# Spencerite, a new Zinc Phosphate from British Columbia.[1]

By T. L. WALKER, M.A., Ph.D., F.G.S.

Professor of Mineralogy, University of Toronto; Director of the Royal Ontario Museum of Mineralogy.

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THE mineral described in this paper occurs at the Hudson Bay zinc mine about five miles east of Salmo, near Nelson in the West Kootenay district of British Columbia. I regret that I have no data as to the exact character of the ore-body except that it occurs in a region where palaeozoic rocks are intruded by biotite-granite and that it is probably genetically connected with the intrusion of the latter. The zinc occurs in the form of the silicate and to a less extent the carbonate. There is also a small amount of oxidized lead-ore, principally cerussite. The main mass of the ore as shipped consists of these minerals mingled with soft friable limonite. In 1915 four thousand tons of ore, said to carry thirty per cent. of zinc, were shipped from this mine to smelters in the United States.

The silicate (hemimorphite), which is the chief economic mineral, forms banded mamillary masses or is a participant in building stalactitic structures. Only rarely is it crystallized, and it then occurs in cavities in the limonite either as small, fan-shaped structures or as radiating clusters of small, clear crystals which are too small for satisfactory goniometric examination.

The mineral here described forms the central portion of these stalactitic growths, being surrounded by a shell of hemimorphite. Sometimes as

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[1] An abstract of this paper appeared in ' Nature ', June 29, 1916, vol. xcvii, p. 375, and Geol. Mag., July 1916, vol. iii, p. 336. In the meantime the same mineral, from the same locality and under the name spencerite, has been briefly described by A. H. Phillips, Amer. Journ. Sci., September 1916, ser. 4, vol. xlii, p. 275. The results of his analysis confirm the chemical formula given below.

a result of solution of the outer zone of the spencerite there is formed, between the silicate and the core of spencerite, an open space into which exceedingly delicate plates of hemimorphite project from the outer wall. This has apparently been brought about by the solution of the outer part of the spencerite, the thin plates of hemimorphite having been included in the spencerite along cleavage-planes before the solution occurred. This type of silicate is spherulitic in structure and is found occasionally in the spencerite in minute, flat plates following the best cleavage. It is readily recognized when the mineral is examined between crossed nicols by the presence of a black cross for each spherulitic individual.

## Chemical Properties.

The mineral dissolves very readily in acids. On adding ammonia to the acid solution a heavy white precipitate forms and dissolves in excess of the reagent. In this respect spencerite resembles the phosphates of zinc previously described. The quantitative analysis shows that the mineral is exceedingly pure and that it agrees very closely with the formula $Zn_3(PO_4)_2 \cdot Zn(OH)_2 \cdot 3 H_2O$, the calculated percentage composition of which is given in column IV. Two analyses were made by the writer (I and II) and a third by Mr. E. W. Widdowson, of Nelson, B. C. (III).

|  | I. | | II. | | III. | | IV. |
|---|---|---|---|---|---|---|---|
| ZnO | 60·18 | ... | 60·18 | ... | 60·05 | ... | 60·32 |
| $P_2O_5$ | 26·14 | ... | 26·23 | ... | 26·74 | ... | 26·82 |
| Water at 160° | 9·79 | ... | 9·83 } | ... | 18·70 | ... | { 10·02 |
| Water above 200° | 8·58 | ... | 8·47 } | | | | { 8·34 |
| MnO | — | ... | — | ... | 0·41 | ... | — |
| Silica | — | ... | — | ... | 0·40 | ... | — |
|  | 99·64 | | 99·71 | | 101·80 | | 100·00 |

When heated in a closed tube the mineral decrepitates and yields water in abundance. While hot the material is yellow, becoming white again on cooling; thus indicating the presence of a basic salt of zinc. The temperatures at which the water is given off are indicated in the above analyses. Between 160° C. and 200° C. there is no loss. At 400° C. the whole of the water is set free except 0·21 per cent., which appears to be still more firmly held and is set free only at a somewhat higher temperature. This difference in the attachment of the water

corresponds with the formula suggested above, in which one-fourth of the water is combined to form zinc hydroxide, while the other three-fourths may be regarded as water of crystallization.

### Physical Properties.

The density of the mineral was determined as 3·145 by means of the hydrostatic balance and as 3·142 by the use of heavy solutions. The mineral is about 3 in the scale of hardness. When the powder is heated to a moderate red-heat the mineral fuses readily. It is pure white in colour. The lustre is usually pearly but occasionally vitreous. The cleavages are in three directions and of different degrees of perfection, one of them being very perfect, while the other two are slightly less so. The best cleavage lends to the mineral a somewhat scaly structure. If a small fragment be broken up and examined with a low power under the microscope it is seen that almost all the pieces lie with the best cleavage parallel to the glass support. The other cleavages as observed on these fragments appear to be at right angles to one another, so that the mineral seems to be in agreement with the rhombic system. That the plates are almost all of a common crystallographic orientation is shown by the fact that they show, when examined in convergent light, a biaxial interference-figure. Such cleavage-plates can be also readily distinguished from the small number following one of the other cleavages, because the former exhibit very low birefringence as compared with the latter.

### Optical Properties.

The mineral is too cleavable to make it possible to cut prisms to determine the indices of refraction. An attempt was made to find these constants by total reflection, using thin plates parallel to the best cleavage. Since these plates give good interference-figures, the acute bisectrix is apparently normal to this cleavage. Owing to the smallness of the cleavage-plates and slight lack of parallelism of different parts of a single plate the results were very unsatisfactory. The value for $\beta$ for sodium-light is about 1·6092. The optic angle for sodium-light was measured on the axial angle apparatus of Fuess, using monobromonaphthalene instead of oil: $2H_y = 46° 26'$, hence $2E_y = 81° 34'$ and $2V_y = 47° 54'$.

The mineral as shown by examination of the interference-figure is negative, the optic normal being at right angles to the trace of the

poorest of the three cleavages and the obtuse bisectrix at right angles to the trace of the second best cleavage. Plates parallel to the best cleavage show low birefringence, so that the difference between $\beta$ and $\gamma$ is not great. Such plates when examined between crossed nicols exhibit peculiar interference-colours, which suggest that the plates are not
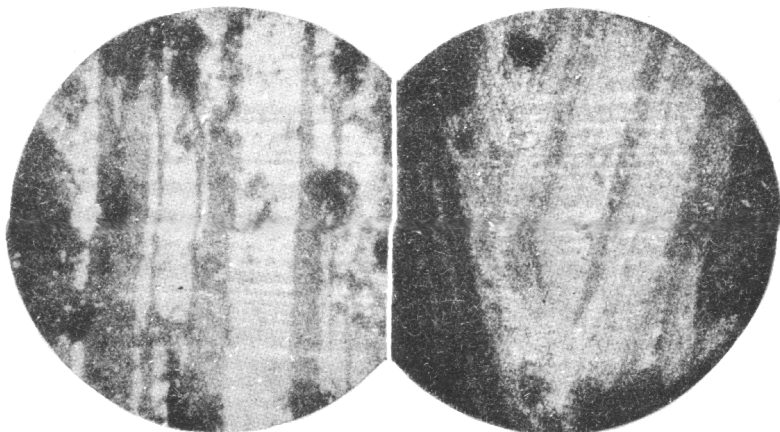


FIG. 1.                    FIG. 2.
Micro-sections of Spencerite showing lamellar twinning.

simple, but rather are composed of several very thin plates arranged so that there is a lack of parallelism. Dispersion $\rho > v$.

### Crystallization.

In general, the optical and physical properties above mentioned seem to suggest that the mineral is rhombic in crystallization. This is not the case however, as shown by the following :

(a) A thin section cut more or less at right angles to the best cleavage shows that the mineral is polysynthetically twinned with an extinction-angle of about 6°. The plates of the twin complex are parallel to the best cleavage. (Figs. 1 and 2.)

(b) By etching with cold, one per cent. nitric acid for five minutes, very definite etch-figures are obtained on the best cleavage. These figures are symmetrical about only one plane (the second best cleavage), and consequently the best cleavage does not correspond to a pinakoidal cleavage in a holohedral

rhombic crystal, but rather to that of a face in the orthodiagonal zone of a monoclinic crystal such as (100) or (001). (Fig. 8 shown on (100).)

It is therefore the opinion of the writer that the mineral may be regarded as monoclinic. If we assume that the best cleavage be (100), the second cleavage (010), and the poorest cleavage (001), then the twinning-plane and composition-face is (100), and the optic axial plane lies in the orthodiagonal zone and nearly normal to the front pinakoid. In this case the optic angles measured are only approximate, being produced from a series of thin twinned plates parallel to (100), each of which, if taken apart from the others would show an angle differing slightly from
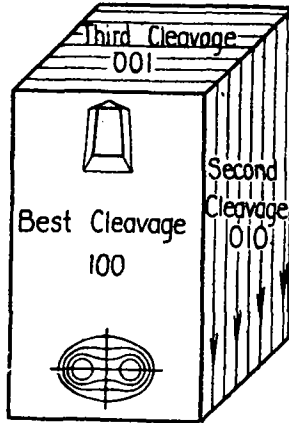


Fig. 8.—Crystallographic scheme of Spencerite.

that obtained on the composite plates. In the same way the value for $\beta$ is not the true value.

The writer has examined carefully the specimens from the Hudson Bay mine for crystals of this new mineral, but without success. The stalactitic masses, which up to the present are the only form in which it has been observed, are always covered by solution surfaces, a zone between it and the covering silicate having been dissolved away. While from the optical properties the mineral appears to be monoclinic, it would be interesting to confirm this conclusion by direct geometrical measurement of crystals. In fig. 3 the chief crystallographic observations are diagrammatically represented.

## General Relationships.

Spencerite is most closely related to hopeite, parahopeite, and tarbuttite, as shown by the following table :

| | | |
|---|---|---|
| Hopeite | ... | $Zn_3(PO_4)_2 \cdot 4\,H_2O$ |
| Parahopeite | ... | $Zn_3(PO_4)_2 \cdot 4\,H_2O$ |
| Tarbuttite | ... | $Zn_2(PO_4)_2 \cdot Zn(OH)_2$ |
| Spencerite | ... | $Zn_3(PO_4)_2 \cdot Zn(OH)_2 \cdot 3\,H_2O$ |

This new mineral may be regarded as the trihydrate of tarbuttite. Prior to 1907 hopeite was the only representative of this series, and this had been found very sparingly at only one locality. Subsequently it was found in some abundance, together with the new species parahopeite and tarbuttite, at Broken Hill in North-Western Rhodesia. The name suggested for this mineral is given in honour of Mr. L. J. Spencer, of the Mineral Department of the British Museum (Natural History), who is responsible for much of our knowledge of the natural zinc phosphates.

University of Toronto,
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