

## Minerals of the Kope Magnetite skarn deposit, Slovenia

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The Kope Mountains are located in the western part of the Pohorje Mountain range, which belongs to a south-eastern part of the Eastern Alps (NE Slovenia). The Pohorje metamorphic complex represents the largest eastern intrusion of granodioritic magma along the Periadriatic Fault, separating the Eastern Alps from the Dinarides. On its north side it borders to the Middle-Miocene Ribnica tectonic basin, on the west and south-west side it is bound to the Labot Fault, whereas to the east and south-east it gradually sinks under the younger sediments of the Pannonian basin.

The polymetallic ore deposit at Kope was formed by contact metamorphism, induced by intrusion of a dacite magma in the northwestern part of the Pohorje Mountain chain (Germovšek, 1954). The intrusion of dacite magma into the carbonate and calc-silicate rocks produced epidote and garnet dominated skarns, richly mineralized with oxide and sulphide ore minerals including magnetite, hematite, pyrrhotite, pyrite, galena, sphalerite, chalcopyrite and minor Ag-, Mo-, W-, Bi- sulphides and tellurides. The ore deposit outcrops in form of small ore-bodies is hosted by skarn rocks, which include garnet, epidote and hedenbergite in various ratios.

The majority of calcareous skarn minerals (Einaudi & Bruk, 1982) show variable chemical composition, often following the crystal growth zones, indicating alternating composition of mineralizing solutions. Garnet compositions are largely dominated by andradite. The growth zones are parallel to the crystallographic faces and their chemical composition varies as their color, from andradite to grossular, almandine, spessartine and their isomorphous mixtures. Epidote group minerals, represented by epidote and clinozoisite, show transitions to piemontite (Mn) and allanite (Ce and La). Epidote crystals include rounded grains of zircon, apatite, rutile and feldspars, while the fractures are filled with quartz or calcite. The next typical skarn mineral group include pyroxenes which are represented by hedenbergite, diopside and pigeonite with compositional changes shifting towards wollastonite (Ca) and ferrosilite (Fe). Calcareous silicates are accompanied by feldspars, orthoclase and plagioclase, and micas (muscovite and biotite). Biotite is often altered to chlorite by younger hydrothermal process and accompanied by idiomorphic titanite crystals.

Magnetite is the main ore mineral of the Kope deposit. It crystallises in form of idiomorphic octahedral crystals together with garnets replacing the primary silicate minerals. It includes amphiboles, apatite, titanite, molybdenite, scheelite, hematite and sulphides. It often fills the pores of fractured skarn minerals, indicating that the hydrothermal event that produced magnetite happened during tectonic activity. Magnetite replacing the silicate minerals commonly shows Si-rich zones. In the final stage of growth, magnetite is associated with idiomorphic quartz crystals. Hematite and ilmenite are less abundant and precede the crystallization of magnetite.

The most common among the sulphide minerals is pyrite. It appears in the form of idiomorphic cubic crystals, sometimes replaced by magnetite. It is followed by chalcopyrite, which often

fills the fractures in pyrite crystals and pyrrhotite that has been attributed to the breakdown of pyrite during metamorphism. Chalcopyrite is accompanied by minor sphalerite and galena. On the onset of oxidation, chalcopyrite alters to bornite and covellite, which further oxidize to hydroxyoxides and hydroxycarbonates. The mineralogy of the oxidation zone comprises goethite, limonite, cerussite, smithsonite, malachite and azurite forming encrustations (Fig. 1) around fractured ore minerals, especially Bi-rich phases.

Bi-rich phases that appear in the Kope skarns are thought to be the product of the last, hydrothermal phase that fills up the pores and fractures in garnet, magnetite and pyrite crystals and mineralizes voids between the primary minerals (Fig. 2). They are represented by native bismuth, bismite, bismutinite, tellurobismuthite, Ag-rich cosalite (Štruel & Kluge, 1991) and tetradymite, in addition to numerous yet unidentified Pb-Bi-S, Ag-Bi-Te-S, Ag-Pb-Bi-S, and Cu-Fe-Bi-S sulfosalts.

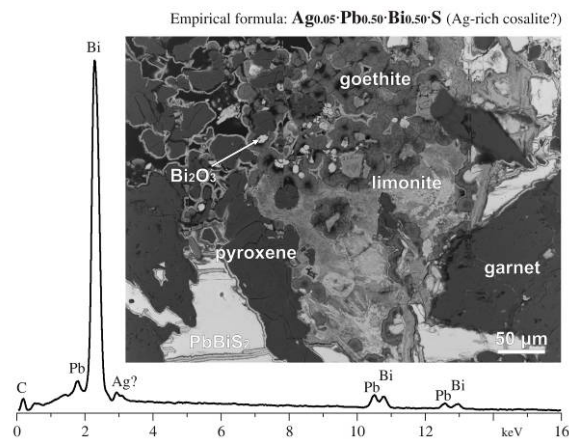


Fig. 1.: Tectonically shattered garnet and pyroxene crystals. The fractures are filled with Bi-rich minerals (Ag-cosalite) and Fe-oxyhydroxydes.

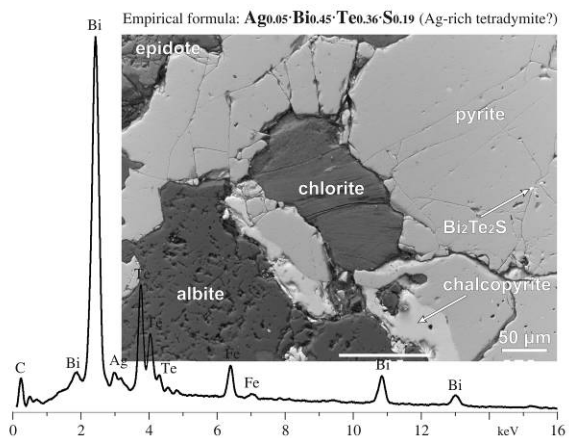


Fig. 2.: Fractured pyrite crystal with albite, epidote, chlorite, chalcopyrite and inclusions of Bi-rich sulfosalts (Ag-tetradymite).

Einaudi, M.T., Brut, M.D (1982): *Econ Geol*, 77: 745-754.

Germovšek, C. (1954): *Geologija*, 2: 191-271.

Štruel, I., Kluge, R. (1991): *Geologija*, 34: 305-335.