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Deducing Different Mineralization Styles of Multi-Stage Sediment-Hosted Cu-Co Deposits: The Dolostone Ore Formation Deposit, Northwestern Namibia

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The Dolostone Ore Formation (DOF) is a sediment-hosted Cu-Co mineralization hosted in Neoproterozoic carbonates and shales of the Ombombo Subgroup, Damara Supergroup (Allen, 2016; Hoffmann et al., 2002). Sediment-hosted Cu(-Co) deposits (such as the central European Kupferschiefer and the Central African Copperbelt) commonly comprise multiple styles of mineralization, most predominantly disseminations and veins. Constraining the paragenetic relationship between different mineralization styles in one mineralization commonly requires a multi-method approach, based largely on microscopic observations and fluid inclusion data.

In the pursuit of better understanding the sulfide geochemistry of the DOF, in situ LA-ICP-MS trace element analysis was done on sphalerite, chalcopyrite, pyrite, and pyrrhotite. Six mineralization styles were identified and analyzed for this study: disseminated, clustered, nodular, “sigma,” veins, and “events”. Disseminations are typically monomineralic sulfide crystals in the host rock. Clusters comprise anhedral iron-sulfide with intergrown sphalerite and chalcopyrite. Nodules are predominantly iron-sulfide mineralized, with interstitially grown chalcopyrite and sphalerite. The “sigma” shows distinct pressure shadows making it texturally different enough from the typical nodule style. The “sigma” has a core clast composed of pyrite, whilst chalcopyrite, sphalerite, and gangue minerals are exclusively limited to the pressure shadows around the pyrite core. Veins can be either sulfide or gangue mineral dominated. Veins are not exclusive to the DOF horizon(s) and can be found unmineralized throughout the stratigraphy. The so-called “events” are still enigmatic and portray ductile and brittle textures. “Events” were interpreted as soft-sediment deformation structures, but also show great likeness to crack-seal veins. “Events” are the only style so far where pyrite and pyrrhotite coexist. Linnaeite is the dominant Co-phase of the DOF and is only absent in the “sigma” and vein styles. Accessory galena, cobaltite, and pentlandite has been identified in some of the styles.

Elements such as Fe, Co, Ni, Ga, Se, and Cd in sphalerite and Co, Ni, Se, and Bi in chalcopyrite show a distinct grouping of concentrations between (1) dissemination, cluster, nodule, and “event” styles and (2) “sigma” and vein styles. The Ge-Ga-In-Mn-Fe-in-sphalerite thermometer (Frenzel et al., 2016) was utilized on sphalerites from each mineralization style, and each style resulted in sphalerite formation temperatures above the system closing temperature of 310 ± 50°C. Trace element compositions of coexisting euhedral pyrite and anhedral pyrrhotite (of the “event” style) suggest that the pyrrhotite may be the metamorphic product from the earlier pyrites. Elements such as Cu, As, Sb, Tl, and Pb are enriched in the “event” pyrite compared to the pyrrhotite, whilst Co, Ni, and Se show similar concentrations in both iron sulfides. This is a trend commonly seen in metamorphically recrystallized iron sulfides.

This work by no means infers that trace element data should, or can, replace the more conventional methods used for paragenetic studies. Our data demonstrates that trends in sulfide trace elements can be utilized to identify groups of mineralization styles, thus suggested to have formed contemporaneously, and also to infer the association of metamorphism to the formation of these sulfides.