Abstract

The sediment-hosted stratabound banded polymetallic deposit at Rajpura-Dariba, Rajasthan, occurs in blackshale-chert-carbonate facies of metasediments within a discrete Precambrian metallogenetic province marked by recurrent basemetal mineralization.

Several conspicuous features characterize the ore deposit. These include : presence of two distinct ore-facies - a major, primary, congruent, banded, ore-facies and a minor, secondary, discordant, ore-facies; virtual absence of any tuffite or other volcanic rock in the stratigraphic column; a prominent stratigraphic metal-zoning with copper, lead-zinc and zinc-iron ($\pm$ baryte) zones successively upwards; absence of any feeder 'stringer-sulphide' zone at the base; extreme variation in metal proportions within the orebody, reflected in widespread scattering of points in the synoptic composition diagram; and near-identical proportions of metals in the over-all 'average' and in the 'richest' grade of ores.

The banded ore-facies and the metasedimentary rocks bear imprints of three phases of deformation (F_1, F_2 & F_3 folding) and amphibolite facies of metamorphism at estimated P-T conditions of $\approx 550^{\circ}C$ and ≈ 5 kb, with $X_{CO_2} \approx 0.13$ $\left[\text{when } P_f = P_{CO_2} + P_{H_2O}\right]$. Mineralogy of the banded ore-facies is relatively simple, with pyrite sphalerite galena and chalcopyrite as major constituents, minor but widespread arsenopyrite fahlore pyrrhotite, and rare gudmundite; all these minerals show evidence of multiple deformation and annealing recrystallization, but rarely any replacement texture. Increase in activities of sulphur and arsenic during metamorphism is indicated by the trends of sulphide and fahlore reconstitution.

The coarse, discordant ore-facies contains mainly galena, with Tl-bearing geocronite, lead- and murcury-bearing fahlores, bournonite-seligmannite$_{s.s}$, owyheeite, native arsenic, Tl-bearing boulangerite and meneghinite, an intermetallic compound $Ag_{74}Au_{16}Hg_{10}$, a 'cuprian' samsonite, ramdohrite, polybasite and an yet-unidentified Tl-Pb-Ag-Sb sulphosalt. Unusual mineralogy and

chemistry, ultra-coarse grain-size, abundance of myrmekitic intergrowth, and reaction-rim texture, virtual absence of deformation texture and occurrence as intergranular space-fillings within incongruent segregation patches of coarse diopsidic rocks unmistakably point to a different mode and a different time of origin of this ore-facies. As/As+Sb ratios in coexisting fahlore$_{s.s}$ and bournonite$_{s.s}$ indicate large variation in As/Sb activity ratios during formation of these ores; consideration of phase relations in minerals of the Fe-As-S system permits estimation of uppermost limits of temperature ($\approx 436^{o}C$) and corresponding a_{S_2} ($\approx 10^{-8}$) for these ores.

The observed pattern of metal distribution is found to be due to the interplay of two factors: (1) the spatial zoning in the banded facies and (2) random juxtaposition of the two facies of ores in different parts of the orebody.

Considerations of regional geologic-metallogenic perspectives as well as of the intrinsic features of the orebody suggest that the primary banded ore-facies was formed, in a 'third-order basin' with low-energy euxinic environment, by emission/flowage of metal-rich brines of non-volcanic origin. The basement granite-granodiorite complex could yield lead zinc and copper in sufficient quantities on leaching by hydrothermal fluid. The spatially-related but genetically and temporally separated discordant facies is believed to have originated from 'metamorphic' water that derived some of its metals from black shales and/or from acid migmatitic end-stage fluid that is generally enriched in thallium.

The Rajpura-Dariba deposit thus represents the end-product of an entire spectrum of geologic events that began with synsedimentary emission of metal-rich brines, continued through the stages of textural-mineralogical reconstitution during diagenesis and again during regional metamorphism (with its attendant deformation), and culminated in a second surge of (minor) mineralization at the waning stage of metamorphism. Such deposits naturally, defy any conventional genetic classification.