MINERALIZATION AND PARAGENESIS OF THE HUANZALA MINE, CENTRAL PERU—A DISCUSSION

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Sir: In a recent paper Imai et al. (1985) presented mineralogical and petrological data on the Huanzala polymetallic ore deposit, central Peru. This paper is an important step in the understanding of physical and chemical conditions of ore formation in Huanzala, but the genetic interpretation they propose is not very convincing because macroscopic and microscopic relations between the ore assemblages and wall rock (e.g., Cretaceous sedimentary formations and Miocene calc-alkaline granodioritic dikes) are not considered in detail.

To begin with, it is of some importance to point out that the Huanzala ore occurs as strata-bound lenses (mantos), 50 to 200 m long, 70 to 250 m high, and 2 to 15 m wide, which are repeated discontinuously along 8 km but always in the same stratigraphic levels (so-called vetas—V1, V2, V3, V4, and V5), wedged up by characteristic lutitic key beds. Mantos V1 to V4 are located in the upper part of the Valanginian limestone Santa Formation and manto V5 is at the base of the overlying, alternating slate–sandstone Carhuaz Formation. No mineralization is known in the limestones of the lower part of the Santa Formation (an alternating slate–sandstone–limestone unit forming a progressive transgression between the underlying deltaic Chimu Formation and the overlying platform limestone, upper Santa Formation), although the granodioritic dikes intersect this lower Santa Formation as well.

The stratigraphic control of ore distribution is rigorous and the mantos are displaced by thrust and wrench faults, not the granodioritic dikes that cut these faults and are obviously post-tectonic. Furthermore, the distribution of ore and the associated alteration, especially the skarn type, does not show any close geometric relationship with the intrusive rocks. Moreover, the intrusion-limestone contacts generally lack any metasomatic or hydrothermal manifestation and are nearly always lacking in ore. On the other hand, no mineralization appears in the fault planes, contrary to what one would expect for a post-tectonic hydrothermal ore deposit. The observations pointed out here make very unlikely a post-tectonic, and therefore, a Miocene hydrothermal origin for the Huanzala ore deposit (Carrascal et al., 1983; Carrascal, 1984).

Furthermore, the ore presents a general macroscopic and microscopic concordance with the strata and shows peculiar structures and textures, such as a pyrite geopetal texture, framboidal pyrite, a ribbon structure of pyrite and sphalerite and/or galena, micro-synsedimentary or syndiagenetic faults, and convolutions involving ore minerals.

A detailed study of ore distribution in manto V3 lenses (Carrascal, 1984) shows that in each lens the zonation is generally concentric with a higher Zn content toward the rims and a higher Pb content toward the center of the lenses. In addition, Carrascal (1984) notes a migration of manto V3 lenses to the northwest (accompanied by a weak increase of Zn and Pb contents and a weak decrease of Cu content) when ascending in the stratigraphic sequence. No vertical zonation of Zn, Pb, and Cu contents appears. Finally, on a larger scale, the distribution of mineral assemblages shows a stratigraphic evolution (Carrascal, 1984), from black, Fe-poor, chalcopyrite-rich sphalerite which dominates in mantos V1 and V2, to red, Fe-rich, chalcopyrite-poor sphalerite which dominates in mantos V4 and V5. All these observations make very probable a synsedimentary and/or syndiagenetic deposition of the greater part of the mineralization.

The ore and gangue mineralogy, as described by Carrascal et al. (1983), Tsuchiya et al. (1983), Carrascal (1984), and in even more detail by Imai et al. (1985) implies introduction of elements by hydrothermal solutions at high temperatures (approximately 300°C). The only source of the introduced elements, according to the Andean geologic context and the pretectonic and probably syndiagenetic character of ore formation at Huanzala, has to be volcanogenic. In fact, the existence of volcanic activity contemporaneous with sedimentation is proved by the presence of tuffaceous limestones and some tuffs interbedded in the upper Santa Formation. Moreover, Huanzala is not an isolated case and the Santa Formation has been recognized as an important metallotect of the central and northern Peruvian Andes (Samaniego, 1981), with numerous, probably volcanogenic, stratabound ore deposits of proximal (El Extraño) or more distal character (Malaquita, Pueblo Libre, Pacclon-Llamac, Pachapaqui).

Therefore, this combination of field and laboratory observations leads us to conclude that Huanzala is a good candidate for a high-temperature Cretaceous volcano-sedimentary ore deposit with some subsequent Miocene remobilization.

As pointed out in the present discussion, the metallogenic interpretation of this deposit is complicated by the presence of Miocene calc-alkaline intrusive stocks and dikes which may modify substantially the previous mineral assemblages. They may eventually be hosts of additional ore deposition by subsequent hydrothermalism, as is known from other Santa ore deposits such as Tuco-Chira (Samaniego, 1981), Venturosa (Diaz Bernal, 1984), and probably Oyon as well.

As shown by Soler and Lara (1983) and Soler (unpub. data), central Peru ores from Santa strata-bound and Miocene hydrothermal deposits, both associated with calc-alkaline Andean magmatism, show very similar geochemical patterns, so that further deductions about the respective parts played by Cretaceous volcanogenic processes and Miocene hydrothermal processes in Huanzala and similar ore deposits, with obvious consequences for exploration and mining schemes, will require more detailed investigation. Work in progress concerning rare earth distributions in fluorites from both Miocene metasomatic and hydrothermal and Santa strata-bound ore deposits and K-Ar dating of alteration minerals of Huanzala will probably provide new material for the answer.

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MINERALIZATION AND PARAGENESIS OF THE HUANZALA MINE, CENTRAL PERU—A REPLY

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Sir: In the Huanzala mining area, the mineralized zone extends 6 to 8 km in the limestone of the Santa Formation; it has a width of 150 to 200 m. The orebodies occur as lenslike forms parallel to the hanging walls and footwalls of the formation.

Soler says that mantos V1 through V5 always exist in the same stratigraphic levels in the Santa and the overlying Carhuaz Formation. This statement is not adequate in the strictest sense. For convenience sake at the mine, the orebodies are divided into five layers, nevertheless they are distributed sporadically in the Santa Formation, as shown here in Figure 1 and in figure 3 of my paper (Imai et al., 1985).

Some zinc and lead ores in this deposit are closely associated with skarn minerals, such as garnet, diopside, vesuvianite, epidote, etc. (Fig. 2 A, B, and C). From this observation, I classify the deposit as pyrometasomatic, or contact metasomatic. Also, the paragenesis of the sulfide minerals in the deposit resembles that of Cerro de Pasco. The deposit at Cerro de Pasco is generally recognized to have a hydrothermal replacement origin.

I emphasized these points in the discussion of the genesis of the Huanzala deposit and it continues to be my basic viewpoint. I find this deposit to be the same as Morococha in Peru (Petersen, 1965), Kamioka in Japan (Imai, 1978a), and Sangdong in Korea (John, 1963, 1978), and to be similar to Cerro de Pasco in Peru (Petersen, 1965; Einaudi, 1977).

Sheetlike dikes, of Miocene-age quartz porphyry occur in the Santa Formation. Granodiorite porphyry is found in the Chimu Formation (figs. 1 and 2, Imai

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