

# Native gold, native silver, and secondary minerals in the quartz veins from Bastogne, Belgium

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## Abstract

Native gold, native silver, and secondary minerals (cerussite, pyromorphite, wulfenite, acanthite, linarite, wroewolfeite, chrysocolla) were identified in the quartz veins crosscutting the Lower Siegenian quartzites and schists from Bastogne. Native silver, acanthite, linarite, wroewolfeite and chrysocolla are new mineral species for Belgium.

These minerals are characterized by qualitative chemical analysis and by X-ray powder diffractometry. The parameters of the wulfenite tetragonal unit-cell have also been calculated:  $a = 5.429(1) \text{ \AA}$  and  $c = 12.097(6) \text{ \AA}$ .

Genetic relationships between primary and secondary minerals have been established.

**Key-words:** Native gold, native silver, secondary minerals, Bastogne, Belgium.

## Résumé

De l'or natif, de l'argent natif et des minéraux secondaires (cérusite, pyromorphite, wulfénite, acanthite, linarite, wroewolfeite, chrysocolle) ont été reconnus dans les veines de quartz recoupant les quartzites et les phyllades du Siegenien inférieur de Bastogne. L'argent natif, l'acanthite, la linarite, la wroewolfeite et la chrysocolle sont de nouvelles espèces pour la Belgique.

Ces minéraux ont été identifiés par analyse chimique qualitative et par diffraction de rayons X (méthode des poudres). Les paramètres de la maille quadratique de la wulfénite ont été calculés:  $a = 5,429(1) \text{ \AA}$  et  $c = 12,097(6) \text{ \AA}$ .

Les relations génétiques entre minéraux primaires et secondaires ont également été établies.

**Mots-clefs:** or natif, argent natif, minéraux secondaires, Bastogne, Belgique.

## Introduction

In the region of Bastogne (Belgian Ardennes), the "boudins", which occur in the Lower Siegenian sandstones and quartzites, are separated by quartz lenses. These lenses are characterized by a rich mineralogy. Biotite, the most abundant mineral of the lenses, was already identified by André Dumont (*in* BUTTGENBACH, 1947). CORIN (1931) described xenotime, whereas chamosite was analyzed by MÉLON *et al.* (1976).

More recently, the discovery of titanite together with fluorapatite, albite and chamosite (HATERT *et al.*, 1996), was the origin of the investigation of new samples from

the quarry "Sur les Roches" near Bastogne. Native gold, native silver and several secondary minerals associated with the sulfides have been identified.

The aim of the present study is to complete the mineralogical inventory of the quartz lenses of Bastogne. In addition to native gold, cerussite, pyromorphite and wulfenite, previously mentioned Belgium, native silver, acanthite, linarite, wroewolfeite and chrysocolla are five new occurrences for the country.

## Analytical methods

Mineralogical identifications were performed by X-ray diffraction using a 114.6 mm Debye-Scherrer camera (Ni-filtered Cu radiation). The lattice parameters of wulfenite were calculated with the LCLSQ program, version 8.4 (BURNHAM, 1991), starting from  $d$  values corrected by the Straumanis method.

Qualitative chemical analyses have been performed using a scanning electron microscope JEOL JSM-840A, equipped with EDS detector.

## Mineralogical descriptions

### GOLD, Au

As disseminations on some samples of Siegenian quartzite, native gold does not seem to be directly related to the quartz lenses. Associated with pyrrhotite and chalcopyrite, this mineral occurs as metallic flakes up to 5 mm, with an irregular outline. Chemical analysis confirms the presence of major Au, associated with lower quantities of Ag.

According to MÉLON *et al.* (1976), native gold has been worked in the past in brooks around the Cambrian Massif of Serpont. Its presence near Bastogne had never been mentioned. Moreover, the presence of gold in the host rocks had up to now only been reported in a quartz vein at Bovigny (LEPERSONNE, 1934; GILLET, 1970).

### SILVER, Ag

Native silver occurs as dendritic aggregates up to 3 mm

long, associated with altered galena (Plate 1a). The aggregates are formed by entangled crystals among which two forms are observed: the cube {100} and the rhombododecahedron {110} (Plate 1b).

The identification of this mineral has been confirmed by chemical analysis which shows Ag with minor Cu, Zn, I, and Cl. The two last elements are probably related to the presence of halogenides such as iodargyrite, AgI, or chlorargyrite, AgCl.

MÉLON *et al.* (1976) only mentioned Belgian silver as corrugated filaments on the surface of a dolomitic sample of highly doubtful origin, and registered in the mineralogical collection of the University of Liège. Native silver from Bastogne is thus probably the first occurrence of that mineral in Belgium.

#### ACANTHITE, $Ag_2S$

Acanthite occurs as fibroradiated tufts of black crystals less than 100  $\mu m$  in size, covering dendrites of native silver (Plate 2a). X-ray powder pattern is similar to that of synthetic acanthite (JCPDS 14-72). A qualitative chemical analysis confirms the presence of major Ag and S, together with minor Cu, Zn and Cl.

#### CERUSSITE, $PbCO_3$

Associated with altered galena, cerussite occurs as colourless to honey brown crystals with a greasy luster and a maximum size of 5 mm. Goniometric measurements on bipyramidal crystals clearly show the (110) pseudohexagonal twin. Depending on the development of the faces parallel to *c*, either an isometric facies (Plate 2b) or a prismatic one can be distinguished. Twinned crystals are frequent with the dominant forms {110}, {010}, {111}

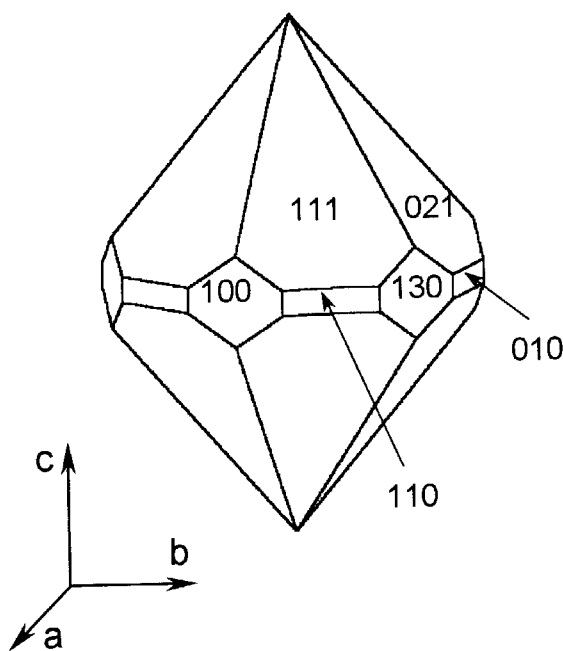


Fig. 1 — Crystal forms of cerussite from Bastogne. The drawing has been performed with the SHAPE software (DOWTY, 1994).

and {021}, less commonly associated with the forms {100}, {114} and {012}. Some less abundant isometric crystals, apparently not twinned, show the combination of the forms {100}{110}{130}{010}{111}{021} (Figure 1). It is the first occurrence of bipyramidal crystals in Belgium, which recalls the morphology of cerussite crystals from Mibladen, Morocco.

Cerussite has been identified by X-ray diffraction whereas the chemical analysis showed minor Cu, Fe, Zn, Cd and Ni associated with Pb.

#### LINARITE, $PbCuSO_4(OH)_2$

Linarite forms fan-like aggregates of tiny tabular crystals up to 500  $\mu m$ , and a light blue color. The mineral is closely associated with cerussite and chalcopyrite. X-ray powder data are similar to those of linarite from the Mammoth mine, Arizona, USA (JCPDS 30-493). Chemical analysis reveals major Cu, Pb and S with low proportions of Cl.

#### WROEWOLFEITE, $Cu_4SO_4(OH)_6 \cdot 2H_2O$

Wroewolfeite exists as microcrystalline turquoise blue coatings of acicular crystals averaging 100  $\mu m$ . X-ray powder pattern of this rare mineral agrees with that of wroewolfeite from Loudville mine, Massachusetts, USA (JCPDS 27-1133). Chemical analysis only confirms Cu and S.

#### PYROMORPHITE, $Pb_5(PO_4)_3Cl$

The lead phosphate is closely associated with galena from which it derives by alteration. It occurs as microcrystalline apple green coatings on the inner side of some cavities in the quartz lenses. Viewed under the scanning electron microscope, the crystals, less than 50  $\mu m$  in size, appear to be formed by a prism {1010} extended by curved faces (Plate 3a).

Qualitative chemical analysis shows major Pb, P and Cl with lower quantities of Ca, Cd and As.

#### WULFENITE, $PbMoO_4$

Associated with altered galena and with pyromorphite, wulfenite occurs as isolated crystals up to 2 mm. They are orange-coloured, with a greasy luster. Crystals generally form very acute tetragonal dipyrramids with curved faces (Plate 3b) unsuitable for goniometric measurements. Wulfenite crystallizes also as {101} tetragonal dipyrramids, of which the orientation has been checked by X-ray diffraction. These crystals are sometimes modified by the forms {001} and {1k0}, with a relatively high *k* value difficult to determine with the classical goniometric methods. Both prismatic (Figure 2a) and tabular (Figure 2b) crystals exist. Some tabular crystals give the combination {100} {001}, sometimes modified by the small faces {101} (Figure 2c). It is to be pointed out that tabular crystals of wulfenite, as well as crystals with {1k0} faces, had never been observed in Belgium as far.

The parameters of the tetragonal unit-cell of wulfenite from Bastogne have been calculated from 26 reflections:  $a = 5.429(1) \text{ \AA}$  and  $c = 12.097(6) \text{ \AA}$ . These values

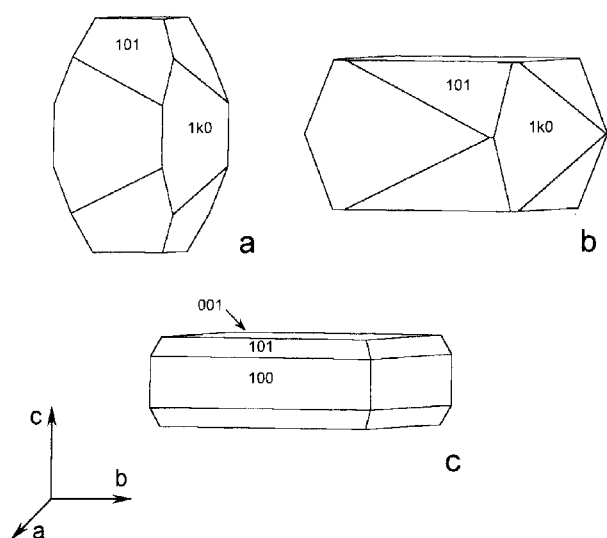


Fig. 2 — Crystal forms of wulfenite from Bastogne. The drawings have been performed with the SHAPE software (DOWTY, 1994).

correspond better with those given by FRANSOLET *et al.* (1977) for the wulfenite from Richelle than with those given by HATERT *et al.* (1998) for the wulfenite from Vielsalm.

Chemical analysis shows Pb and Mo together with minor Fe and Cd. The presence of noticeable quantities of Fe and Cu into the lattice of the wulfenite from Vielsalm (HATERT *et al.*, 1998) could be responsible for the lower values of its unit-cell parameters when compared with these calculated for minerals from Bastogne and Richelle.

#### CHRYSOCOLLA, $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

The turquoise blue coatings of chrysocolla resemble wroewolfeite but can be distinguished by their conchoidal fracture. The mineral has been identified by X-ray diffraction and its composition confirmed by a chemical analysis. In addition to Si and Cu, Zn, Mn, Fe, Ca and S exist as minor elements.

### Discussion

During the last few years, the number of minerals which occur in the quartz lenses of Bastogne progressively

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Table 1 — Relationships between primary and secondary minerals occurring in the quartz lenses from Bastogne

Primary minerals	Secondary minerals
Pyrite, marcasite, chalcocopyrite, pyrrhotite	→ Goethite
Ilmenite, titanite	→ Rutile, anatase
Silver	→ Acanthite
Chalcocopyrite	→ Malachite, wroewolfeite, chrysocolla
Chalcocopyrite + galena	→ Linarite
Galena	→ Pyromorphite, cerussite, wulfenite

increases. The new species include both primary and secondary minerals.

Primary minerals have crystallized during the formation of the quartz lenses. The conditions of temperature and pressure were very close to those existing during the metamorphism peak. The paragenesis of Bastogne, which is similar to that of the Alpine fractures (HATERT *et al.*, 1996), mainly includes chamosite, biotite, muscovite, albite, titanite, fluorapatite and ilmenite, with as less abundant minerals xenotime, pyrite, marcasite, galena, chalcocopyrite, native gold and pyrrhotite.

The secondary minerals, which are reported in this paper, result from the oxydation of the primary minerals. The following species have been observed: goethite, rutile, anatase, acanthite, malachite, wroewolfeite, chrysocolla, linarite, cerussite, pyromorphite and wulfenite. Relationships between primary and secondary minerals are given on Table 1.

The origin of native silver, formed by alteration of galena, is not evident. Either silver is a primary mineral present as inclusions into galena, or silver has a secondary origin. In this case low amounts of silver, which were disseminated in the lattice of galena, have been released during alteration and then crystallized as native silver.

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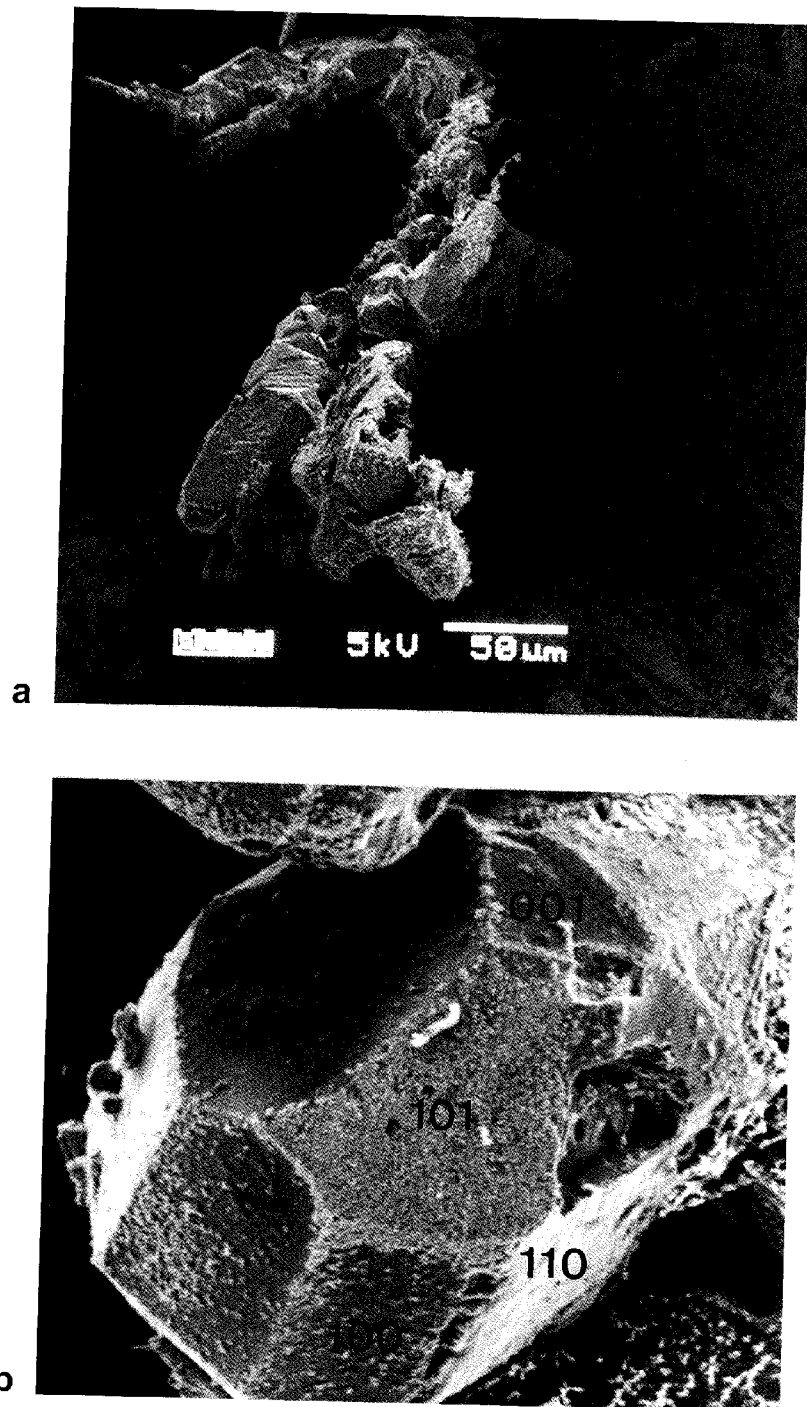


Plate 1 — a. Dendritic aggregate of native silver crystals, Bastogne. b. Isolated crystal of native silver showing the cube {100} and the rhombododecahedron {110}, Bastogne.

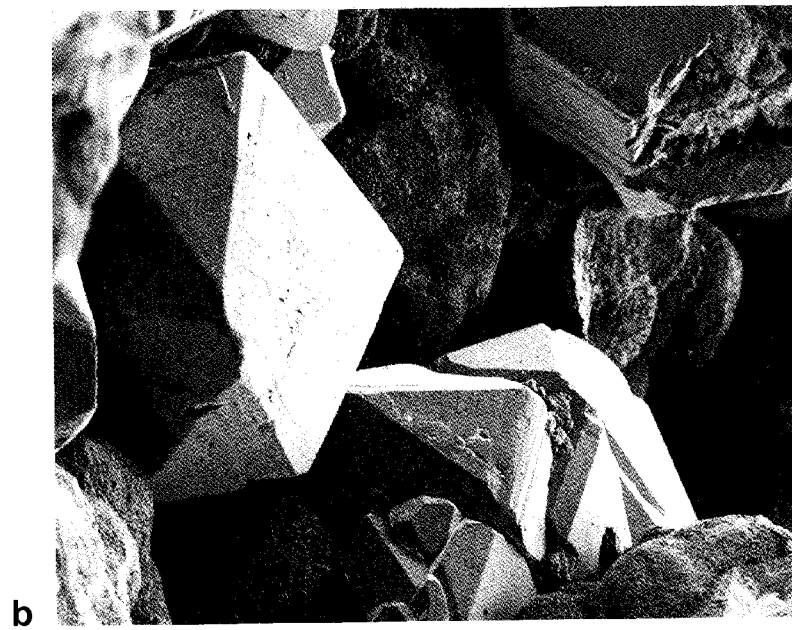


Plate 2 — a. Fibroradiated tufts of acanthite crystals, Bastogne. b. Pseudohexagonal twin of cerussite crystals, Bastogne.

Plate 3 —

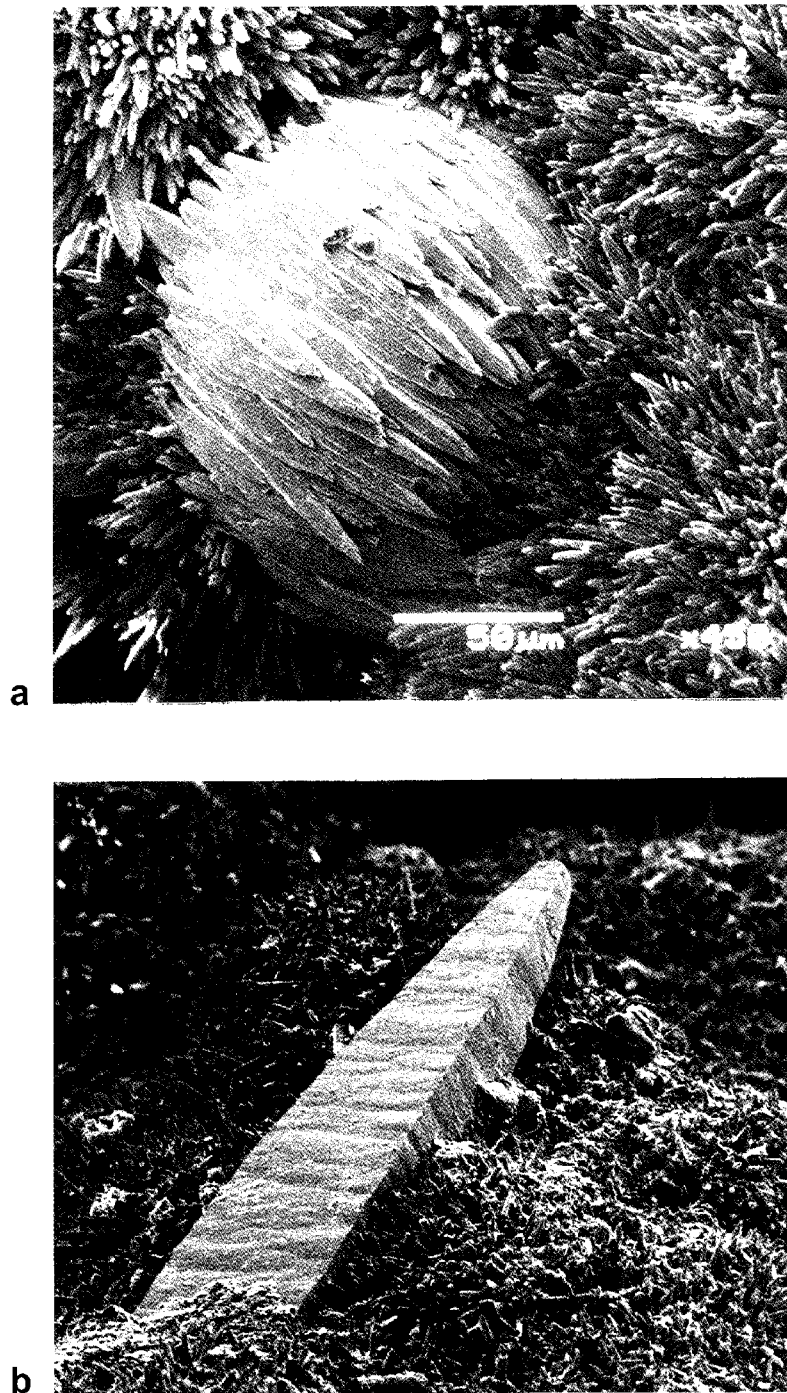


Plate 3 — a. Aggregate of pyromorphite crystals, Bastogne. b. Acute tetragonal dipyramid of wulfenite, lying on a pyromorphite coating, Bastogne.