

The mineralization of Brannberget (Central Norwegian Caledonides): mineral paragenesis, geochemistry, genesis

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INTRODUCTION & AIMS OF THE STUDY

- The Brannberget area is situated within the Løkken Ophiolites, in the Central Norwegian Caledonides (Fig.1). The area is known for its VMS-related base metal mineralization, which contains mainly pyrite with minor chalcopyrite (Grenne, 1989; NGU, 2024).
- The area represents an artificial outcrop (former small mine) extending to approx.15m in length and is ~ 4-5m height and contains two short tunnels in the hill (Fig.2).
- This study aims to characterize the mineralization and its governing hydrothermal processes. Both contributing to the evaluation of strategy/critical metal potential of the region.

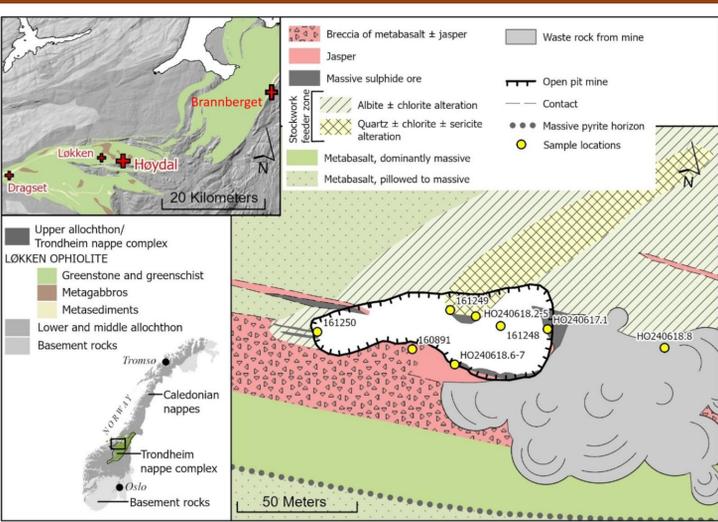


Figure 1. Detailed geological map showing the study area in a close vicinity to the world-famous ophiolite hosted VMS deposit at Løkken (based on (Grenne, 1990), modified after Mina et al., 2026 subm).

METHODS

- Petrography: transmitted and reflected light polarizing microscopy (Zeiss Axioplan), SEM-EDS (AMRAY 1830I) Scanning Electron Microscope (SEM-EDS).
- Analyses of fine-grained alteration products: X-ray powder diffraction (XRD Siemens D5000).
- Whole-rock geochemical analyses: A portable Olympus Vanta VCR XRF.

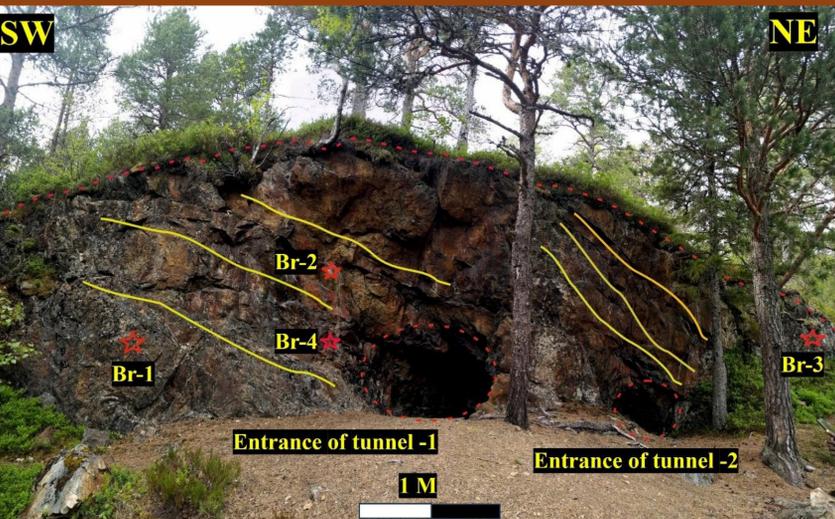


Figure 2. Panorama view of the Brannberget outcrop showing the sample locations (red stars) and the two short tunnels (dotted circle). Yellow lines = strike direction of the veins.

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RESULTS & DISCUSSION

The results of field observations, petrography, mineral chemistry, and preliminary whole-rock geochemistry analyses reveal that the mineralization at Brannberget is hosted within metabasaltic-doleritic greenstone and occur as stockwork system. The mineralization is characterized by a dense network of 3-5 cm thick quartz veins surrounded by Fe-oxyhydroxide and clay mineral-bearing alteration halos (Fig.3).

The host basalt exhibits significant albitization, sericitization, chloritization, and silicification, indicating extensive hydrothermal overprinting. Quartz veins contain iron-rich clay minerals, K-feldspar, and disseminated pyrite and chalcopyrite, indicating the formation of sulfides as a result of fluid circulation (Thien et al., 2015).

The quartz vein rocks are enriched in Cu (~7,270 ppm), Zn (~236 ppm), and Bi (~74) compared to altered greenstone host rock (Cu ~ 1104, Zn ~ 79, and Bi below detection limit).

The observed mineral assemblage (Fig. 4) reveals early albitization, followed by intensive chloritization and later silicification and sericitization as the fluid cooled owing to water-rock interaction. This multi-stage hydrothermal evolution, the appearing sulfides and the observed geochemical data are typical of VMS stockwork feeder zones (Galley et al., 2005)

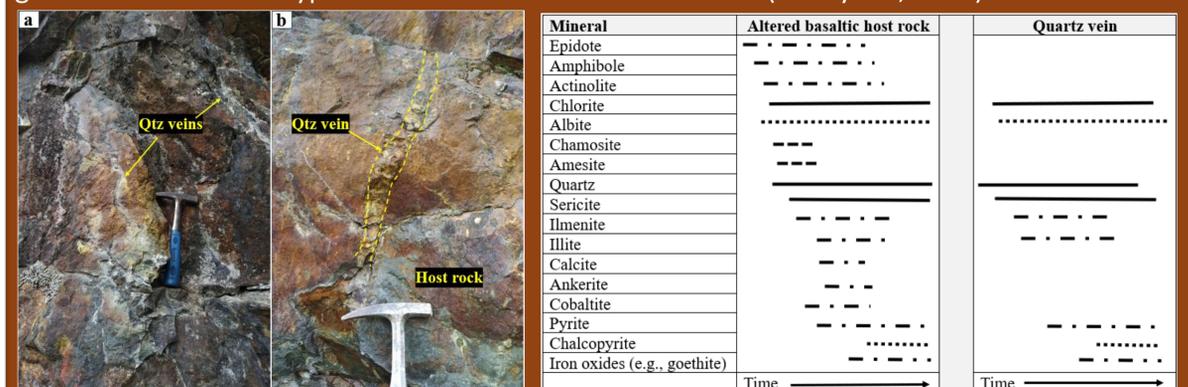


Figure 3. Field photographs showing the major rock units within the Brannberget area. a: highly altered host rock with stockwork zone and weathered surface. b: quartz vein cross-cutting through the host rock.

Figure 4. Mineral paragenetic sequence of the Brannberget basaltic host rock and associated quartz vein.

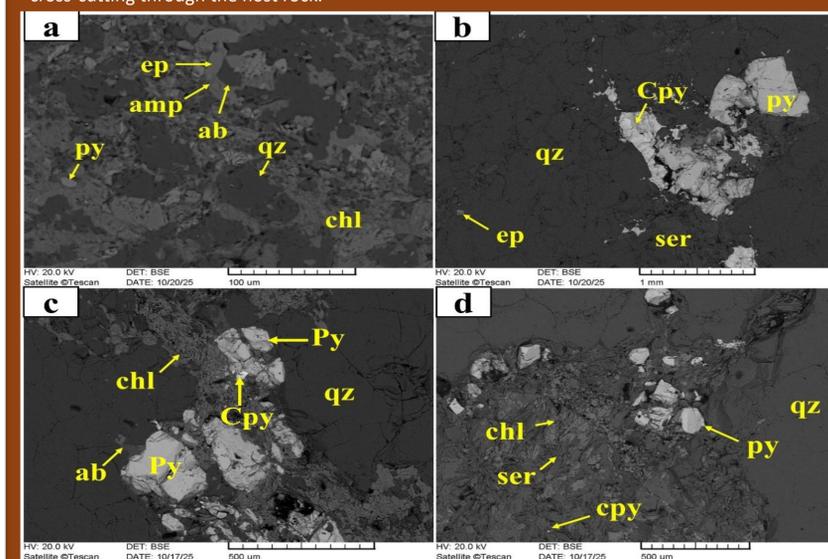


Figure 5. BSE images showing mineralogical composition and their textural features. a: Epidote (ep), amphibole (amp), quartz (qz), albite (ab) phenocryst are found in a fine-grained chlorite (chl) and sericite (ser) groundmass from the altered host rock. b: anhedral pyrite (py) grains surrounded by fine-grained quartz (qz) from the altered basaltic rock. c: chlorite (chl) filling open spaces between sulfide minerals from the quartz vein. d: pyrite grains together with fine-grained chlorite and sericite surrounded by quartz from the quartz vein.

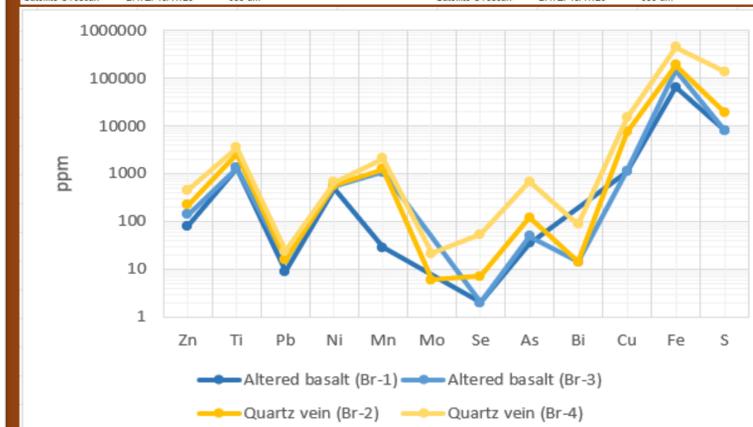


Figure 6. Spider-type diagram showing metal and trace elements concentrations of the studied samples from Brannberget. Strong Cu, Se, As and S enrichment in quartz vein relative to altered basalt host rock.

Note the high Cu/Zn ratio in the veins, which is a primary characteristic of VMS stockworks (compared to typical massive sulfides). The elevated S content of quartz vein samples suggest that sulfides are responsible for the high metal content.

Furthermore, the similar pattern observed in the altered basalt host and the quartz vein rocks shows the intensity of the alteration process and how the alteration mineralogy overprint the original basaltic characteristics.

CONCLUSIONS/FUTURE WORK

- The Brannberget area represents VMS stockwork feeder zone with Cu enrichment, however, it is hosted within basalt/dolerite and not gabbro as suggested previously.
- The Cu and Bi concentrations indicate some potential regarding CRW content, therefore further studies are suggested.