

DIABANTITE, STILPNOMELANE, AND CHALCODITE OF THE TRAP QUARRIES OF WESTFIELD, MASSACHUSETTS.

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Throughout the Triassic area of the Connecticut Valley the diabasic sills, dikes, and flows are decomposed to a greater or less extent, the most universally common product of this alteration being an earthy deep-green chlorite. Similar chlorites occurring as coloring matter in altered diabases of Frankenwald and Voigtland were early analyzed by Liebe and named diabantachronnyn. In 1875 Hawes¹ analyzed such a chlorite from the amygdaloid trap of the Farmington Hills, Connecticut, deducing a rational formula from four careful analyses made upon pure homogeneous material. Hawes shortened Liebe's ponderous name to diabantite. So far as known to the writer no chemical work on this mineral has since been published. Emerson in his description of the Deerfield Dike,² in his Monograph on the Geology of Old Hampshire County,³ and in the accompanying Mineralogical Lexicon,⁴ mentions many and varied occurrences of green chlorite which he referred to diabantite, but he apparently made no chemical analyses. In fact, in the Deerfield paper he remarks as follows: "That the mineral is chemically identical with that analyzed by Hawes and named diabantite by him is extremely probable in view of their identity in all chemical and especially optical properties, and of the monotonous similarity of the many diabase dikes of the Connecticut basin in which both occur. That the mineral is distinct from delessite, as the word is used by Zirkel, Rosenbusch, and Heddle, is much less certain."

During the past year the writer has frequently visited the quarries of the Lane company, in the outcrop of the Holyoke Trap sheet along the west line of the town of Westfield, Massachusetts. These quarries are well known to mineralogists for the many superb specimens of datolite which they have produced. The location of the quarries and the general mode of occurrence of the minerals have been noted in a brief paper published by the present writer after a first visit.⁵

¹ Amer. Journ. Sci., vol. 9, 1875, p. 454.

² Idem, vol. 24, 1882, pp. 198-201.

³ U. S. Geol. Survey, Mon. XXIX.

⁴ U. S. Geol. Survey Bull. 126.

⁵ Amer. Mineral., vol. 4, 1919, No. 1, p. 5.

Since then a dozen days spent in careful observation have enabled the list of species known to occur here to be considerably enlarged. Early in the examination, the chloritic decomposition product was noted and many specimens were collected none of which, however, was of sufficient purity to encourage chemical investigation. In January of this year, there was found, in the extreme southeastern corner of the No. 2a quarry, a narrow fissure extending upward from the floor of the quarry, on either side of which the trap for a distance of from one to three feet was completely altered to a sandy friable material of deep green color when wet and pale grayish-green when dry, the appearance of the whole suggesting hydrothermal alteration by ascending waters rather than any change dependent upon ordinary surficial weathering agencies. About two-thirds of the distance up the wall this fissure widened into a filled cavity from two to four inches in width. The walls of this cavity were lined with a layer of well developed prismatic quartz crystals averaging 5 mm. in length over and around which was a thick deposit of a green clayey mineral, the remaining space being filled with translucent calcite with a strong twinning tendency. The calcite masses are impregnated by the green mineral for a space of a few millimeters but are for the most part clear. In the narrower portions of the cavity the calcite was absent and the whole of the space between the quartz lining of the two walls was occupied by the green mineral. This substance was of the appearance and consistency of not very plastic clay. When obtained the specimens were saturated with water and frozen and of a bright deep green color. Upon drying, the mineral shrunk remarkably, becoming completely filled with cracks and most of the specimens fell to pieces spontaneously. When dry the color was pale olive green. In all about 6 kilograms of this mineral were obtained, a small part of which had been triturated by movement along the fissure and contained scattered angular fragments and broken crystals of quartz and calcite. Ideally pure material was available in abundance for analysis and several complete analyses were made. The dried mineral can be readily crushed to powder between the fingers. In the closed tube it becomes brown, yields neutral water and finally fuses to a black magnetic glass. It is readily soluble in hot hydrochloric and sulphuric acids and difficultly so in nitric acid in each case with separation of flocculent silica. The specific gravity was found to be 2.77. Under the microscope, this material is seen to be composed of minute micaceous scales of uniform size and wholly irregular outline. Basal plates extinguish between crossed nicols the mineral being sensibly uniaxial and optically negative. It is transparent and exhibits pleochroism in tones from pale brown to moderately deep greenish brown. The mean index of refraction is high for a chlorite, being about 1.62, about the same as that of delessite. While these

analyses differ slightly from those of Hawes on Farmington material they are sufficiently close that the material may be referred to diabantite without question. The results of the analyses are tabulated below:

Analyses of diabantite.

Constituents.	1	2	3	4	Average.
SiO.....	28.12	27.90	28.50	28.09	28.15
Al ₂ O ₃	15.93	16.13	14.39	14.23	15.17
Fe ₂ O ₃	3.99	3.85	3.91	3.64	3.85
FeO.....	25.09	25.22	25.28	25.31	25.23
MgO.....	14.48	14.67	14.35	14.74	14.56
CaO.....	.78	.53	.56	.50	.59
MnO.....	.17	.17	.27	.23	.21
H ₂ O-105°C.....	.40	.63	.64	.62	.57
H ₂ O+105°C.....	11.02	11.41	11.13	11.44	11.25
Total.....	99.98	100.51	99.03	98.80	99.58

Some time after the above analyses had been completed, there was found, on the face of the No. 4 quarry, a similar vein containing abundant clayey green material. This vein was not marked by any such pronounced alteration of the walls and its first lining was a crystal crust made up of calcite in peculiar trigonal crystals formed by half of an obtuse rhombohedron truncated by a bright basal plane. Over and around these crystals was the thick layer of clay which varied in color from bright verdigris to olive green. Last here as before came calcite in broad translucent cleavage masses containing cavities lined with nearly cubic rhombohedrons of calcite. This being the second occurrence of fine homogeneous material suited for chemical investigation, which was found, its examination was undertaken in order to determine whether it conformed more closely than did the previous lot to the diabantite of Hawes. Surprisingly enough, this material was found to be entirely unlike diabantite in composition and to be quite clearly referable to stilpnomelane. The structure is in places somewhat platy as though pseudomorphous after some platy mineral or as though it had been deposited between the plates of some mineral now entirely removed. In color it is more bluish than the diabantite, the clayey variety is more plastic, when micaceous it is apparently more opaque and there is a peculiarly submetallic luster, which is wanting in diabantite. In drying these specimens do not develop many shrinkage cracks and the dried material instead of being soft and friable is so compact and tough that it is difficult to pulverize in a mortar. Under the microscope this mineral, like the diabantite, is seen to consist of micaceous scales, imperfectly transparent and pleochroic in tones of light to dark brownish-green. Basal plates are dark

between crossed nicols, the mineral evidently being approximately uniaxial. The birefringence is higher than that of diabantite where the scales lie upon a face perpendicular to the basal cleavage. The optical character is negative. Occasionally a scale shows hexagonal outline and curved vermicular aggregates occasionally occur. The minimum and maximum indices of refraction are approximately 1.560 and 1.575, respectively. The analyses gave the results tabulated below.

Analyses of stilpnomelane, from Lane's No. IV quarry.

Constituents.	I	II	Average.
SiO ₂	44.14	44.02	44.08
Al ₂ O ₃	5.24	4.24	4.74
Fe ² O ₃	5.21	5.33	5.27
FeO.....	23.09	23.53	23.31
MgO.....	8.89	7.84	8.36
CaO.....	Trace.	Trace.	Trace.
MnO.....	.88	.87	.87
H ₂ O-105°C.....	1.58	2.84	2.21
H ₂ O+105°C.....	10.24	11.71	10.28
Total.....	99.27	100.38	99.12

It was disconcerting to find that in a very large number of occurrences of green chlorite, the only two suitable for accurate analysis belonged to distinctly different species. All specimens were then reexamined, an attempt being made to determine silica if nothing else. This was in many cases possible and the results seemed to show that but the two species were present, that they did not intergrade and that individual specimens were distinctly referable to one or the other and none were either mixtures of the two nor intermediate compounds. Quite early in the investigation a reliable qualitative means of distinguishing these two minerals was found in their behavior when boiled with 1.20 specific gravity nitric acid. Powdered diabantite dissolves slowly without change in the acid while stilpnomelane is wholly oxidized yielding a rust-like brown substance. Through handling many specimens the writer became able to distinguish the two by megascopic features alone. Under the microscope they may be readily distinguished by the difference in refractive index and this means served to classify a number of specimens where the amount of the mineral was insufficient for a chemical examination. In one or two specimens anomalous optical properties served to suggest that a third chlorite might be present or that diabantite and stilpnomelane might be intergrown. Most of the greenish-black varnish-like material on joints and slickensides is diabantite as is most of the very fine-grained green chlorite in the altered rock. In the old No. 1 quarry, many small veins and frac-

tures have a thin layer of fibrous greenish-black material in which as in similar material described by Emerson from Cheapside the fibers are inclined at a small angle to the wall and appear as if combed into position by movement along the fissure. At Deerfield such fibers consist of diabantite and prehnite but at Westfield the fibers are entirely calcite coated externally with diabantite with occasionally a little interstitial stilpnomelane. Many small veins in the upper quarries especially are lined with quartz crystals above which is a layer of deep blackish to bluish-green submetallic stilpnomelane in foliated small-micaceous or beautifully concentric botryoidal surfaces. The series is closed by calcite which is easily separated from the earlier minerals leaving fine broad surfaces of the stilpnomelane exposed. The visibly scaly or micaceous and botryoidal forms are all, so far as tested, stilpnomelane, diabantite being in all cases megascopically structureless. Botryoidal diabantite in amgdaloid is described by Emerson from Larrabee's quarry on the north line of Holyoke. The writer visited this quarry but was unable to find any specimens showing the chlorites in megascopic aggregates. Well characterized stilpnomelane was found in quartz coated by calcite at the quarry at the The Notch still farther north.

Chlorophaeite which was found in the Deerfield trap at Cheapside by Emerson was not observed at Westfield. The chlorophaeite, however, is an alteration product of an early generation of prehnite which does not seem to be represented here. It is interesting at this point to consider the similarity in composition between chlorophaeite and stilpnomelane, the former being not unlike a greatly hydrated and peroxidized variety of the latter. The stilpnomelane displays the same tendency toward oxidation, in less marked degree, as is evidenced by its behavior in nitric acid and in its alteration as discussed below.

From time to time specimens were found in the various quarries which contained micaceous scales of a pure deep golden yellow color and metallic luster. This was supposed to be the diabantite-vermiculite of Emerson but none of the fragments exfoliated when heated. In one place in the No. IV quarry this substance occurred in broad surfaces of foliated and botryoidal aggregates of scales on quartz surmounted by epidote prehnite and calcite. The superposed minerals were easily separated from the golden coating which had exactly the form and structure of the stilpnomelane of other parts of the quarry, but appeared precisely as though coated with commercial gilt paint. None of this material showed the characteristic exfoliation of a vermiculite. Though abundantly present this mineral was of exceedingly small bulk, and it was found to be impossible to secure enough

for an analysis. A very minute amount of pure material gave 45.77 per cent of silica, strong qualitative tests for ferric iron, no ferrous iron, and very small amounts of alumina and magnesia. In one or two specimens the interiors of lumps of this golden substance were still green and contained ferrous iron. Later a specimen was found in the collection of William Fitts, of Springfield, which contained more of the yellow mineral than any found at the quarries. Some small lots of the mineral taken from this specimen were analyzed, and the results of the analyses after deducting calcite indicated that it was essentially of the composition of stilpnomelane in which the ferrous iron is completely oxidized to ferric iron and the hydration is increased by the addition of hygroscopic water. It will thus be seen that in physical characters and chemical composition it is essentially identical with the chalcodite of Shepard.¹ Shepard included under this head also the associated green material high in ferrous iron which Brush² has shown to correspond to stilpnomelane. Brush attempted to include all chalcodite under stilpnomelane, but it now appears that stilpnomelane is the wholly ferrous chlorite, while the varietal name chalcodite should be restricted to the golden ferric alteration product and indeterminate intermediate minerals containing varying amounts of iron in both states of oxidation are merely transition products in the change of stilpnomelane to chalcodite. The samples analyzed gave the following results:

Analyses of chalcodite, Westfield.

Constituents.	1	2
SiO ₂	44.64	48.16
Al ₂ O ₃	6.75	} 30.11
Fe ₂ O ₃	23.59	
MgO.....	9.86	4.43
H ₂ O-105° C.....	6.21	3.97
H ₂ O+105° C.....	7.14	7.10
Total.....	98.19	93.77

The material was not of sufficient purity nor in sufficient amount to permit very exact analytical work, and the results give no sufficiently reliable basis for speculation as to the exact chemical nature of or the correct formula for chalcodite. For the present it must be regarded as an indefinite oxidation product of stilpnomelane. Under the microscope the material is micaceous and partly transparent. The scales lie upon the flat face and are dark in all positions between crossed nicols. The mean index of refraction is about 1.64, but

¹ Shepard, Rep. Amer. Assoc. Adv. Sci., vol. 6, 1851, p. 232.

² Brush, Amer. Journ. Sci., vol. 25, 1858, p. 193.

varies slightly in different specimens. The minute scales vary in color and transparency and appear as though dusted with a sub-microscopic brown pigment, quite probably limonite, which has separated out in the process of oxidation.

In a recent paper Emerson¹ gives a brief description of specimens from this locality, in which he mentions crystal cavities or molds of anhydrite now entirely removed. In some cases the anhydrite has been replaced, he writes, by diabantite, which has altered to diabantite-vermiculite and then to limonite. Many specimens of these flat negative crystals are included in the writer's collections from these quarries. The hollow cavities are of several forms which are not all of the same age. So far as can be determined from these specimens the chloritic mineral is all stilpnomelane and the golden product of its alteration, as above mentioned, is chalcodite and not a vermiculite. The complete change to limonite was not observed, although when very fine grained the chalcodite might readily be mistaken for limonite. Judging from the fact that the interior surfaces of the stilpnomelane pseudomorphs are always clear and sharp where the anhydrite or other mineral has been removed with no rounding of angles, etc., and the exterior of the stilpnomelane crust is indistinct and irregular the writer has regarded the stilpnomelane as having encrusted the crystals of the removed mineral without replacement. The penetration along cleavage planes where it occurs is in laminae so sharp and uniform in thickness as to suggest simple filling of cleavage cracks opened by strains. The crystal cavities and molds will be described more fully in a later paper on the paragenesis and miscellaneous minerals which with a paper on the crystallography of the datolite will conclude this series.

It may be well here to state the nomenclature used in designating the quarries. Going north from the Boston and Albany Railroad these are numbered 1-1*a*, 2-2*a*, 3-3*a*, and 4 respectively, this being substantially the designation used by the quarrymen who include the two openings each of the first, second, and third quarries under the single number.

The type material described above has been deposited in the United States National Museum, catalogue numbers as follows: Diabantite 93440, 93441; stilpnomelane 93447, 93438; chalcodite 93442.

¹ Emerson, Amer. Journ. Sci., vol. 42, 1916, p. 233.