Unearthing genetic insights through a multi-method geochemical approach of the sediment-hosted Cu-Co Dolostone Ore Formation deposit, Namibia

V. Bertrandsson Erlandsson[1*], R. Ellmies[2], F. Melcher[1]

[1]Montanuniversität Leoben, Leoben, Austria
[2]Gecko Namibia, Swakopmund, Namibia
e-mail: viktor.erlandsson@unileoben.ac.at

The sediment-hosted Cu-Co-Zn Dolostone Ore Formation (DOF) deposit is a recently discovered Cu-Co-Zn mineralization in the Kunene region of northwestern Namibia and is the first recognized Co mineralization in Namibia (Ellmies 2018). Understanding the geological formation processes responsible for Co deposits is vital due to the ever-increasing demand of Co for modern high-tech and green technologies (Alves Dias et al. 2018). As sediment-hosted Cu-Co deposits from the Central African Copperbelt are responsible for ca. 70% of global Co supplies (USGS 2020), the DOF deposit could prove to be a valuable asset for future Co production, especially as the DOF is situated in analogous stratigraphic and tectonic settings to the Co deposits of the Central African Copperbelt (Miller 2013; Bertrandsson Erlandsson et al. 2022). This study applies an array of geochemical methods to constrain genetic aspects of the DOF deposit, with the aim of better the understanding of sediment-hosted Cu-Co deposits.

Hosted in calcareous siltstones and argillites of the Ombombo Subgroup, which is part of the Neoproterozoic Damara Supergroup, the DOF is expressed as a horizon with a bell curve-like Cu-Co-Zn distribution. The highest metal (in particular Co) enrichment is referred to as the "Main DOF horizon", whilst the extended Cu-Zn enrichment is called the "Wider DOF horizon" (Fig. 1). The sulfide mineralogy is relatively simple, with predominantly pyrite, pyrrhotite, chalcopyrite, sphalerite, linnaeite, and subordinate amounts of cobaltpentlandite and galena. Sulfides occur in six types of mineralization styles: disseminated, nodules, clusters, veins, pressure shadows, and "Events". Events are a term coined by the exploration company Gecko Namibia and refer to vein-like structures that portray both ductile and brittle deformation. (Bertrandsson Erlandsson et al. 2022).

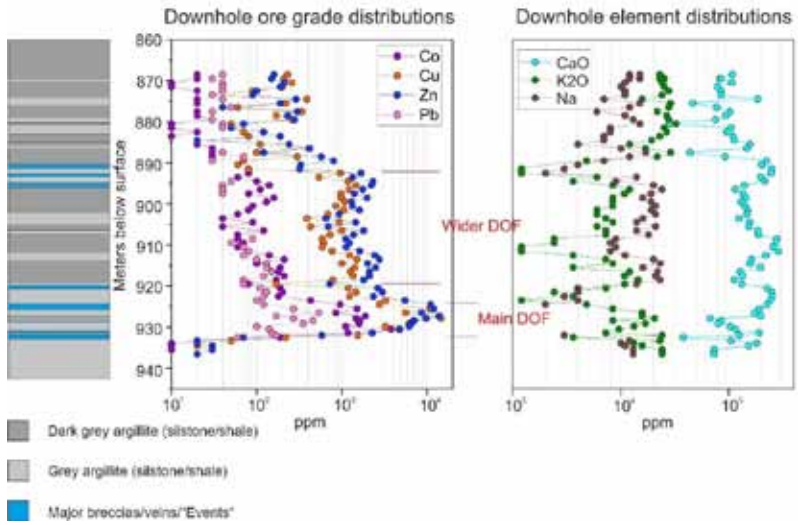

Figure 1. Simple drill core log from one of the studied DOF boreholes, with additional exploration assay data of selected elements, shown besides the drill core log.

Laser ablation inductively coupled mass spectrometry (LA-ICP-MS) analyses of sulfides from the six different mineralization styles reveal two main populations; disseminated, nodule, cluster, and Event sulfides group together (Group 1), whilst Group 2 comprises vein- and pressure shadow-hosted sulfides (Bertrandsson Erlandsson et al. 2022). The Ga-Ge-In-Mn-Fe in sphalerite geothermometer (Frenzel et al. 2016) indicates that the DOF mineralization formed at temperatures >310 °C, which suggests that they formed during regional metamorphism of the Damara Orogeny. Group 2 sulfides seem to have formed at relatively lower temperatures. This together with petrographic observations indicates that Group 2 sulfides (veins and pressure shadows) formed during a late orogenic stage of the Damara Orogeny (Bertrandsson Erlandsson et al. 2022). This interpretation is also supported by ore-associated hydrothermal monazite ages.

Petrographic evidence shows that Group 1 sulfides did not all form at once, but rather through several progressive stages. Cobalt is believed to have been initially hosted in pyrite, which was later remobilized due to changes in oxygen and/or sulfur fugacity to first form cobaltpentlandite and eventually linnaeite. It was after this that Group 1 sphalerite and chalcopyrite precipitated, partially overgrowing the preexisting sulfides. This resulted in extremely Co-rich sphalerite (>1 wt%). Atom probe tomography of this extremely Co-rich sphalerite revealed that the Co^{2+} occurs through direct substitution of Zn^{2+} (Bertrandsson Erlandsson et al. 2023).

Trace element comparison of DOF sulfides to other sediment-hosted Cu(-Co) metallogenic districts (i.e., the Polish Kupferschiefer and the Central African Copperbelt) by Random Forest and Factor analyses indicate that sulfide trace element composition is heavily host basin dependent and that local metal sources dictate the sulfide composition (Bertrandsson Erlandsson et al. *in review*).

Alves Dias P, Blagoeva D, Pavel C, Arvanitidis N (2018): Cobalt: demand-supply balances in the transition to electric mobility. - Publications Office of the EU 10, p. 97710

Bertrandsson Erlandsson V, Foltyn,K, Muchez P, Rantitsch G, Ellmies R, Melcher F (in review). Sulfide geochemistry in sediment-hosted Cu(-Co) metallogenic districts: LA-ICP-MS analyses of chalcopyrite, sphalerite, and pyrite. - Mineral Dep (*in review*)

Bertrandsson Erlandsson V, Gopon P, Waldl H, Misch D, Ellmies R, Melcher F (2023): Sphalerite as a non-traditional critical metal source: Correlative microscopy (EPMA, EBSD, and APT) of cobalt-enriched sulfides from the sediment-hosted copper-cobalt Dolostone Ore Formation deposit, Namibia. - Front Earth Sci, 10.3389/feart.2023.1171859

Bertrandsson Erlandsson V, Wallner D, Ellmies R, Raith JG, Melcher F (2022): Trace element composition of base metal sulfides from the sediment-hosted Dolostone Ore Formation (DOF) Cu-Co deposit in northwestern Namibia: Implications for ore genesis. - Jour Geoch Expl 243, 107105

Ellmies R (2018): Extensive stratiform Cu-Co-mineralisation at Okondaurie, Kunene Region. - Internal Report, Kunene Resources (Pty) Ltd. (unpublished)

Frenzel M, Hirsch T, Gutzmer J (2016): Gallium, germanium, indium, and other trace and minor elements in sphalerite as a function of deposit type—A meta-analysis. - Ore Geo Revs 76, 52–78

Miller R (2013): Comparative Stratigraphic and Geochronological Evolution of the Northern Damara Supergroup in Namibia and the Katanga Supergroup in the Lufilian Arc of Central Africa. - Geosci Canad 40, Article 2, 118–140

USGS (2020): Mineral commodity summaries 2020, DOI: 10.3133/mcs2020