts are also identified between pyrite crystals. Hydrothermal alteration of host rock consists of chlorite, illite and quartz. Apatite, rutile and Ca-Mn carbonates also occur as alteration minerals.



GEOCHEMYSTRY

We obtained linear correlation statistically significant only for Ag, As Au, Cd, Cu, Pb, Sb and Zn and therefore we generated an enhanced scatter plot matrix of these elements. Bulk rock analyses of drill cores show that Ag is strongly and positively correlated with Pb and As, moderately with Cd, Sb, Au and Zn and weakly with Cu, while Au is moderately and positively correlated with Ag, As, Cd, Sb and Zn and weakly with Cu and Pb. These results are consistent with bulk rock analyses of selected and mineralizated samples were similar correlations have been obtained.

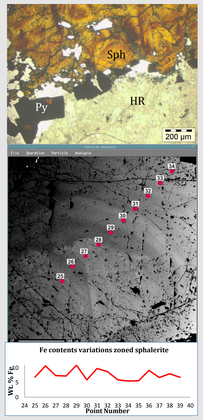
Ag positive correlations indicate that the formation of Ag-bearing minerals is mainly associated with galena, arsenopyrite and sphalerite occurrence. Au positive correlations indicate that this element occurs in close relationship with Ag-bearing minerals, arsenopyrite and sphalerite. The weak correlation between Cu and Ag and Au indicate that the formation of chalcopyrite is not related with the main stages of Ag-Au mineralization.
The main conclusion of this study is that geochemical analyses along drill cores that cut mineralization confirm that the occurrence of Ag and Au in the Paguanta deposit is associated with the formation of galena, arsenopyrite and sphalerite.



Matrix of scatter plot of Ag, As, Au, Cd, Cu, Pb, Sb and Zn. Least squares linear regression line (green) and nonparametric regression smooth line (red) is displayed in each scatter plot. Density plots of each element are also displayed down the diagonal. Units are ppm for all elements but ppb for Au.

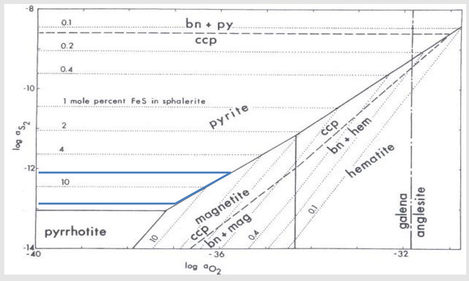
Pearson coefficients obtained for least squares linear regression of each pair of element

R^2	Ag	As	Au	Cd	Cu	Pb	Sb	Zn
Ag		0.95	0.66	0.72	0.59	0.96	0.77	0.66
As	0.95		0.71	0.74	0.61	0.91	0.67	0.70
Au	0.66	0.71		0.61	0.45	0.49	0.62	0.66
Cd	0.72	0.74	0.61		0.90	0.64	0.51	0.97
Cu	0.59	0.61	0.45	0.90		0.49	0.47	0.86
Pb	0.88	0.91	0.67	0.84	0.81		0.57	0.57
Sb	0.77	0.67	0.62	0.51	0.47	0.57		0.53
Zn	0.66	0.70	0.66	0.97	0.86	0.57	0.53	



SPHALERITE GEOCHEMISTRY

The sphalerite coexisting with pyrite exhibits variations in the Fe content (wt %) from 5.5 to 10.9% (9.8 to 19% FeS molar). According to the log aS_2 vs. log aO_2 plot, and given the pyrite and sphalerite textural relationships, the sphalerite would have precipitated from a fluid with values of log aS_2 ranging from -12 to -12.8 and values of log aO_2 lower than -36.



CONCLUSIONS

-The main conclusion of this study is that geochemical analyses along drill cores that cut mineralization confirm that the occurrence of Ag and Au in the Paguanta deposit is associated with the formation of galena, arsenopyrite and sphalerite.

-The lack of correlation between Fe and Ag-Au indicates that the Fe is not an exclusive element during the mineralization phase in which silver minerals are formed. Mineralogical studies indicate that pyrite is formed throughout the paragenetic sequence but Fe is present in more mineral phases including chalcopyrite and the alteration minerals.

-The alteration assemblage indicates near-neutral pH conditions during regional propylitic alteration, and more acid conditions during the mineralizing event. The presence of carbonates cross-cutting previous alteration indicates neutral-alkaline pH at the end of the process.

-Ore precipitation occurred in different pulses, with variation of Fe as it could be seen in zoned sphalerite.

-Pyrite and shalerite are not only texturally related . According to the log aS2 vs. log aO2 plot, the molar percent FeS present in sphalerite is within pyrite field, so the sphalerite would precipitate from a fluid with values of log aS2 ranging from -12 to -12.8 and values of log aO2 lower than -36.

-Acid conditions and fluids with values of aO2 lower than -36 confirm that the precipitation of metal ores are carried out by complex chlorinated.

-Patricia Pb-Zn-Ag ore deposit probably represents an example of epithermal mineralization of intermediate sulfidation state, with periods of lower sulfidation state during sphalerite deposition.