HISINGERITE FROM BLAINE CO., IDAHO.*

D. F. HEWETT AND W. T. SCHALLER.

Introduction.—During the progress of the examination of areal geology and mines in the Mineral Hill district, Blaine County, Idaho, in 1913, specimens containing hydrous ferric silicates were encountered in several mines under circumstances that indicated an uncommon origin of these minerals. Although the specimens were studied shortly thereafter and an analysis of the best material was made, several circumstances have prevented the publication of the results until the present.[1] In the following statement, the account of the occurrence of the material and paragenesis have been prepared by D. F. Hewett and that of the properties and analysis by W. T. Schaller.

Those descriptions of hisingerite and similar hydrous ferric silicates which refer to its origin generally assume, without much consideration, that it is a product of weathering. In this region the evidence is very clear that hisingerite, a ferric compound, has been formed by the attack, on siderite, a ferrous carbonate, of hotspring waters probably of hypogene origin. It is worthy of record that ferrous compounds can be altered to ferric compounds in zones of the earth's crust below the lower limit of oxygen-bearing surface waters.

Occurrence.—The hisingerite and related hydrous ferric silicates that are described below were found in two mines, the Minnie Moore and Bellevue King.[2] The Minnie Moore mine lies a mile west of Bellevue and has been explored by three inclined shafts to a maximum depth of 1,150 feet on an incline or to a point about 565 feet vertically below the outcrop. The greatest depth at which the ferric silicates were found is the 1,000-foot level, or about 520 feet vertically below the outcrop. The

* Published by permission of the Director, U. S. Geological Survey.

[1] The geology and mineral resources of the Hailey quadrangle and the adjacent area on the south are described in considerable detail in a forthcoming report by the U. S. Geological Survey.

[2] C. P. Ross, who visited the district in 1923, reports that it is also present in workings on the Whale claim of the Eureka mine 5 miles west of Hailey.

original water level in the mine was about 50 feet vertically below the surface, but in recent years, during periods of idleness, water has risen to only 150 feet vertically below the surface.

The country rocks at the Minnie Moore deposit are hornstone and fine-grained calcareous sandstone altered to diopside rock near its contact with quartz diorite. The vein contains siderite, quartz, sphalerite, galena, and small amounts of tetrahedrite, pyrite and chalcopyrite. The siderite and quartz were deposited by replacing the diopside rock, and the sulphide minerals have largely replaced the siderite. In several parts of the mine, largely in the footwall of the vein, the zeolite, stilbite, is found on fractures. Hydrous ferric silicates are widespread in the vein zone, but are most abundant in the western part of the mine, which has not yet yielded ore shoots. They are most abundant on the 470-foot level footwall crosscut from the Allen shaft (282 feet vertically below the outcrop), but are also common on the 570-foot level west drift from the Allen shaft (334 feet vertically below the outcrop), and on the 1,000-foot level west from the Minnie Moore shaft (520 feet vertically below the outcrop). These localities are from 230 to 470 feet below the original water level and there is no evidence of the common products of oxidation nearby. Limonite, cerussite, etc., were originally found to a maximum vertical depth of about 100 feet.

The relations of the hydrous ferric silicates to the other minerals in this mine are characteristically shown in Figure 1. This illustration was chosen from a number of specimens which were polished and etched in order to study the paragenesis of the minerals. The hisingerite is uniformly in contact with siderite and commonly envelops fragments of it. There are sporadic minute grains of pyrite in both siderite and hisingerite. These appear to be unrelated to the veins of marcasite and calcite which cut across the mass, and are thought to have been deposited with the siderite during the period of ore deposition. It should be noted that some of the grains of pyrite are terminated crystals and none show evidence of corrosion or oxidation.

In most places the hisingerite is cut by or enveloped in veins of marcasite with which a little calcite is associated. In one place on the 1,000-foot level, radiating needles of stibnite are embedded in hisingerite and undoubtedly were formed simultaneously with the growth of the latter mineral. Hisingerite is not only formed by replacing the siderite but here and there is also deposited as botryoidal crusts in veinlets. In the lower left hand

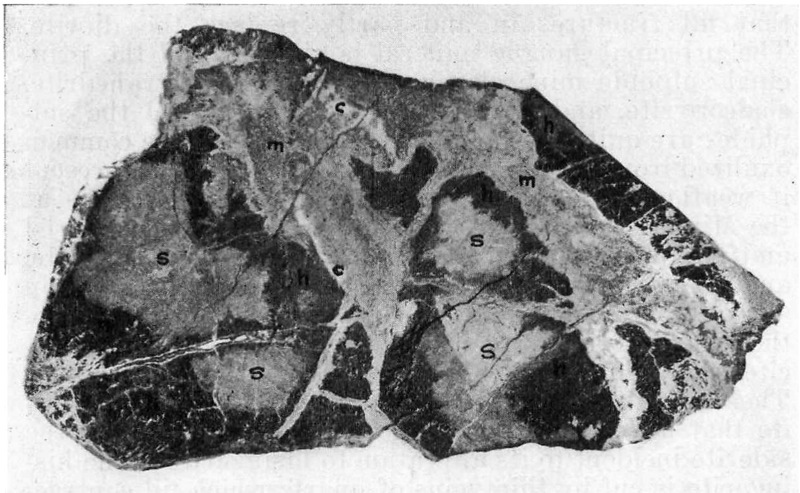

Fig. 1.—Photograph of polished and etched specimen from the 470-level, Allen shaft, Minnie Moore mine. Siderite (= s) of the ore-deposition period is bordered by hisingerite (= h) and the two are enveloped by veins of marcasite (= m) and calcite (= c). The last three minerals are considered to have been deposited during the late Tertiary period of vulcanism.

quarter of Figure 1, the vein is made up of a layer of marcasite, a layer of hisingerite, and middle area of calcite.

One can draw several conclusions from the relations and distribution of the minerals in this mine. The hisingerite was formed later than and at the expense of the siderite and was followed by deposition of marcasite, calcite, and probably stibnite. Also, hisingerite and stilbite have a broadly similar distribution in the mine but are locally mutually exclusive, the first occurring only in the vein zone where there is siderite, and the latter, in the unchanged country rock nearby.

The Bellevue King mine lies 2 miles southwest of Bellevue and unlike the Minnie Moore lies in a large intrusive mass of quartz diorite. The workings of the mine are largely confined to one tunnel on which a total of 720 feet of work has been done. In the area where the hisingerite occurs, the vertical depth below the surface is about 80 feet, but a winze is sunk 40 feet lower. The workings explore several veins 2 to 5 inches wide that fill fractures in and partly replace the diorite. The principal gangue mineral is siderite and the principal sulphide minerals are silver-bearing tetrahedrite, chalcopyrite, and pyrite. On the tunnel level the sulphides are quite fresh and there are none of the common oxidized iron and other minerals which should be present if weathering had been effective at this depth. As at the Minnie Moore mine, the siderite veins are fractured and fragments are enveloped in a layer of hisingerite, and fractures remote from the veins commonly contain a zeolite, which in this case is laumonite. Here, also, the siderite veins are cut by later veins that contain calcite, chalcedony, and angular fragments of hisingerite. These angular fragments appear to be portions of siderite that have been broken away by the swelling of the siderite incident to its alteration to hisingerite. The hisingerite is cut by thin veins of quartz which fill contraction cracks.

The hisingerite shows a curious change in color after exposure that justifies mention. As exposed underground, on a recently broken surface, it is very dark greenish to black. For several minutes after freshly broken underground, however, the mineral is claret red before it turns black. This change was verified several times by two observers using both candle and acetylene light. In the dry air outside, it slowly turns to dark brown and develops many shrinkage cracks, probably caused by dehydration. No explanation of these two changes in color can be offered. It is not difficult to obtain pure material for analysis at this mine, for fragments from 0.5 to 1.0 cm. in diameter are common.

Here, as at the Minnie Moore mine, hisingerite is wholly in the vein in contact with or near siderite. The zeolite, laumontite, occurs abundantly in an area near the vein but the two minerals appear to be mutually exclusive.

Properties of the Hisingerite, Bellevue King Mine.

Color.—Freshly exposed, claret red; rapidly turns black, then slowly dark brown. The analyzed specimen was very dark brown, but other specimens became lighter with time.

Fracture.—Conchoidal; locally inherits rhombic cleavage of siderite. *Luster.*—Vitreous to greasy.

Streak.—Yellowish brown. *Hardness.*—3.5.

Optical properties.—Wholly isotropic. Index of refraction, 1.57 when analyzed in 1914; 1.44 ± in 1924. Thin sections show granular structure.

Pyrognostics.—Before the blowpipe flame it slowly fuses to black feebly magnetic slag. Slightly attacked by cold dilute hydrochloric acid, rapidly by hot acid, leaving a silica skeleton, but not gelatinizing.

Composition and ratios:

	Per cent		Ratios				
SiO_2	38.14	.633	8.80	or	9	x	0.98
Fe_2O_3	36.66	.229	3.18	or	3	x	1.06
FeO	0.84 }	.073	1.01	or	1	x	1.01
MgO	2.45 }						
MnO	trace						
CaO	none						
P_2O_5	none						
SO_3	none						
CO_2	none						
H_2O+	8.53 }	1.207	16.79	or	17	x	0.99
H_2O-	13.20 }						
Total	99.82						

Discussion.—The determined ratios do not yield a simple formula. Not only is the water content changing according to the moisture in the air, but there is no simple exact ratio of ferric oxide to silica.

Minnie Moore Mine.

Color.—Freshly exposed, very dark brown; no change in color with exposure to air.

Fracture.—Conchoidal, locally inherits rhombic cleavage. *Lustre.*—Vitreous. *Hardness.*—3.

Streak.—Light brown; not so yellow as Bellevue King material.

Optical properties.—Part is isotropic and part is birefringent. By contrast with the isotropic material from the Bellevue King mine, that from the Minnie Moore mine is olive brown, but both have similar granular structure. The index of refraction remained constant at 1.66 ± .01 from 1914 to 1924. The birefringent material is nearly uniaxial (2V, very small) and may be negative.

Pyrognostics.—Same as other specimens.

Composition.—The isotropic and birefringent parts cannot be separated for analysis. Blowpipe tests indicate that ferric iron, silica, and water are the principal ingredients. The manganese content of these specimens is appreciably higher than that in specimens from the Bellevue King mine.

Resemblances.—The known hydrous ferric silicates appear to fall readily into two groups: (1) chloropal, nontronite, and morencite which are green to dark green in color, fibrous or earthy in structure, and are birefringent; (2) hisingerite, and the closely related species or varieties, such as gillingite, etc., which are dark brown, dark green or black in color, compact, vitreous structure, and are isotropic. Recently the crystalline phase of hisingerite, canbyite, has been identified and described by Hawkins and Shannon.[3] Among these groups the minerals from Blaine Co., Idaho, are clearly related to hisingerite in color, structure, optical character, and composition.

Any investigator who reviews the literature concerning these minerals will be impressed with the unsatisfactory character of the data concerning them and the need for a further critical comparison of the properties of the several hydrous ferric silicates.

Judging alone from the values of the refractive indices, three substances would seem to be represented in the hisingerite from Idaho, with mean indices of about 1.44, 1.57, and 1.66 respectively, differences too great to be neglected. However, a satisfactory interpretation of the relationships of these possible three substances cannot be given. The composition of the material from the Bellevue King mine is not closely related either to that of canbyite (mean index 1.57), to that of the associated

[3] Hawkins, A. C., and Shannon, E. N., Canbyite, a new mineral, Amer. Mineral. vol. 9, pp. 1-5, 1924.

amorphous hisingerite (mean index 1.46), or to the hisingerite from Parry Sound, Ontario[4] (mean index between 1.50 and 1.56). It may be noted too that hisingerite from Riddarhyttan, Sweden, has an index of from 1.49 to 1.53, average 1.51, as determined by Larsen.

The silica given in the analysis is the highest recorded value except for one analysis (No. 13, p. 703, Dana's System of Mineralogy). The ratios deduced from the analysis correspond fairly well to the formula $9SiO_2$.-$3Fe_2O_3$.1MgO.17H_2O. This gives an oxygen ratio of acid to base (not considering the water) of 9 to 5, whereas the analysis of material from Delaware and from Parry Sound is consistent in the similar oxygen ratio of 6 2/3 to 5, with a ratio of SiO_2 to Fe_2O_3 of 2:1. The simpler 2:1 ratio, as given by many analyses, may well represent a distinct compound. Whether the 3:1 ratio found in the material from the Bellevue King mine is valid, is not known. Adding the small quantity of magnesia (RO) to the total water (R_2O), the formula simplifies to $3SiO_2$.-$1Fe_2O_3$.$6H_2O$. The amorphous hisingerite from Delaware having about the same low index as the mineral from Idaho, does not support the idea of a distinct 3 to 1 compound.

It does not seem feasible to interpret the amorphous hisingerites as mixtures of gels of silicon hydroxide and iron hydroxide, unless the values of the refractive indices of the mineral as determined represent, in part at least, the average aggregate index of a porous material. This index would then represent an average value of several components, of which the air in the pore spaces must be considered as one of the components. On such a basis, the indices of amorphous hisingerites become interpretable. Considering the material as a mixture of a substance for example, like tabasheer (index 1.1) which may be a porous silica gel, and an iron hydroxide (index about 2.1), then indices around 1.4 could be obtained by combining varying proportions of the components.

At present the interpretation of the amorphous hisingerite must be considered a problem for the future, with much more correlative study on abundant material.

Origin of the hydrous ferric silicates.—Minerals of this group are not common and most of the analyses that

[4] Schwartz, G. M., On the nature and origin of hisingerite from Parry Sound, Ontario: The American Mineralogist, vol. 9, pp. 141-44, 1924.

are recorded have been made upon material in which homogeneity was assumed rather than proven and the associations were not studied. In the problem of genesis, therefore, there is some doubt concerning the actual identity of materials to which a certain origin is ascribed. Fortunately, several recent articles summarize and describe occurrences of the mineral.

Sustschinsky[5] has reëxamined specimens of hisingerite from the original locality, Riddarshyttan, Sweden, and from Långban, Orijarvi, Gillinge and Vestra Silfberg, Sweden. Although the appearance of the material in thin section is described, and the conclusion is reached that the materials are not amorphous, but cryptocrystalline, like chalcedony and probably birefringent, uniaxial negative, no indices of refraction are given by which their identity can be established elsewhere, however. The general conclusion is that the mineral is formed in veins and crevices where iron from weathering sulphides meets silica in solution.

Ivanov[6] presents an analysis of hisingerite from Paromawka, Volhynia, Ukrania, but gives no suggestion of its origin.

Simpson[7] describes hisingerite which has dark brown color, conchoidal fracture, and although largely isotropic is partly birefringent. It was found in the Edna May Deeps gold mine, West Australia, at a depth of 740 feet (vertical?) and, although normal water level is only 75 feet below the surface, the mineral is interpreted to be a product of weathering. The vein contains quartz, siderite, and a little pyrite, and the hisingerite probably replaces the siderite. The material and associations closely resemble those in Blaine County, but no indices of refraction are given, so that the identity cannot be proven.

Zenzen[8] presents a brief description of an earthy material from the Yxsjo mines, considered to be hisingerite but the description of its associations is inadequate.

[5] Sustchinsky, P. P., Uber den Hisingerite, Zeit. für Kryst. und Min. vol. 47, pp. 231-237, 1910. The author gives references to 10 descriptions of European material, published before 1884, but does not give an American reference.

[6] Ivanov, L., Mineralogy of Volhynia, Abt. Ges. Erforsh Volhynian, vol. 6, pp. 225-232, 1911. See also Chem. Abstr. vol. 9, 144, 1915.

[7] Simpson, E. S., Hisingerite, Journal and Proc. Royal Soc. West Australia, vol. 5, pp. 95-97, 1920.

[8] Zenzen, N., Contribution to the Mineralogy of the Yxsjo mines, Geol. For. Forh. vol. 44, pp. 539-543, 1921, also Chem. Abstr., p. 2650, 1922.

Schwartz[9] describes and presents an analysis of hisingerite from Parry Sound, Ontario. He concludes that both the amorphous and crystalline varieties are present, and that the mineral has been formed by replacement of hypersthene, pyrite and chalcopyrite through the agency of meteoric waters.

Most of the descriptions of the occurrence and properties of hisingerite, chloropal, and nontronite in the United States that have been found were written prior to 1888 and do not give much of the data now desired in mineral identification. Their identification has been based largely on analysis of small quantities of material, and their origin has either been ignored or assumed to be related to weathering processes.[10]

Local Geological Conditions in Blaine Co.: No comprehensive account of the local geology near the mines that yield hisingerite can be presented here. For this the reader is referred to the report by Westgate, Umpleby, Ross and the writer (in press). The following summary is presented:

1. Deposition of Paleozoic sediments.
2. Folding and thrust faulting; late Mesozoic.
3. Intrusion of quartz diorite.
4. Intrusion of granite and pegmatite.
5. Intrusion of andesite and lamprophyre dikes.

   } Late Cretaceous or Tertiary (3–5)

6. Deposition of ores.
7. Great erosion of region, developing forms much like those now seen; early Tertiary.
8. Extensive normal faults; middle Tertiary.
9. Extrusion of extensive lava flows and intrusion of lamprophyric dikes; upper Miocene-middle Tertiary.
10. Considerable erosion, developing present surface forms.

[9] Schwartz, G. M., On the nature and origin of hisingerite from Parry Sound, Ontario: The American Mineralogist, vol. 9, p. 141-4. 1924.

[10] *Hisingerite.*

Clarke, F. W., Studies of the Mica Group: this Jour., vol. 34, p. 133, 1887.

Genth, F. A., Contributions to Mineralogy: Proc. Amer. Phil. Soc., vol. 24, p. 44, 1887.

Rand, T. D., Notes on Feldspars and some other minerals of Phila. and vicinity: Proc. Acad. Phila., p. 304, 1871.

Chloropal.

Smith, E. F., Minerals from Lehigh Co., Penna. Amer. Chem. Jour., vol. 5, p. 277, 1883.

Turner, H. W., Notes on unusual minerals from the Pacific States: this Jour., vol. 13, p. 344, 1902.

The only elements in this history to which attention need be directed here are (1) ore deposition following a period of intrusion of large masses of granitic rocks and fine-grained dikes; (2) a much later period of volcanic activity which yielded great areas of surface flows and many dikes. The deposition of zeolites in all of the rocks is common and widespread. Several hot springs are active in the region and may have begun in middle Tertiary time.

Conclusions.—Hisingerite occurs in several Blaine County mines as a product of alteration of siderite 200 to 450 feet below water level and the lower limit of oxidized minerals commonly considered products of weathering. The local associations indicate that the same hotspring waters which deposited stilbite and laumontite in fractures in the country rocks, produced hisingerite in the veins which carry siderite. Although the ferrous carbonate, siderite, is altered to hydrous ferric silicate, the next mineral to be formed was marcasite and this indicates that conditions no longer permitted oxidation of ferrous to ferric compounds. It is not clear whether the hot waters were juvenile from deep-seated igneous sources, or whether they are local waters, possibly originally near the surface, set in circulation locally by small bodies of intrusive rocks.

It may be questioned whether local water level in the mines is not higher now than at some early Pleistocene or late Tertiary period. It is true that Wood River valley, less than a mile away from these mines and 300 to 500 feet lower, has a filling of alluvium whose depth is unknown. It is quite possible that it is several hundred feet or more thick at Bellevue and that, at an earlier time, water level in the mines might have been about that much lower than it is now. On the other hand, there are none of the common oxidized minerals below the water level first encountered in the mines. The development of hisingerite did not affect nearby pyrite, chalcopyrite, and other sulphides. If hisingerite were a product of normal processes of oxidation by waters of surface origin, it should be widespread in the region; it seems to be confined to those mines which contain zeolites and therefore related to them in origin.

U. S. Geological Survey,
Washington, D. C.