Mineralogical and geochemical characterization of the Dolostone Ore Formation, Kunene region, Namibia

Wallner, Daniela[1]; Bertrandsson Erlandsson, Viktor[1]; Raith, Johann G.[1]; Rantitsch, Gerd[1]; Melcher, Frank[1]; Ellmies, Rainer[2]

1 Department of Applied Geosciences and Geophysics, Montanuniversität Leoben, Peter-Tunner-Straße 5, A-8700 Leoben, Austria; 2 Gecko Namibia, 10 Einstein Street, 8912 Swakopmund, Namibia.

In 2012 Namibia's first potential cobalt-copper deposit – the Dolostone Ore Formation (DOF) – was discovered close to Opuwo (Kunene region, Namibia). The Kunene region is located in the Eastern Foreland of the Neoproterozoic Kaoko Belt, which is the northern branch of the Damara Orogen and formed during the amalgamation of Gondwana. The Kunene region is characterized by a thick Neoproterozoic sedimentary succession deposited during the break-up of Rodinia within a terrestrial to marine environment and was affected by two global glaciations (Sturtian and Marinoan glaciation). The DOF has an E-W extend of ca. 50 km and is a ca. 30–70° dipping, sediment-hosted, stratiform/stratabound mineralization with a sharp footwall contact and a gradual hangingwall contact. The DOF is bound to pre-Sturtian low-grade metamorphosed dolomitic marlstone underlain by terrestrial sediments in the west evolving to carbonate richer rocks and shales in the east. According to the cobalt and copper concentrations, the ore horizon is divided into a high grade DOF, a Wider DOF, a Cu-rich Wider DOF, and a low grade Wider DOF. The thickness of the highly mineralized horizon varies from 4 to 8 m and it thickens towards the east. In addition to the geochemical characteristics, these horizons also show differences in mineralization types. Ore minerals are predominantly linnaeite, cobaltite, Co-rich pyrite, chalcopyrite, and sphalerite. Cobalt is hosted primarily in linnaeite and a Co-rich pyrite (ca. 2.25 mass% Co) and Co-enriched sphalerite (< 2.70 mass%). According to its Co:Ni ratio linnaeite refers to a Co-rich grimmite ($Ni_{0.6-0.7}Co_{2.3-2.4}S_4$). EPMA mineral chemical analyses document slight differences in the Fe, Ni, Co and Cu concentrations of various generations of ore minerals (i.e., pyrite, pyrrhotite, chalcopyrite, sphalerite, linnaeite, and cobaltite). The ore minerals are found in several mineralization types: (1) irregular to clustered disseminated mineralization, (2) mineralized nodules and concretions, (3) mineralization within strain shadows, (4) veinlet hosted mineralization of different generations, and (5) "DOF events", which are distinctive structures with a ductile and/or brittle deformation and seem to be a combination of several mineralization styles. In general, irregularly distributed ore minerals pyrite, pyrrhotite, chalcopyrite, sphalerite and linnaeite are most frequent. Mineralization is assigned to four paragenetic stages thought to have mainly formed during the Damara Orogeny (560–550 Ma): Stage I) early stage with framboidal pyrite, Stage II) Co-Ni-Fe stage that formed during the main deformation event and includes mainly Co-rich pyrite, pyrrhotite and linnaeite, Stage III) Cu-Zn-Fe-(Co-Ni) stage which is characterized by veinlets containing quartz, chalcopyrite and sphalerite postdate the former stages, and Stage IV) with the formation of decomposition structures within pyrite, pyrrhotite and linnaeite. Raman spectroscopy of carbonaceous material yielded a metamorphic peak temperature of 345 ± 32 °C indicating also hydrothermal alteration in the DOF and in the Cu-rich Wider DOF. The Cu-rich Wider DOF is characterized by a high concentration of quartz-rich veinlets formed during Stage III of the paragenetic sequence. Mineralization in the Kunene region show many similarities to the sediment-hosted Cu-Co deposits in the Central African Copper Belt but there are also marked differences (e.g., lack of evaporites in the stratigraphic sequence).