BOQUIRA (2.5 Ga) AND MORRO AGUDO (0.65 Ga) LEAD-ZINC DEPOSITS, BRAZIL: NEW SEDEX SUBTYPES?

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INTRODUCTION

Sedimentary exhalative deposits (SEDEX) are defined as sulfide deposits hosted by sediments and "formed from the discharge of hydrothermal fluids onto the sea floor" (Goodfellow et al., 1993). They represent more than 50% of the world's reserves of zinc and lead. Detailed geological, petrographic and isotopic investigations are being carried out on seven sediment-hosted sulfide deposits of Brazil. Of these the Boquira mine in Bahia state (non operational since 1991), and Morro Agudo in Minas Gerais state, show geologic and isotopic characteristics that could be interpreted in terms of a SEDEX model. Lack of detailed studies led earlier workers to classify these deposits as volcanogenic (Boquira) and Mississipi Valley Type (Morro Agudo). Hoewever, they display certain characteristics which are different from classical SEDEX deposits.

THE BOQUIRA DEPOSIT

The lead-zinc sulfide mineralization is hosted by parametamorphic sequences lying along a N-S linear zone in the central part of the Sao Francisco Craton. Stratiform massive sulfides, composed of galena, sphalerite, magnetite, maghemite, amphiboles, pyrrotite, pyrite, quartz and minor chalcopyrite, are hosted by banded grunerite-cummingtonite+magnetite facies, a silicate facies of the Boquira Banded Iron Formation (BBIF)(Carvalho et al. 1982). Mid-Proterozoic siliciclastic sedimentary sequences, intercalated with acidic to intermediate volcanic rocks (1.7 Ga), overlie the BBIF. Boquira was a small mine, with 650.000 t of Pb+Zn.

Lead isotope data of six galena samples and one pyrite were plotted in $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ curves and the ages were interpreted according to classical plumbotectonic two stage model ages.The ages indicate a time span between 2.86 Ga and 2.55 Ga for the stratiform sulfides (Carvalho et al., 1995). Twelve sulphur isotope determinations from sulphide samples indicate a narrow range of $\delta^{34}S$ between +8.2 and +12.7 per mil CDT (ave. +10.5), suggesting a sea water

sulfate source for the sulfur. Temperature calculated from the sulfur isotope data of a cogenetic galena-sphalerite pair is of the order of 300 degrees celsius. The data suggest that metals were scavenged from the Archean terranes by submarine exhalative processes and combined with sulfur from dissolved HS ions within the reducing aqueous environment of the rifting Early Proterozoic Basin (2.5 Ga).

THE MORRO AGUDO DEPOSIT

The deposit is mainly hosted by dolarenites of the Vazante Formation, Upper Proterozoic Bambui Group. Reserves at Morro Agudo mine are 17 million tons with 5.14% Zn and 1.53% Pb. Lead-zinc mineralizations in the area, including the Vazante mine (8 million tons, 23% Zn, located about 80km south of Morro Agudo), are situated along a 300 km N-S linear trend. In Morro Agudo, sulfide concentration (sphalerite, galena and minor pyrite) is clearly related to a N-S normal fault zone dipping 20 to 70 degrees to the west. Several types of mineralization have been described by the mine geologists (Romagna & Costa, 1989): massive, fine grained, stratiform (N orebody), massive, fine to coarse grained, cementing oolitic dolostone (JKL), coarse grained, cementing breccia (GHI). JKL and GHI orebodies are closest to the fault zone than N orebody. There is also a coarse grained, venular mineralization, apparently remobilized (M orebody). Detailed petrographic studies by the present authors revealed the close association of the stratiform mineralization with nodules of microcristaline, lenght slow quartz, which is a clear indication of the presence of a previous evaporitic facies that apparently controlled the stratiform sulfide mineralization.

Lead isotope data of galenas carried out by Iyer et al. (1992) in the Vazante-M.Agudo area plot close to 650 Ma on the evolution curve. Twelve galena samples from this area show a remarkable zonality: The lead becomes progressively radiogenic away from the fault zone. This is an indication that the normal fault at Morro Agudo was a feeder zone. In fact, the detailed sulfur isotope studies recently carried out by the present authors on 34 samples of sulfides, confirm this interpretation. There is a clear trend from high positive values in the lowermost, breccia-type GHI orebody (ave. $\delta 34S$ = +26.1‰ CDT, n = 2) to less positive values at the oolitic, stratabound JKL (ave. +18.5, n=12) and moderate negative values in the uppermost, stratiform N orebody (ave. -3.0, n=11). Temperatures obtained from cogenetic sphalerite-galena pairs show a remarkable trend ranging from 246 degrees celsius in the GHI orebody, 188, 156 and 126 in the JKL and 105 and 40 degrees in the N orebody. The M orebody indicate very low temperatures, plotting outside the temperature curves, confirming the possibility of a origin by late remobilization. Temperature obtained from a cogenetic sphalerite-galena pair of the Vazante mine indicate about 250 degrees celsius, a consistent data considering the lowermost position of the Vazante mineralization in the area. Temperatures obtained are higher than is normally found in MVT deposits.

The above data indicate that metal-rich solutions migrated from the basement through the fault zone during the extensional evolution of the basin and reacted with reduced seawater sulfur.

CONCLUSIONS

Boquira and Morro Agudo deposits are syngenetic to syndiagenetic metal concentrations originated from hydrothermal circulation along extensional zones in Proterozoic sedimentary basins. They differ from classical SEDEX deposits by the absence of contemporaneous magmatism associated with mineralization. Morro Agudo is hosted by carbonate rocks, with no siliciclastic facies directly associated. Boquira is probably a unique example of a sedimentary exhalative lead concentration of Early Proterozoic age. The present interpretation offer new guidelines for exploration and could indicate important metallogenic epochs in South American continent.

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