

Trace-Metal Content of the Cerro Quema High Sulfidation Epithermal Au-Cu Deposit (Azüero Península, Panama)

/ ISAAC CORRAL (*), MERCÈ CORBELLA, ALBERT GRIERA, DAVID GÓMEZ-GRAS, ESTEVE CARDELLACH

Departament de Geologia, Unitat de Cristal·lografia i Mineralogía. Universitat Autònoma de Barcelona. 08193, Barcelona (Espanya).

INTRODUCTION

The trace element abundance and distribution in ore deposits is important because ore deposits contain anomalies for many elements other than those which are mined (Kesler et al., 2003). Trace element distribution may help to understand the genetic processes and evolution of an ore deposit, and can be used as a powerful exploration tool.

Geochemical data of trace elements in high sulfidation epithermal deposits are not abundant (e. g., Nansatsu, Japan, Hedenquist et al., 1994; Rodalquilar, Spain, Hernández et al., 1989; Pueblo Viejo, Dominican Republic, Kesler et al., 2003). In this study we present the first trace element data from the Cerro Quema Au-Cu high sulfidation epithermal deposit (Panama). The present work is based on analyses of Au, Ag, Cd, Cu, Ni, Pb, Zn, S, As, Ba, Sb, Mn, Hg and W from surface and drill core samples of the deposit. Our aim is to know the trace element concentration, distribution and association in order to be used as an exploration tool.

GEOLOGIC SETTING

The Cerro Quema Au-Cu deposit is located in the Azüero Peninsula, SW Panama (Fig. 1). The deposit is constituted by several mineable bodies named (from East to West) Cerro Quema, Cerro Quemita and La Pava. The estimated total resources of 7.23 Mt with an average gold grade of 1.10 g/t,

containing 256.000 oz of Au in La Pava ore body (Valiant et al., 2011).

Panama constitutes a microplate situated in South Central America. It is the youngest segment of the landbridge between the North and South American Plates.

The geology of Panama is conditioned by a subduction zone of the Cocos and Nazca plates beneath the Caribbean plate and its consequent arc magmatism, since Cretaceous times to present. The Cerro Quema deposit is hosted by the fore-arc basin rocks of the Cretaceous volcanic arc (Corral et al., 2012).

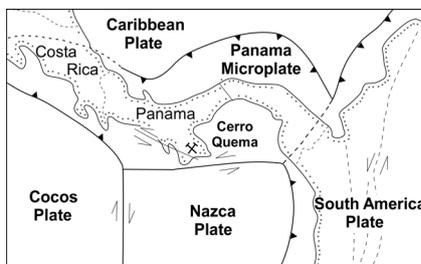


Fig. 1. Location of the Cerro Quema Au-Cu deposit, adapted from Corral et al. (2011).

Cerro Quema is a fault controlled high sulfidation deposit, hosted by a dacite dome complex, which intruded in a submarine volcanosedimentary sequence (Río Quema Formation; Corral et al., 2011, 2012).

As usual in epithermal systems, a hydrothermal alteration characterizes

the Cerro Quema deposit. This alteration developed concentric halos in the host rock, following E-W trending regional faults. The hydrothermal alteration is composed of vuggy silica, advanced argillic, argillic and finally propylitic alteration zones. Moreover, a supergene alteration process due to weathering also affects the deposit, developing a silicified and oxidized lithocap up to 150m thick.

METHODOLOGY

Samples of the present study correspond to the vuggy silica and the advanced argillic alteration zones. 35 surface and drill core samples were selected and analyzed at Activation Laboratories (Canada). 30g of each sample were analyzed by INAA and ICP.

In order to better observe the enrichment, distribution and association of trace elements in the Cerro Quema deposit, we have discriminated the analyses according to the alteration type. Thus, we report concentrations of trace elements in the oxide zone (affected by supergene alteration) and the sulfide zone (affected by hypogene alteration).

TRACE ELEMENT CONCENTRATION AND DISTRIBUTION

The elemental average concentrations of Au, Ag, Cd, Cu, Ni, Pb, Zn, As, Ba, Sb and W, in the two alteration zones, are reported in Table 1. Other elements such

	Au	Ag	Cd	Cu	Ni	Pb	Zn	As	Ba	Sb	W
Sulfide zone average	289	0.4	2	12023	7.4	43.4	51.6	2536	34137	19.3	273
Sulfide enrichment degree	48	2	8	6	0.5	17.	1	2029	124	97	1
Oxide zone average	698	0.5	1	737	2.7	80.8	5.8	765	3250	40.8	238
Oxide enrichment degree	116	2	4	4	0.2	32	0.1	612	12	204	0.6

Table 1. Average concentration of elements in ore samples and enrichment with respect to country rocks in the Cerro Quema deposit. Concentrations are expressed in ppm except for gold which is expressed in ppb

palabras clave: Elementos traza, Alta sulfuración, Oro-Cobre, Cerro Quema, Panamá **key words:** Trace element, High sulfidation, Gold-Coper, Cerro Quema, Panama.

as Mn and Hg were also analyzed but their abundance is below the detection limits.

An indication of the enrichment degree is shown by comparing the average concentration of each element in the two zones respect to the average concentration of that element in diorites and quartz diorites of the area, with which the mineralization is probably genetically associated.

Although Au and Cu are the elements of mining interest, the highest enrichment degree is showed by As and Ba. However, Au and Sb also show a high enrichment degree. Other elements such as Ag, Ni, Zn and W are poorly enriched or present in a non significant enrichment degree in comparison with the country rocks.

The average concentration of Cd, Cu, As, and Ba is higher in the samples from the sulfide zone than in those of the oxide zone. Nevertheless, in average, Au, Ag, Pb and Sb appear more concentrated in the oxide zone (Table 1).

Correlation coefficients (not shown) are used to define element affinities as well as mineral correlation. Fig. 2 shows the most significant correlations among the analyzed elements. A positive correlation between Cu and As is clear in the sulfide zone samples, and seems consistent with the analyses of the oxide zone, as well. Au and Ba seem to be positively correlated, although the scatter of data is large. Cu and Au do not present a clear correlation.

DISCUSSION AND CONCLUSIONS

Although Au is more concentrated in the oxide zone, its correlation with Ba, present as barite, suggests the precipitation of gold at the redox interface where reduced fluids of magmatic origin were oxidized.

Gold in the Cerro Quema deposit is found as invisible gold (Corral et al., 2011), within the pyrite lattice. Therefore, it was easily concentrated in the oxide zone due to the weathering (oxidation) of pyrite.

The high Ba enrichment in the sulfide zone (124 times) implies that Ba was introduced by the mineralizing fluids. It may have also been liberated from feldspars during advanced argillic alteration. This contrasts with what

occurs in Nantsatsu (Hedenquist et al., 1994) and Pueblo Viejo (Kesler et al., 2003).

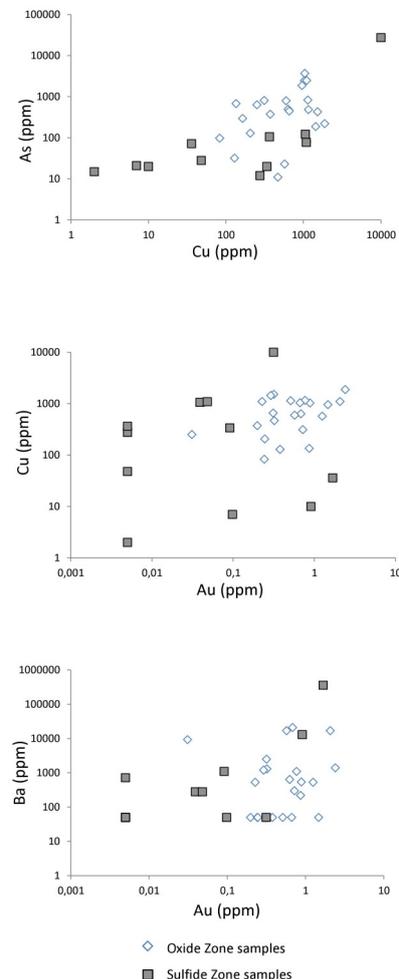


fig 2. Concentration plots showing correlation between copper and arsenic, gold and copper, and between gold and barium.

Correlation between Cu and As must be due to the presence of enargite-luzonite, bornite and tennantite in the Cerro Quema deposit. Cu is also associated with weathering, which produced the precipitation of secondary copper sulfides (chalcocite and covellite) below the redox boundary, increasing the Cu grade. Minor Zn and Pb enrichment is related to the presence of sphalerite and galena dissemination and as trace mineral in veins.

Hg is commonly partitioned into a rising vapor phase by boiling (Barnes and Seward, 1997). In this study only two samples have detectable concentration of Hg (11 and 8ppm). This scarcity suggests that the upper part of the system, where evidences of boiling are usually found, has been eroded. Thus, what we see today probably corresponds

to the remaining deep part of the hydrothermal system.

Gold exploration should be focused in the parts of the oxide zone where the barium anomaly is high. On the other hand, copper exploration should be centered in the sulfide zone, below the redox boundary, where the primary copper sulfides (enargite-luzonite, bornite and tennantite) and secondary copper sulfides (chalcocite, covellite) are present.

ACKNOWLEDGMENTS

This study was supported by the Spanish Ministry of Science and Education (MEC) project CGL2007-6269/BTE, a predoctoral grant of the "Departament d'Universitats, Recerca i Societat de la Informació" (Generalitat de Catalunya) and by the Society of Economic Geologists Foundation (SEGF) student research grants (Hugh E. McKinstry, 2009, 2010 and 2011).

REFERENCES

Barnes, H.L. & Seward, T.M. (1997): *The stability of Au-chloride complexes in water vapor at elevated temperatures and pressures. Geochim. Cosmochim. Acta.*, **65**, 4413-4423.

Corral, I., Gómez-Gras, D., Griera, A., Corbella, M., Cardellach, E. (2012): *Sedimentation and volcanism in the Panamanian Cretaceous intra-oceanic arc and fore-arc: New insights from the Azuero Peninsula (SW Panama). B. Soc. Geol. Fr.*, accepted.

Corral, I., Griera, A., Gómez-Gras, D., Corbella, M., Canals, À., Pineda-Falconett, M., Cardellach, E. (2011): *Geology of the Cerro Quema Au-Cu deposit (Azuero Peninsula, Panama). Geol. Acta.*, **9** (3-4), 481-498.

Hedenquist, J.A., Matsuhisa, Y., Izawa, E., White, H.C., Giggenbach, W.F., Oaki, M. (1994): *Geology, geochemistry, and origin of high sulfidation Au mineralization in the Nantsatsu district, Japan. Econ. Geol.* **89**, 1-30.

Hernández, P.A., García-Estrada, P.A., Cowley, P.N. (1989): *Geological setting, alteration and lithogeochemistry of the Transacción epithermal gold deposit, Rodalquilar mining district, Southeast Spain. Inst. Mining Metall. Trans. Sect. B* **98**, 78-80.

Kesler, S.E., Russell, N., McCurdy. (2003): *Trace-metal content of the Pueblo Viejo precious-metal deposits and their relation to other high-sulfidation epithermal systems. Miner. Deposita.* **38**, 668-682.

Valiant, W.W., Collins, S.E., Krutzmann, H. (2011): *Technical report on the Cerro Quema Project, Panama, prepared for Pershimco Resources Inc., by Scott Wilson Roscoe Postle Associates Inc., January 14, 2011, 109 p.*