

A NEW SKORPION IN PERU: THE ACCHA NONSULFIDE ZINC DEPOSIT

Boni M¹, Balassone G.¹, McCunn G.², Arseneau V.², Schmidt P.³

¹ Dipartimento Scienze della Terra, Università di Napoli, Italy (boni@unina.it)

² Zincore Metals Ltd. Vancouver, Canada ³ PRS Associates Mississauga, ON Canada

INTRODUCTION

The recovery of zinc in nonsulfide ores (also called “Zn oxides”), and therefore their economic value, is dependent not only on the geological knowledge of each deposit, but mainly on the specific characteristics of the mineralogical association of zinc and gangue minerals (de Wet and Singleton 2008). As extraction testwork has shown that certain structures and distributions of the various minerals can impede the economic differential extraction of the zinc minerals, research on the mineralogy and petrography of these types of ores has therefore been found to be of considerable importance for their evaluation. In fact, seemingly ‘rich’ zinc deposits such as Accha have been largely neglected by zinc producers as no economical extraction methods were available only a decade ago.

Accha is a nonsulfide Zn(Pb) deposit (indicated resources 5.1 Mt @ 8.2% Zn and 0.9% Pb) currently owned by Zincore Metals, located in the 30-km long Accha-Yanque belt in Peru, approximately 70 km south of the city of Cuzco (Fig. 1). After the classification of Hitzman et al. (2003), the Accha ores can be assigned to both “Direct Replacement” and “Wall Rock Replacement” types. At the southwestern extremity of the belt, the Yanque deposit occurs, where Pb minerals prevail over Zn non-sulfides. The climate (temperate and arid to semi-arid) had a direct effect upon the weathering profile in the Accha-Yanque belt and on the supergene minerals that have been formed. A thorough mineralogical and petrographic examination has been carried out on the Accha orebody, whose results will be briefly reported here.



Figure 1. Schematic map of Zincore properties and location of the Accha deposit (from Zincore Metals web page)

LOCAL GEOLOGICAL SETTING

The geological setting at Accha has been firstly described by Carman et al. (2000), Hudson et al. (2000) and then summarized by Winter (2006). Recent mapping conducted by Zincore (Marsden 2006) offers new insights into local geology. The ores are hosted by the Mesozoic sediments of the Pucará Basin. The basal units of the basin in the area belong to the Jurassic-Cretaceous Yura Group, which is unconformably overlain by the Middle to Upper Cretaceous limestone of the Ferrobamba Fm, host of the mineralization.

The Mesozoic sediments have been intruded by the Apurimac batholith believed to be Oligocene in age. The Puno Group sandstones and conglomerates of probable Oligocene-Miocene age are more than 1.5 km thick in the region, and unconformably overlie the Mesozoic rocks. The fold-thrust belt in the Cuzco region has a regional northwest-southeast structural grain, developed by the early-mid Tertiary northwest-southeast compression (Winter 2006). The main tectonic lineaments in the Accha area, however, are characterized by a change in direction from northwest-southeast to east-west. This is due to the interference effect between the intrusive body of the Apurimac batholith and the crustal scale easterly-trending basement structure.

Of major geological importance in the mining district are (1) the Ferrobamba Fm (mainly consisting of carbonates), (2) the Puno Group detrital succession and (3) the Tertiary magmatites.

(1) FERROBAMBA FORMATION LIMESTONE

The Ferrobamba limestones are subdivided into six main lithological units (Winter 2006, Marsden 2006):

- a. thin bedded to laminated limestone and limestone breccia with interbeds of massive limestone.
- b. thin bedded, commonly dark, laminated limestone with 2-10m thick interbeds of massive limestone.

This unit appears to be about 80-100 m thick;

c. massive to thick bedded micritic limestone. This is a massive limestone unit with poorly defined bedding. The unit is roughly 120 m thick;

d. cherty limestone up to 140 m thick. This unit consists of medium to thick bedded limestone with chert layers, nodular chert and massive micrite interbeds;

e. thin to medium bedded dark limestone (about 20 m) with minor chert nodules and local interbeds of massive limestone;

f. medium bedded micritic limestone, characterized by patchy yellow dolomite/ankerite alteration. The top section of this unit has not been observed, except where unconformably overlain by the Puno Group.

(2) PUNO GROUP CONGLOMERATE

Coarse haeterolithic conglomerate with polymictic intrusive clasts, limestone and quartzite. Matrix and interbeds of red mud-supported sandstone to breccia.

(3) MAGMATIC ROCKS

The Tertiary Apurimac batholith is dioritic to granodioritic in composition. It consists mainly of intrusive magmatites, with a minor contribution of porphyry stocks and tuffitic products. The most common magmatic rocks in the Accha district are:

- a. hornblende-feldspar porphyry stocks;
- b. feldspar porphyry and quartz-feldspar porphyry.

The nearest major intrusion to the Accha deposit occurs about 4 km to the south.

DEPOSIT TYPE

The primary sulfide mineralization at Accha should be considered as a syntectonic replacement type (MVT/CRD), related to the Tertiary igneous activity and strongly controlled by the local tectonic setting (brecciation in the limestone is associated to two major thrust faults). Primary sulfides consisted of sphalerite-pyrite>galena. Currently the Zn mineralization is almost fully oxidized and is amenable to be processed by solvent extraction and electrowinning, using special process conditions developed over the last decade and now successfully practiced by Anglo-American zinc refinery in Namibia and currently under advanced development by Zincore Metals. The economic mineralization consists of a laminated, highly porous, brown to yellow-brown lithotype, containing Fe(hydr)oxides and banded nonsulfide Zn minerals. Stockwork- to isolated pods of iron oxides and zinc mineralization are also present throughout the sequence. Due to the intense oxidation in surface outcrops, however, the primary mineral textures are difficult to decipher. Sulfides are very rare, but galena with associated anglesite is locally present.

The more massive mineralization is concentrated in the a. and b. carbonate units of the Ferrobamba Fm. It

is well ascertained that the mineralized bodies are contained within strongly brecciated stratabound horizons (Fig. 2) pertaining to the mentioned units, whose total thickness can range between 50 and 100 m. The breccias are poorly sorted, polymictic (consisting of angular/sub-rounded limestone and rare quartzite clasts), and mostly supported by a carbonate-clay matrix.

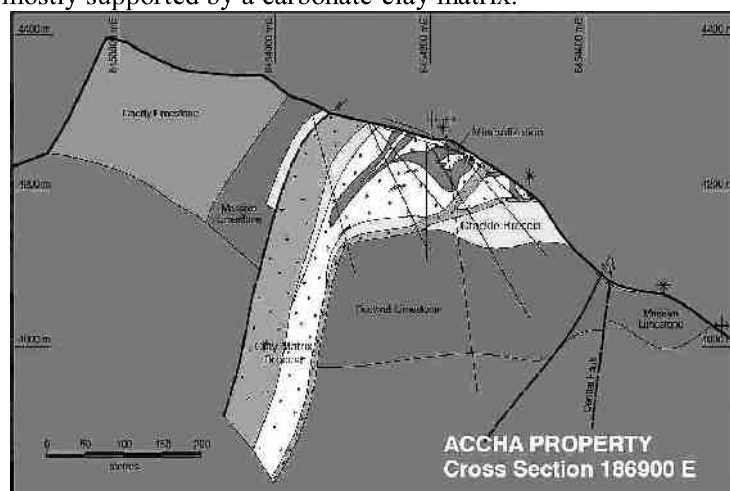


Figure 2. Schematic profile of the Accha orebody (from Zincore Metals webpage)

In the mining area the “gossans” rich in zinc carbonates, silicates and oxides are exposed at the surface over an area measuring about 300 by 100 m (Winter 2006). The best outcrops can be seen in the Titiminas area (Fig. 2). Drilling shows that the oxide mineralization is continuous along strike to the west for at least 700 m and is also continuous to the south.

MINERALOGY AND PETROGRAPHY OF THE NONSULFIDES

Mineralogical, petrographical and geochemical research (Boni 2007) has been performed on a wide number of samples from the cores MET 1-2-3-4, drilled between 2006 and 2007 by Zincore metals for metallurgical purposes. Table 1 shows the mineralogical average values from several specimens sampled from drillcore MET 1 and evaluated quantitatively with the Rietveld method.

The nonsulfide Zn association consists mainly of smithsonite and hemimorphite replacing both primary ore minerals and carbonate host rocks. Rare hydrozincite has been detected only in the surficial samples. Smithsonite occurs in zoned concretions with goethite, Mn-oxides and Zn-clays, as well as replacive cement in the limestone intervals. Most smithsonite analyses show a Zn content between 60 and 62%. FeO is also contained in smithsonite, with values between 0.1 and 1.50% FeO (all values are expressed in weight percent). There are also lower (down to 0.03 FeO) and higher (up to 6-7%) value. The former have been detected in the clear smithsonite crystals at the border of small concretions, the latter in the finely intergrown nuclei of the same concretions. MgO (between 0.02 and 1.58%) and CaO (between 0.11 and 1.19%) also commonly occur in the smithsonite lattice. CdO is present, with values between 0.05 and 0.70%. Minor to trace contents of manganese (MnO 0.01-1.58%), lead (PbO 0.02-0.35%), antimony (Sb₂O₃ 0.01-0.13%) and arsenic (0.03-0.07% reported as As₂O₃) have been locally detected in the Zn carbonate.

samples MET	Sm	Hem	Sau	Goe	Qz	Kf	Cc	Ka	Ill	Cha
1										
from 83.45 m	36.09		22.13	36.57	4.01	1.20				
—	2.00	75.36	2.64	18.76	1.24					
—	38.00	23.42	2.91	35.00			0.56		0.11	
—	35.02	9.60	8.05	40.86	0.96		5.51			
—		43.20	6.42	10.44			39.94			

—	83.91	11.99	1.87	2.23
—	76.04	17.84		6.12
—	2.76	47.78	3.30 1.23	6.95 37.98
—	2.56	35.95	22.59	38.90
to 99.25 m	1.98	92.25	0.50 2.70	2.57

Sm=smithsonite, Hem=hemimorphite, Sau=sauconite, Goe=goethite, Qz=quartz, Kf=K-feldspar, Cc=calcite, Ka=kaolinite, Ill=illite, Cha=chalcophanite

Table 1. Quantitative mineralogy of samples from MET 1 (core for metallurgy)

Hemimorphite shows the usual composition recorded in many other non-sulfide deposits. ZnO ranges between 65 and 70%, while SiO₂ has a much smaller variability: 25-26%. Both hemimorphite I (early diagenetic “stars” in sediment) and II (pure hemimorphite in veins and cements) do not differ in their composition. However, especially in the hemimorphite I generation, Al₂O₃ has been quantified up to 2%, K₂O up to 0.5%, FeO up to 1% and MgO up to 0.5%. Traces of MnO (0.02-1.36%), PbO (0.02-0.20%), CdO (0.02-0.36%) and Sb₂O₃ (0.04-0.05%) have been randomly detected. Clear hemimorphite II is late in the paragenesis and commonly occurs in a network of minute veinlets.

	MET1			MET2		
	1	2	3	4	5	6
SiO₂	39.47	31.80	37.63	38.58	35.87	65.45
Al₂O₃	7.30	4.26	7.06	8.10	14.02	17.92
ZnO	36.35	47.23	39.97	34.06	28.98	0.75
FeO	1.48	1.11	1.44	0.19	3.38	0.10
MgO	0.90	0.65	0.83	0.09	0.84	
CaO	1.18	0.78	1.19	0.62	0.52	0.03
K₂O	0.71	0.44	0.60	2.78	2.63	16.11
TOT	87.39	86.27	88.72	84.42	86.24	100.36

Table 2. Chemical composition of several sauconites (no. 1-5) and of K-feldspar (no. 6) in the Accha deposit

One of the most peculiar supergene Zn mineral of the non-sulfide assemblage at Accha is sauconite (33.80% Zn), a zincian smectite (Fig. 3a-b, Table 2). Sauconite is quite rich in K (0.44 – 0.70% K₂O), whereas Al₂O₃ is slightly below the published stoichiometric value. Sauconite is very abundant throughout the deposit: it has been found in the limestone groundmass, or in association with Mn-rich bands. Locally sauconite occurs as replacement of detrital feldspars and/or of possible detrital volcanic fragments occurring in sediments filling cavities in the host rock. Additionally, sauconite has been found replacing other supergene zinc-bearing minerals deposited in earlier stages, namely hemimorphite and smithsonite. It has been also observed that the composition of the sauconite measured near the weathered K-feldspars (Table 2, analysis no. 5), tends to increasingly approach the feldspar composition (see the Al₂O₃ values Table 2, analysis no. 6) (Table 2). This can be an indirect evidence of a genetical relationship at Accha between K-feldspar and sauconite. The latter mineral should be therefore derived from the supergene transformation of the potassic aluminosilicates. Although zinc mineralization predominantly consists of hemimorphite and smithsonite, Zn-smectite is always present in small to moderate amounts (up to ~10%) and being a ‘clay’ is somewhat more difficult to extract economically within the mineralogical makeup of deposits such as Accha and is taken into account during the ore treatment.

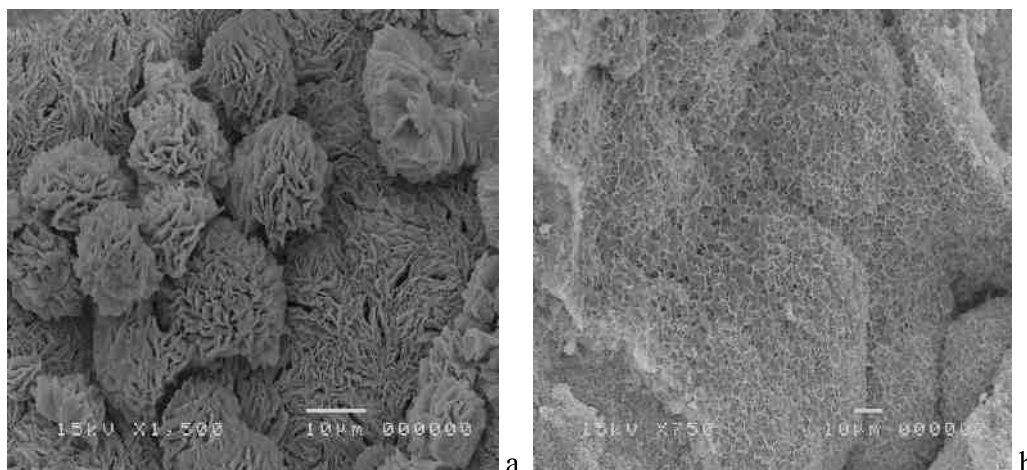


Figure 3. MET 1: Sauconite (Zn-smectite) concretions. SEM images

Other very characteristic minerals commonly detected at Accha are several Mn-hydroxides of the chalcophanite group (containing beside Mn and Zn also some SiO_2 and Al_2O_3) as well as coronadite-type minerals, associated to fair amounts of Pb and Fe.

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