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Ore-Forming Processes at the Rosh Pinah Zn-Pb-Ag Deposit, Southern Namibia: Evidence from Mineralogy, Geochemistry, and Metal Distribution

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The Rosh Pinah deposit (19.94 Mt @ 7.38 wt % Zn, 1.83% Pb and 27.7 g/t Ag) in Namibia is hosted in carbonaceous argillites, siltstones, carbonate rocks, and volumetrically minor volcaniclastic rocks of the Neoproterozoic Rosh Pinah Formation. To better understand the metallogenesis of the deposit, we present an integrated analysis of petrography, metal distributions, C-O-Sr isotope and in-situ and whole-rock geochemistry. Despite the simple sulfide mineralogy (sphalerite, galena, pyrite, and chalcopyrite), the paragenetic sequence of alteration and mineralization was complex, strongly controlled by sedimentary lithofacies. The highest Zn, Cu, and Fe contents are located adjacent to structures that appear to have served as conduits for metal bearing fluids. The richest orebodies occur where these are juxtaposed to pre-existing carbonate horizons. Replacement of pre-existing marine carbonate cements by hydrothermal carbonates with concomitant sulfides indicates that carbonate buffering played a key role in metal precipitation. This is corroborated by C-O-Sr isotope data and REEY patterns from LA-ICP-MS trace element data on subsequent carbonate phases. These observations combined with textural relationships indicate that the Zn-Pb-Ag ore formed via sub-seafloor replacement by hydrothermal fluids and was overprinted by later barite during and after the main ore stage. Petrography and whole-rock geochemistry show increasing enrichment of Ba (as barite, barian K-feldspar, and barian carbonate minerals) and depletion of K and Na in argillites and siltstones towards well-mineralized zones in carbonate bodies provide potential vectors to Zn-Pb mineralization. Although the ore at Rosh Pinah is associated with subtle alteration haloes, exploration for additional orebodies in the district should focus on identifying favorable sedimentary facies and structural architecture for hydrothermal fluid flow and metal precipitation.