THE MINERALS OF PŘÍBRAM

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Among the old European metal mines, especially those of lead and silver, Příbram in Bohemia is one of the most famous, both from the mineralogical and technical as well as from the historical points of view. Not less interesting are the geological features of the Příbram region with its classical outcrops and fossil occurrences of the Cambrian (near Jince) and with its rich and variable development of Algonkian sediments and eruptives.

The city of Příbram, situated 82 kilometers southwest of Prague, is almost connected with the town of Březové Hory (=Birch Mounts), the center of the mining industry of to-day. Both Příbram and Březové Hory are located in Cambrian graywackes and sandstones which form a syncline underlain in the south-east Algonkian schists, beyond which the granite massive of cental Bohemia with its more basic differentiation products (quartz diorites, etc.), intrude and metamorphose the sediments.

In the north-west a great fault, called the Clay Fault (Jílová rozsedlina, Lettenkluft), separates the Cambrian formation from a second body of Algonkian schists over which again lie Cambrian conglomerates forming the mighty mountain chain of Brdy.

In general, the strata trend north-east and dip north-west except that portion of the Cambrian sediments along the Clay Fault, which form the northern wing of the synclinal cut off by the Fault. In this part where the dips are south-east and the beds are badly dislocated and are penetrated by numerous diabase dykes, the metalliferous veins are concentrated.

This briefly is the geological situation of the Příbram region, well known through the publications of Pošepný and his predecessors. Recently Mr. Kettner has made important contributions to the stratigraphy of the Cambrian formation and the tectonic features of this part of the Barrandien; his comprehensive paper on the geology of Příbram was published by the Czechoslovakian Geological Survey (vol. 5, 1925).

The metalliferous veins of Příbram accompany in most cases the diabase dykes, trending northerly with them and dipping almost vertically to the east. All principal veins lie in the "first graywacke" zone of Březové Hory; some veins however are of a different character and are included in the small quartz diorite massive of

Bohutín, south-west of Březové Hory, and in the Algonkian "second slate zone."

The vein filling at Příbram is very complicated and varies in different parts of the mining district and at different depths. The paragenesis of the Příbram veins has been studied by August E. Reuss[1] who discovered twenty-seven generations of minerals. An additional generation has been added by Adolf Hofman.[2] This list of succession is based on the observation of symmetrical development of the veins, which in Reuss' time was predominant in the whole district, in the upper horizons and to a depth of 650–700 meters. However at greater depths many of the veins become less interesting and the filling consists almost entirely of fine grained quartz with disseminated inclusions of sulphide ores; almost without a trace of symmetrical banding and with variable metallic values. This quartz filling is called at Příbram "krušek." In 1910 the late professor Adolf Hofman and the writer carried out a detailed microscopic study of the "krušek" of the mining district Březové Hory. The paragenesis and texture of the "krušek" seem to indicate a combination of four or five of the oldest members of Reuss' paragenetic series. The microscopical presence of cassiterite and the determination of diaphorite as the principal silver mineral in the "krušek" is interesting. We regard, therefore, the "krušeks" as those parts of the veins prevailing at depths where the entire opening has been filled with the oldest minerals and lacking the symmetrical banding caused by later depositions. Local changes produced various complications but the view that the "Krušek" fillings are an independent second generation of veins, younger than the symmetrical ones, is not supported by comparative observations in the new mine openings.

In the paragentic series of Reuss, Babánek and Hofmann, the following generations of minerals are enumerated:

1. Sphalerite I.
2. Galenite I.
3. Quartz I.
4. Siderite (all)

(1–4: Often alternating and grown together, sometimes with admixtures of minerals from the following (5) sequence.)

5. Sulphide minerals and sulphosalts containing copper, lead, silver, arsenic and antimony; locally cobalt, nickel ores and cobaltiferous dolomite; uraninite, found very sparingly, also seems to belong to this period of formation.

[1] A. E. Reuss; *Sitzungsb. Akad. Wiss. Wien*, **1856** and **1863**.

[2] Hofman and Slavik; *Rozpravy and Bull. international of the Czech Acad. of Sciences*, **1920**.

6. Sphalerite II, apatite.
7. Barite I, gray large crystals of rectangular size with a dolomite crust.
8. Calcite I and pyrite I.
9. Calcite II.
10. Dolomite II.
11. Galenite II. (including so-called steinmannite, octahedral crystals with rounded corners).
12. Calcite III.
13. Pyrite II with younger sulphosalts (pyrargyrite, proustite, polybasite, pyrostilpnite), marcasite, pyrrhotite. Cronstedtite and lillite are alteration products.
14. Goethite ("velvet ore").
15. Calcite IV.
16. Quartz II.
17. Dolomite III.
18. Witherite.
19. Metallic silver (partly changed to argentite) and millerite.
20. Cerussite.
21. Smithsonite, hemimorphite, brown iron ore, psilomelane and pyrolusite.
22. Pyromorphite and campylite.
23. Wulfenite.
24. Barite II, transparent prismatic crystals with (102) dominant, of yellow and bluish colors.
25. Valentinite.
26. Calcite V.
27. Pyrite III.
28. Quite recent products of weathering include: malachite, xanthochroite, erythrite, annabergite, pharmacolite, zippeite; aragonite crusts on mine timber, formerly thought to be hydrozincite; gypsum.

Some of the minerals of Příbram, especially those found recently, are not included in this series because of their uncertain position, such as arsenic, antimony, allemontite, copper, hematite, kermesite and gummite; palygorskite.

Some doubts have been expressed as to the exactness of this detailed paragenetic list, and indeed it is hardly possible to prove for *every* mineral its place in the succession; some of the determinations, especially those in the second part of the series, have been based on isolated observations. The main features of the paragenesis, however, are remarkably constant in all Příbram veins, *e.g.* all siderite is older than all the other carbonates and we never find it among the younger oxide salts; the differences between the two generations of barite are very distinct, those between the five generations of calcite less so, but still discernible, etc. From a more genetic point of view there is no doubt but that this succession of minerals corresponds to stages of chemical deposition from solutions of decreasing temperatures, and that the metallic substances originated in the granitic magma of the Middle-Bohemian massive, as indicated also by the presence of some typically granitic-pneumatolytic minerals, cassiterite, scheelite, uraninite, etc.

In the earliest phases, the ore and gangue minerals of the first four or five numbers of Reuss' series were deposited almost contemporaneously, and therefore a more massive vein structure resulted, as in the "krušek." The following stage of vein filling is characterized by the presence of carbonates and the first generation of barite; among the sulphide minerals, sulphosalts are frequent. In this period undoubtedly ascending solutions were still the main sources for ore deposition and locally they changed their chemical character rather quickly, causing the well developed banded structure of the veins. In the third period (from Nos. 14 to 28 in Reuss' series), an intense oxidation of the sulphide minerals took place, and the native elements silver and copper were also formed. The genetic features of the oxydized minerals need further study to determine their relationsip to the older vein minerals and to the alteration products. It may be noted in passing that goethite (typical velvet ore) was found in 1918 at the 27th horizon, over 800 metres below the surface and that the beautiful crystals of the younger barite certainly can not be placed with the typical gossan minerals (numbers 20–22 of Reuss' series).

To the mineralogist Příbram is well known as the locality for numerous minerals, some of which are quite rare. Many of them have been found in magnificent specimens. The number of mineral species found at Příbram is over seventy. The following is a tabulated list.

(a) Native Elements

1. Arsenic } Allemontite has been shown to be an intimate mixture of
2. Antimony } arsenic and antimony.
3. Copper
4. Silver

(b) Sulphides and Sulphosalts

5. Stibnite, frequently in veins cutting the quartz diorite of Bohutín.
6. Sphalerite
7. Wurtzite, for which Příbram is the classical locality.
8. Xanthochroite
9. Niccolite
10. Millerite, very rare.

11. Pyrrhotite
12. Galena and so called steinmannite.
13. Argentite
14. Chalcocite
15. Pyrite (also in pseudomorphs after pyrrhotite and polybasite).
16. Smaltite
17. Chloanthite
18. Marcasite
19. Arsenopyrite
20. Löllingite—"leucopyrite"
21. Chalcopyrite
22. Bornite
23. Miargyrite
24. Berthièrite, at Bohutín with stibnite.
25. "Feather ores," described as boulangerite, to which most of the best specimens seem to belong; and jamesonite, the existence of which is, however, questioned because of the absence of basal cleavage.
26. Diaphorite, described for the first time from Příbram by von Zepharovich in 1871.
27. Proustite
28. Pyrargyrite, often very well crystalized.
29. Pyrostilpnite ("fire blende").
30. Bournonite, found to this day in large tabular twinned crystals of simple combinations.
31. Tetrahedrite, argentiferous.
32. Stephanite, classical material of Vrba's monograph.
33. Polybasite
34. Stannite, only microscopic inclusions in galena.
35. Kermesite

(c) Oxydes

36. Valentinite, rare and at present exhausted.
37. Quartz
38. Cassiterite, only microscopic in the "krušek".
39. Pyrolusite, principally at Narysov, S. W. from Příbram.
40. Uraninite, found locally.
41. Hematite, subordinate.
42. Goethite, mostly as spherules with a finely fibrous structure ("velvet ore").
43. Brown iron ore
44. Psilomelane
45. Wad

(d) Carbonates

46. Calcite
47. Dolomite
48. Siderite
49. Smithsonite
50. Aragonite
51. Witherite, very rare, at Bohutín.

52. Cerussite in numerous forms, commonly in twins.
53. Malachite
54. Azurite

(e) Sulphates, etc.

55. Barite in two generations (see above).
56. Scheelite, found only once in very few specimens.
57. Wulfenite, in gray prismatic and tabular crystals, formerly more frequent.
58. Gypsum
59. Zippeite alteration product of uraninite

(f) Phosphates and Arsenates

60. Apatite, almost colorless, in tabular crystals, rare.
61. Pyromorphite, one of the most frequent gossan minerals.
62. Campylite
63. Mimetite
64. Vivianite, accidentally formed on bones in an abandoned mine at Bohutín.
65. Erythrite
66. Annabergite
67. Pharmacolite
68. Pitticite.

(g) Silicates

69. Hemimorphite
70. Palygorskite (xylotile)
71. Cronstedtite, first described in 1820 from Příbram and known from very few other localities.
73. Lillite, imperfectly known leptochloritic mineral, found at Příbram, as an alteration product of pyrite, associated with "velvet ore."
74. Kaolinite
75. Gummite, rare alteration product of uraninite.

Outside of the veins, as secondary minerals in diabase, epidote, chabazite, harmotome and desmine have been found.

A beautiful collection of Příbram minerals and vein specimens are exhibited in the National Museum at Prague; and in the Mining Directory and High School in Příbram.

While the story of the mining at Příbram dates from the 14th century it was not until the beginning of the 16th century that the mines were extensively worked. In 1875, the Adalbert mine was the only mine in the world reaching a depth of 1000 meters. Actually, the mine workings are limited to the central part of the "first graywacke zone" at Březové Hory and to a less extent, to the quartz diorite of Bohutín. All mines are State possessions.

The Mining High School was founded in 1849; the Mineralogical Laboratory was united with the Geological Department until 1920. Among the numerous professors who have been connected with this school, Professor František Pošepny is perhaps the best known.