Mineralogy of Doña Amanda Prospect, Bayaguana, Dom. Rep.: a transitional epithermal-porphyry deposit in Los Ranchos Formation?

/ LISARD TORRÓ I ABAT (1), PAULO LEÓN BENAVIDES (2), JOAQUÍN A. PROENZA FERNÁNDEZ (1), JÚLIA FARRÉ DE PABLO (1), JOAN CARLES MELGAREJO I DRAPER (1), ELÍAS REYES (2), CEVERO CHÁVEZ (2), JOHN F. LEWIS (3)*

(1) Departament de Crisal·lografia, Mineralogia i Dipòsits Minerals, Facultat de Geologia, Universitat de Barcelona. C/ Martí i Franqués s/n Barcelona, Catalonia, Spain

(2) Corporación Minera Dominicana. Av. Máximo Gómez, 29B, Ed. Plaza Gazcue, local 401. Santo Domingo, Dominican Republic

(3) Department of Earth and Environmental Sciences, George Washington University, Washington, DC 20052, USA

INTRODUCTION

The Bayaguana concessions are situated about 65 kilometers northeast of Santo Domingo, and 5 kilometers north of the town of Bayaguana (Fig. 1). Perilya/ Cormidom is currently developing an extensive exploration program that follows previous efforts commenced by the Dominican Mining Department and Falconbridge in the 80's. Current inferred reserves reported by the company in the different concessions include Cerro Kiosco (4.36 MT @ 2.01 g/t Au, 5.17 g/t Ag, 0.98% Cu), Doña Amanda (127.77 MT @ 0.31% Cu, 1.43 g/t Ag, 0.19 g/t Au) and Doña Loretta (8.20 MT @ 0.50% Cu, 0.3 g/t Au) (Perilya, 2012).

Ore hosting rocks in Perilya's concessions in Bayaguana are part of the *Los Ranchos* Formation (Kesler et al., 2005). This formation also hosts the world-class Au-Ag-Cu Pueblo Viejo deposit (Fig. 1), operated by Barrick and which produced 488,000 ounces of gold in 2013 and had proven and probable reserves of this metal of 9.7 million ounces in April 2014 (Barrick, 2014). The origin of the Pueblo Viejo deposit is still controversial (Nelson et al., 2011).

Here we present a detailed mineralogical and textural study of mineralized samples from the Doña Amanda prospect. Ore and alteration mineral assemblages are used to classify the deposit and to assess similarities and differences from those present at the Pueblo Viejo deposit.

GEOLOGICAL SETTING

The late Early Cretaceous–Eocene Circum-Caribbean island-arc system is a complex collage of crustal units which were initially formed in an intra-oceanic setting during Early Cretaceous (Pindell & Barrett, 1990).

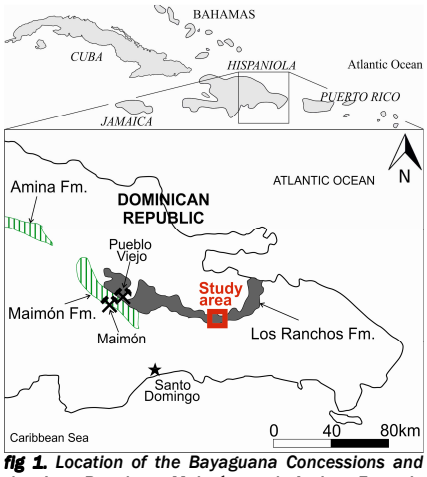

fig 1. *Location of the Bayaguana Concessions and the Los Ranchos, Maimón and Amina Fms. in Hispaniola.*

Host rocks at Bayaguana prospect areas belong to the Early Cretaceous Los Ranchos Fm. This unit forms part of the oldest and chemically most primitive island-arc in the Caribbean region. It is composed of LREE-depleted tholeiitic island arc basalts and normal island arc tholeiites with an interval of felsic volcanism and tonalitic plutonism dated at 110-118 Ma (Escuder-Viruete et al., 2007).

In Bayaguana concessions, geology is dominated by 1) variably amygdaloidal, clinopyroxene- and plagioclase-phyric microcrystalline to glassy groundmass basalt and basaltic andesite flows; 2) quartz-phyric dacite to rhyolite domes and 3) volcaniclastic/sedimentary sequences including hyaloclastites and turbiditic deposits. All samples display strong negative Nb anomalies with low LREE/HREE ratios, indicating a subduction-related origin, in an intraoceanic arc setting (Hawkestorn et al., 1993). Mafic samples display low TiO_2 contents, from 0.35 to 0.74 wt. %; similar minor and trace element geochemistry is described by Escuder-Viruete et al. (2006) as low-Ti tholeiites and boninites for the Los Ranchos Fm. in the Cevicos-Miches area.

MINERALOGY STUDY

Mineralogy was studied by optical and scanning (SEM-EDS) microscopy and XRD. Studied rocks are in general pervasively altered. However, a few less altered samples partially preserve original mineralogy; that includes millimeter to sub-millimeter-sized plagioclase and clinopyroxene euhedral crystals commonly displaying polysynthetic lamellae. Clinopyroxenes are apparently of augite-diopside. Variable proportions of phenocrysts are included in a fine grained plagioclase and minor pyroxene or alternatively glassy groundmass.

Alteration assemblage flooding the original rock is commonly composed of quartz, kaolinite, sericite-white mica and minor barite, alunite supergroup minerals (Fig. 2) and tourmaline. Quartz occurs as small cloudy anhedral crystals with sizes commonly among 50 and 250 microns, locally displaying granoblastic textures. Kaolinite (not rarely recrystallized to feather-shaped pyrophyllite) tends to appear forming millimeter-sized massive patches of minute acicular crystal radial aggregates. Small sericite-white mica bundles of minute acicular crystals are observed decussately distributed along with quartz as well as concentrated as a

palabras clave: Epitermal, Alta Sulfuración, Formación Los Ranchos, República Dominicana, Bayaguana, Pueblo Viejo

key words: Epithermal, High Sulfidation, Los Ranchos Formation, Dominican Republic, Bayaguana, Pueblo Viejo

* corresponding author: **lisardtorro@hotmail.com**

replacement product of plagioclase in those samples preserving this phase. Tourmaline is rare and appears forming small radial aggregates of acicular crystals. Subeuhedral tabular to platy crystals of natroalunite [$(Na,K)Al_3(SO_4)_2(OH)_6$] appear with variable irregular replacements of woodhouseite [$CaAl_3(PO_4)(SO_4)(OH)_6$]. Individual platy to completely anhedral crystals of woodhouseite present in turn variable grades of replacement by svanbergite [$SrAl_3(PO_4)(SO_4)(OH)_6$] and intermediate compositions among woodhouseite and weilerite [$BaAl_3(AsO_4)(SO_4)(OH)_6$] end members, with systematically lower Ba than Ca contents.

Sulfide and to a lesser extent sulfosalts are the main ore minerals in Bayaguana studied samples, occurring both scattered and/or as vein-forming. Pyrite is by far the most abundant sulfide scattered in the rock, commonly forming submillimeter-sized rounded to sub-angular, occasionally sub-euhedral, grains along with minor chalcopyrite, enargite and sphalerite; pyrite grains are commonly fractured and variably corroded and contain fairly abundant chalcopyrite, enargite, sphalerite, covellite, rutile and gangue inclusions and infillings. Scant galena, stannite, acanthite and stibnite minute crystals or infillings of a few micrometers occur.

Complex veining is a common feature in Doña Amanda samples. A diversity of vein types is described, with an apparent chronology from observed crosscutting relations, as follows: 1) massive quartz; 2) quartz with suture and rims of sulfide (Fig. 3); although pyrite is the main sulfide, this vein type presents remarkable concentrations, especially in rims, of molybdenite and enargite, the last partially replaced by goldfieldite [$Cu_{12}(Te,Sb,As)_4S_{13}$]; 3) kaolinite and pyrite-kaolinite; 4) massive pyrite with subordinated quartz; 5) woodhouseite and 6) woodhouseite with extremely elongated pyrite grains. Crosscutting relations of type 6 were not observed, nor those of types 5 and 6.

DISCUSSION AND CONCLUSIONS

The bulk of the described alteration and ore mineral assemblages are typical of high sulfidation epithermal deposits (White & Hedenquist, 1990). However, presence of central sutured stringers with molybdenite-chalcopyrite inevitably recalls B-type veins described in many porphyry Cu-Mo deposits (Sillitoe, 2010).

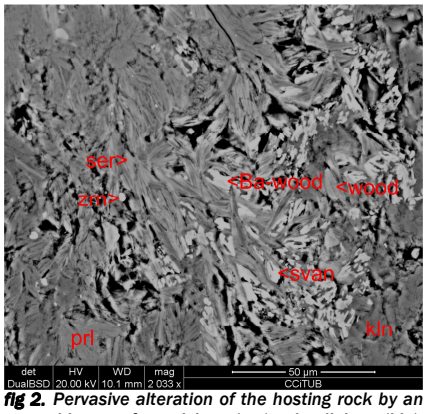

fig 2. *Pervasive alteration of the hosting rock by an assemblage of sericite (ser), kaolinite (kln)-pyrophyllite (prl), woodhouseite (wood) and svanbergite (svan). SEM-BSE image.*

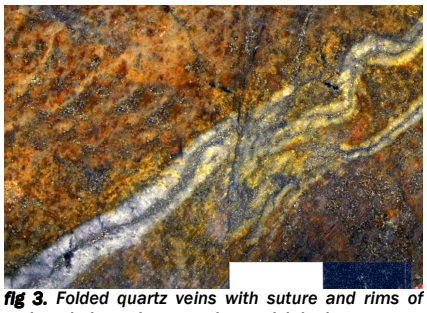

fig 3. *Folded quartz veins with suture and rims of pyrite+chalcopyrite+enargite+molybdenite cut a pervasively silicified and sulfidized rock.*

These observations suggest an overprinting or telescoping of both mineralization styles in the studied drill cores. In addition to that, diversity of veins and veining chronology here established points to a complex thermal evolution of the mineralization.

Setting aside differences in ore grades, practically identical ore and alteration assemblages were described by Muntean et al. (1990) for Monte Negro Deposit (Pueblo Viejo). These authors described two stages of alteration and mineralization, the 1st related to advanced argillic alteration and disseminated ore deposition and the 2nd to high grade veining. Although molybdenite is not described in Pueblo Viejo deposits, it was recently detected in drill cores outside the mine area over the western limit of Pueblo Viejo concession.

Doña Amanda classification as epithermal (transitional to porphyry) would support the idea that Los Ranchos Fm. preferably hosts this deposit type whereas the Maimón Fm. (Fig. 1) tends to host VMS mineralization style (Nelson et al., 2011).

The results from this research support the view that Bayaguana is a further case of a porphyry-epithermal deposit related to tholeiitic magmatism in the Los Ranchos belt (Kesler et a., 2005).

ACKNOWLEDGEMENTS

L.T.' fieldwork in the Dominican Republic was partially founded by a Student Grant from the SEG (Society of Economic Geologists) – Hugh E. McKinstry Foundation. This research has been financially supported by the Spanish project CGL2012-36263 and a FPU Ph.D. grant to L.T. by the Ministerio de Educación of the Spanish Government.

REFERENCES

Barrick (2014): Pueblo Viejo operations. http://www.barrick.com/operations/dominican-republic/pueblo-viejo/default.aspx *[consult: 25 May 2014].*

Escuder-Viruete, J., Díaz de Neira, A., Hernaiz Huerta, P. P., Monthel, J., García-Senz, J., Joubert, M., Lopera, E., Ullrich, T., Friedman, R., Mortensen, D., Pérez-Estaún, A. (2006): Magmatic relationships and ages of Caribbean Island arc tholeiites, boninites and related felsic rocks, Dominican Republic. Lithos, ***90****, 161-186.*

Hawkestorn, C. .J., Gallagher, K., Hergt, J. M., McDermott, F. (1993): Mantle and s contributions in arc magma. Annual Review of Earth and Planetary Sciences, ***21****, 175-204.*

Kesler, S. E., Campbell, I. H., Allen, C. M. (2005): Age of the Los Ranchos Formation, Dominican Republic: Timing and tectonic setting of primitive island arc volcanism in the Caribbean region. Geol. Soc. Am. Bull., ***117****, 987-995.*

Muntean, J. L., Kesler, E. K., Russell, N., Polanco, J. (1990): Evolution of the Monte Negro Acid Sulfate Au-Ag Deposit, Pueblo Viejo, Dominican Republic: Important Factors in Grade Development. Econ. Geol., ***85****, 1738-1758.*

Nelson, C. E., Proenza, J. A., Lewis, J. F., López-Kramer, J. (2011): The metalogenetic evolution of the Greater Antilles. Geol. Acta, ***9****, 229-264.*

Perilya (2012): Bayaguana Concessions. http://www.perilya.com.au/our-business/exploration/dominican/bayaguana-concessions *[consult: 25 May 2014].*

Pindell, J. K., Barrett, S. F. (1990): Geological Evolution of the Caribbean region: A plate-tectonic Caribbean Region. Geol. Soc. Am., Geology of North America, H, 405-432.

Sillitoe, R.H. (2010): Porphyry Copper Systems. Econ. Geol., ***105****,3-41.*

White, N. C., Hedenquist, J. W. (1990): Epithermal environments and styles of mineralization: variations and their causes, and guidelines for exploration. J. Geochem. Explor., ***36****, 445-474.*