
All photos by Paul M. P. B. Meulenbeld unless otherwise noted

*Figure 1 (left).* Locality map of the Albert Silver mine, Mpumalanga, South Africa, prepared by William Besse.

*Figure 2 (below).* The Albert lode and Shaft 1 in the background.

# The ALBERT Silver Mine and TRIPPKEITE Occurrence

## Mpumalanga South Africa

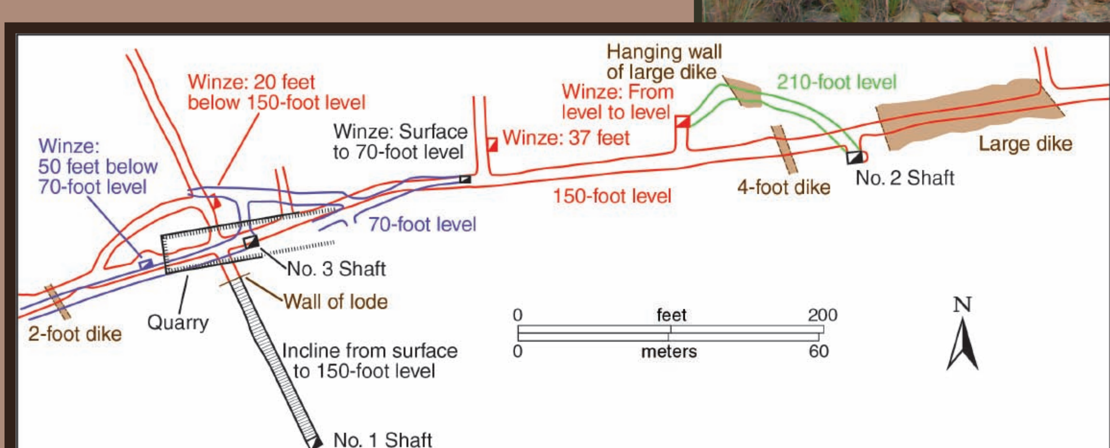


*Figure 3.* Plan of the underground workings at the Albert Silver mine based on Van Zijl (1965), prepared by William Besse.

**PAUL M. P. B. MEULENBELD**
**Department of Water Affairs**
**PO Box 1745**
**Bela Bela, South Africa**
**meulenbeldp@dwa.gov.za**

**WIEBKE GROTE**
**Department of Geology**
**University of Pretoria**
**Private Bag X20**
**Hatfield, Pretoria 0028**
**South Africa**
**wiebke.grote@up.ac.za**

**SABINE VERRYN**
**XRD Analytical & Consulting**
**75 Kafue Street**
**Lynnwood Glen**
**Pretoria 0081**
**South Africa**
**sabine.verryn@xrd.co.za**

# AROUND 1885

the ore deposit of the Albert Silver mine was discovered, and production continued intermittently until 1914 (Robb, Robb, and Walraven 1994). The Albert Silver mine is situated on the farm Roodepoortjie 250JR, north of Bronkhorstspruit, some 80 kilometers east-northeast of Pretoria in Mpumalanga, South Africa (fig. 1) (Robb, Robb, and Walraven 1994). No detailed description of the mine is known to have been published, but a layout plan and a plan indicating the extent of the underground workings (fig. 3), amongst a surface geophysical study of the ore bodies, was given by Van Zijl (1965). The old workings took the form of two development drives along the strike of the lode at the 23-meter and 47-meter levels below surface, together with a number of raises and winzes that passed the mineral alteration zone (Champion 1970). The mine is situated on and close to the southeastern bank of the Moos River. The topography is undulating countryside with gentle hills and granite outcrops, where depressions are caused by intrusions, mostly diabase.

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*Dr. Paul M. P. B. Meulenbeld is a scientific manager with the Department of Water Affairs, a trained geophysicist, and mineral collector. He has a sound knowledge about southern Africa's mineral deposits and visits abandoned mines in his spare time. One of his recent discoveries was the occurrence of chapmanite at the old Argent silver and lead deposit, Delmas, Mpumalanga, South Africa.*

*Wiebke Grote is responsible for XRD analysis at the Department of Geology, University of Pretoria; prior to this position she was the curator of the Geological Museum at the same institution.*

*Dr. Sabine Verryn is the owner of XRD Analytical & Consulting. She is the current vice chair of the Mineralogical Association of South Africa.*

*Figure 4.* **The Albert lode.**

marked on the surface by gossans to about 15 meters wide (fig. 4). The zone is laterally displaced along a northwest-trending diabase dike in the subsurface (Van Zijl 1965), as displayed in figure 5 from another locality on the surface (road cut). This dike divides the Albert lode into a western and an eastern sector. In addition to the Albert lode, there are minor intermediate lodes and a northern lode, which has a high uranium-hematite content (Champion 1970). The presence of uranium was indicated by a radiation counter (fig. 6). The mineralized veins are macroscopically characterized by an increase in the amount of quartz and the disappearance of feldspar relative to quartz (Van Zijl 1965). However, at the surface very little can be seen of the orebodies.

The Albert lode crops out most prominently in the immediate vicinity of the Moos River where it stands out as a resistant barrier to erosion when compared with the altered granite along its northern flank. Along the southern flank of the orebody the lode rises only about 0.3 meter above the general surface level. However, on the northern flank, overlooking the river, the lode consists predominantly of quartz and hematite and rises more than 2 meters above the granite of the flanking alteration zone, which has been highly weathered and eroded by the action of the nearby river (Champion 1970), such as at Shaft 3 (fig. 7).

According to Champion (1970), the lode continues as a prominent, slightly projecting body for a distance of about

The mine produced high grades of silver from 1885 until 1899 and then intermittently until 1914 (Robb, Robb, and Walraven 1994). During production the mine's ore was high-graded and yielded an estimated 20,000 tons of ore at 1.14 kilograms per ton silver and 10 percent copper. Results from explorations after the 1950s indicated ore reserves to a depth of 150 meters to be around 1.2 million tons at 73 grams per ton of silver, 0.42 percent copper, and 0.27 percent lead (Robb, Robb, and Walraven 1994). The history of the mine is well documented by Reeks (2012).

The mine was visited by the first author in February 2013 after some investigations about its location and access. The mine's locality was confirmed by the use of various maps (topographic and geological), Google Earth imagery, and an understanding of the area based on previous field work in this region.

Currently, the mine workings are flooded, making mineral collection impossible within the mine. Only the mine dumps are accessible, or where the Albert lode crops out and around the entrance portals to the shafts (fig. 2). The mine is located on remote private land, which restricts access.

## Geology

The ore deposit occurs in an east-west-trending, 700-meter-wide fissure zone of vertical quartz veins in pink to gray porphyritic Bushveld Igneous Complex granite, namely the Nebo Granite of the Lebowa Granite Suite. The margins of the fissure zone are

*Figure 5.* **A shale layer laterally displaced by a diabase dike, Ithala Nature Reserve, Louwsburg, KwaZulu-Natal, South Africa.**

*Figure 6.* **The presence of uranium indicated by an instant reading of 0.69 μSieverts/hour.**


150 meters east and 50 meters west of the river. To the west the orebody splits into a number of closely spaced hematite and quartz-hematite veins separated by layers of altered country rock. The western extremity of the body is not prominently exposed, but the minor veins are easily located due to the rocky nature of the steep slope leading down to the river. Some of the many barren crosscutting quartz veins that traverse the area are well exposed in this area. These bodies are coarsely crystalline and probably relate to the transverse dislocations that have occurred at a stage subsequent to mineralization. The crosscutting veins consist of successive paired layers of coarse-grained quartz that give the rock a sutured appearance.

The mineral assemblage comprises copper, silver, lead, antimony, and uranium. Copper and silver are the most abundant. Uranium occurs as microcrystals of uraninite, together with quartz, magnetite, hematite, and purple fluorite, a unique association in the Bushveld metallogenic province (Champion 1970; Martini and Vorster 1994). The principal sulfides in order of abundance are bornite, pyrite, chalcopyrite, tetrahedrite, and chalcocite (Van Zijl 1965). In addition, subordinate quantities of arsenopyrite, sphalerite, galena, and jamesonite occur. Hematite is a secondary product of pyrite. The sulfide paragenetic sequence is pyrite and arsenopyrite, sphalerite and tetrahedrite, galena and jamesonite, bornite and chalcocite, and, lastly, chalcopyrite. The deposit is mesothermal (Van Zijl 1965). Silver values are the highest in the western sector of the lode and are attributable partly to secondary native silver and partly to silver-bearing sulfides of low tenor of hypogene origin.

## Mineralogy

Many examples of supergene-enriched silver deposits are known, including the famous bonanza deposits of the Western Hemisphere that extended through the United States, Mexico, Central America, and along the western slopes of the South American Andes. From an extensive examination of the Albert Silver mine's ore assemblage by Champion (1970), it appears that the silver-bearing sulfides would be incapable of providing silver values as high as those encountered at the mine pre-1914. In addition, the discovery of argentite and native silver by Champion (1970) suggests that the silver values encountered partly owe their existence to supergene enrichment. The kind of mineralization at the Albert Silver mine has closely followed those described for the more famous supergene-enriched silver deposits of the Western Hemisphere, such as in Zacatecas, Mexico, and Chañarcillo, Chile. Structurally, the Albert Silver mine has followed the same sequence of events as Chañarcillo in that the ore-bearing veins of hypogene origin have been reopened during periods of displacement, thus permitting erosion and weathering to redistribute the silver minerals in the lode. The best examples of supergene leaching and enrichment are to

*Figure 7.* **Shaft 3 into the Albert lode. Note the secondary copper mineralization (green) on the lode.**

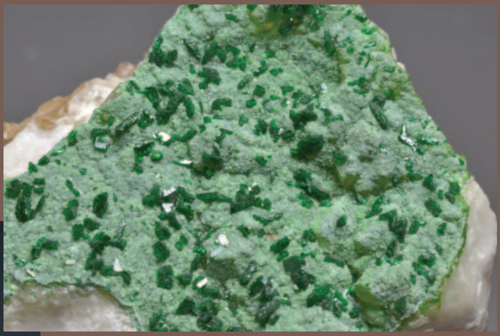
**Mineral occurrences at the Albert Silver mine.**

| Mineral | Composition | Reference |
|---|---|---|
| Acanthite | $Ag_2S$ | Cairncross and Dixon 1995 |
| Anglesite | $PbSO_4$ | XRD |
| Arsenopyrite | FeAsS | Van Zijl 1965; Champion 1970; XRD |
| Azurite | $Cu^{2+}_3(CO_3)_2(OH)_2$ | Champion 1970 |
| Bornite | $Cu_5FeS_4$ | Van Zijl 1965; Champion 1970 |
| Brochantite | $Cu^{2+}_4(SO_4)(OH)_6$ | XRD |
| Calcite | $CaCO_3$ | Champion 1970 |
| Cassiterite (adjacent to the copper lode) | $SnO_2$ | Cairncross and Dixon 1995 |
| Cerussite | $PbCO_3$ | XRD |
| Chalcanthite | $Cu^{2+}SO_4 \cdot 5H_2O$ | Champion 1970 |
| Chalcocite | $Cu_2S$ | Van Zijl 1965 |
| Chalcopyrite | $CuFeS_2$ | Van Zijl 1965; Champion 1970; XRD |
| Chlorite | group collective name | Champion 1970 |
| Clinoclase | $Cu^{2+}_3(AsO_4)(OH)_3$ | XRD |
| Covellite | CuS | Champion 1970; XRD |
| Fluorite | $CaF_2$ | Champion 1970 |
| Galena | PbS | Van Zijl 1965; Champion 1970 |
| Gold | Au | Champion 1970; Cairncross and Dixon 1995 |
| Hematite/specularite (oxidized portions of the lode) | $\alpha$-$Fe_2O_3$ | Van Zijl 1965; Champion 1970; XRD |
| Jamesonite | $Pb_4FeSb_6S_{14}$ | Van Zijl 1965 |
| Libethenite | $Cu^{2+}_2(PO_4)(OH)$ | Cairncross and Dixon 1995 |
| Limonite | $\alpha$-$Fe^{3+}O(OH)$ | Champion 1970 |
| Linarite | $PbCu^{2+}(SO_4)(OH)_2$ | XRD |
| Lindackerite-group (turquoise blue) | $H_2Cu^{2+}_5(AsO_4)_4 \cdot 8–9H_2O$ | Champion 1970 |
| Malachite | $Cu^{2+}_2(CO_3)(OH)_2$ | Champion 1970; Cairncross and Dixon 1995; XRD |
| Magnetite | $Fe^{2+}Fe^{3+}_2O_4$ | Champion 1970 |
| Marshite | CuI | XRD |
| Metatorbernite | $Cu^{2+}(UO_2)_2(PO_4)_2 \cdot 8H_2O$ | Cairncross and Dixon 1995 |
| Metazeunerite | $Cu^{2+}(UO_2)_2(AsO_4)_2 \cdot 8H_2O$ | Champion 1970; Cairncross and Dixon 1995 |
| Molybdenite | $MoS_2$ | Champion 1970 |
| Muscovite | $KAl_2(Si_3Al)O_{10}(OH,F)_2$ | XRD |
| Olivenite | $Cu^{2+}_2(AsO_4)(OH)$ | Cairncross and Dixon 1995 |
| Onoratoite | $Sb_8O_{11}Cl_2$ | XRD |
| Pitchblende | $UO_2$ | Champion 1970 |
| Pyrite | $FeS_2$ | Van Zijl 1965; Champion 1970 |
| Quartz (gangue), variety jasperoid and milky | $SiO_2$ | Van Zijl 1965; XRD |
| Siderite | $Fe^{2+}CO_3$ | Van Zijl 1965 |
| Silver | Ag | Cairncross and Dixon 1995 |
| Sphalerite | (Zn,Fe)S | Van Zijl 1965; Champion 1970 |
| Sulfantimonides | yellow complex Bi, As, Sb, Pb oxides | Champion 1970 |
| Tennantite | $(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$ | Cairncross and Dixon 1995; XRD |
| Tetrahedrite | $(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$ | Van Zijl 1965; Champion 1970; Cairncross and Dixon 1995 |
| Torbernite | $Cu^{2+}(UO_2)_2(PO_4)_2 \cdot 8–12H_2O$ | Cairncross and Dixon 1995 |
| Trippkeite | $CuAs_2O_4$ | XRD |
| Uraninite | $UO_2$ | Cairncross and Dixon 1995 |
| Zeunerite | $Cu^{2+}(UO_2)_2(AsO_4)_2 \cdot 10–16H_2O$ | Cairncross and Dixon 1995 |

*Note:* The compositions given for previously reported minerals are taken from Fleisher and Mandarino (1995). This study's mineral analyses are referenced as XRD, as all were confirmed by XRD analysis.

be found in pyrite-bearing silver and copper deposits (Park and McDiarmid 1963).

The presence of trippkeite, a copper arsenite, in association with malachite is only known from Bou Azzer, Morocco (Favreau et al. 2007), as represented in the first author's mineral collection (fig. 8). The association is not similar, as the malachite is a distinct later-generation cover on the trippkeite, whereas at the Albert Silver mine the minerals are a mixture of each other and responsible for the pale green coating in and on quartz crystals (fig. 9), and the quartz-trippkeite-malachite are encountered in the Albert lode (hematite dominated). However, the Co-Ni-As mineralization at Bou Azzer is associated with serpentinites, dolomite, granite, gabbro, and quartz diorite along various secondary



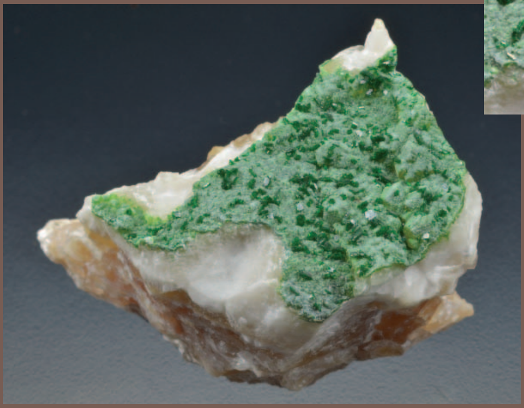
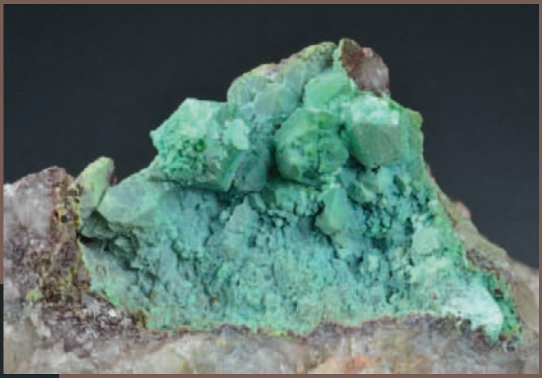


*Figure 8.* Trippkeite (pale green) and malachite (dark green needles), Bou Azzer, Morocco. Paul Meulenbeld specimen, 22 × 26 × 38 mm.

Photos this page by Bruce Cairncross



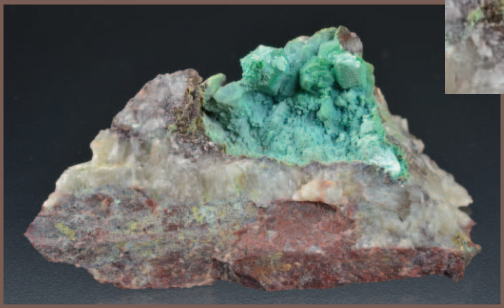


*Figure 9.* Trippkeite and malachite mixture, Albert Silver mine. Paul Meulenbeld specimen, 37 × 46 ×70 mm.

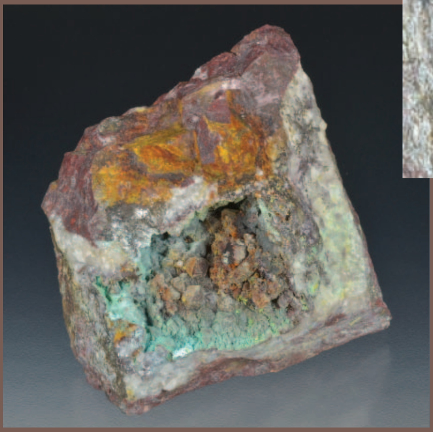


*Figure 10.* Hematite inclusions in quartz (red) with minor trippkeite and malachite coatings on smaller quartz crystals, Albert Silver mine. Paul Meulenbeld specimen, 64 × 65 × 86 mm.

structures such as faults and brecciated zones (Favreau et al. 2007) and is distinctly different from that at the Albert Silver mine.

The inclusion of distinct hematite coloring within quartz crystals (fig. 10) is similar to quartz crystals associated with the Messina (Musina) Copper Mines, Limpopo, South Africa (Cairncross 1991).

The mineral samples collected during the February 2013 visit were subsequently analyzed by X-ray diffraction (XRD) at both the Department of Geology at the University of Pretoria and at XRD Analytical & Consulting. The XRD analyses revealed numerous secondary copper minerals in association with sulfates and arsenates (for example, linarite) (fig. 11). As in previous studies by Van Zijl (1965), Champion

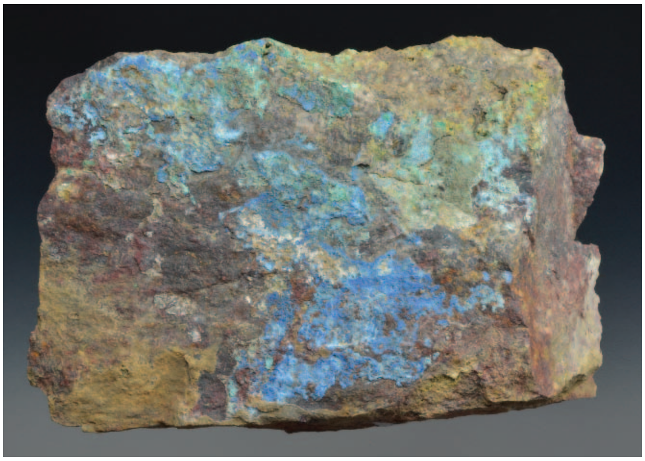


***Figure 11.*** **Linarite (pale blue) and brochantite (pale green) with minor clinoclase on a fragment of the Albert lode, Albert Silver mine. Paul Meulenbeld specimen, 56 × 103 × 136 mm.**

(1970), and Cairncross and Dixon (1995), the contribution of sulfide and arsenic to the formation of secondary minerals was less obvious. These mineral assemblages indicate that the Albert Silver mine is also a source of arsenic, which is not common in South Africa's mineral deposits.

The minerals so far described from the Albert Silver mine are given in the table.

**ACKNOWLEDGMENTS**

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