ART. XXX.—*Mineralogical Notes.* No. V. *On the occurrence of Garnets with the Trap of New Haven, Connecticut;* by
by EDWARD S. DANA.

GARNETS have been recently discovered in connection with the New Haven trap rocks, at two distinct localities; and their method of occurrence presents some points of considerable interest.

These "trap rocks," as they are commonly called, belong to the system of dikes of igneous rocks which characterize the Mesozoic sandstone areas of the Atlantic border. Mr. G. W. Hawes has given these rocks a thorough chemical examination,* and has shown that they have all essentially the same composition, being for the most part true dolerites, but including also the hydrous, chloritic variety called diabase. I take the liberty of quoting here Mr. Hawes's analysis of the trap from West Rock, which, as he states, is "the typical rock of this region." Specific gravity 3.03.

Silica	51.78
Alumina	14.20
Iron sesquioxide	3.59
Iron protoxide	8.25
Manganese protoxide	0.44
Lime	10.70
Magnesia	7.63
Soda	2.14
Potash	0.39
Phosphorus pentoxide	0.14
Ignition	0.63
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	99.89

The writer has made a microscopic examination,† by means of thin sections, of this series of rocks, including, among many others, specimens from West Rock (see the analysis above) and also from the two localities where the garnets have been found, viz: East Rock and Mill Rock. These three points, it should be stated, are within four miles of each other, all lying just outside of the limits of the city of New Haven. It was found that the specimens from the localities named were identical in mineralogical character, and that they were all quite free from any alteration. The mineralogical constituents are as follows: A triclinic feldspar which Mr. Hawes has shown chemically to be labradorite, pyroxene, and magnetite, also more or less chrysolite, and a little apatite in minute acicular crystals.

* This Journal, III, ix, 185, March, 1875.

† This Journal, III, viii, 390.

Garnets from East Rock.

At the East Rock locality the trap is very distinctly columnar, and the garnets occur on the vertical surfaces of the columns where they have been exposed in the process of quarrying. The spot at which they are found is in the body of the dike, far away from the line of contact with the sandstone: they are scattered here quite freely over a considerable surface; a careful search for them, however, along the extended front of the Rock, failed to reveal any other locality.

The associated minerals are: Magnetite, apatite, pyroxene now altered to chlorite, calcite, and also in traces chalcopyrite and sphalerite.

The garnets themselves are uniformly crystallized in rhombic dodecahedrons, with the edges truncated by the planes 2-2. Isolated crystals, however, are rare; more commonly they are grouped together in nearly parallel positions in very pretty little rosettes. These groups are scattered over the exposed surface of the rock, and are quite characteristic of the locality. Still, again, the crystals are crowded together, without any regularity of position, into crusts of some little thickness.

The color of the garnets is generally dark-brown to jet-black, though occasionally they are yellowish-brown. Their luster is very brilliant, and in general they are entirely free from alteration. An analysis of the garnets proved, what indeed was suggested by their appearance, that they belonged to the variety *melanite*, or a calcium-iron garnet having the formula $\text{Ca}_3\text{FeSi}_3\text{O}_{12}$. The material analyzed was taken from the crystalline crusts which have been mentioned. It was selected with care to ensure freedom from the rock, and still more from the apatite crystals, which, as remarked below, were intimately associated with the garnet. The specific gravity was 3.740.

The mean of two analyses gave:

Silica	35.09
Iron sesquioxide (with AlO_3 trace)	29.15
Iron protoxide	2.49
Manganese protoxide	0.36
Lime	32.80
Magnesia	0.24
Ignition	0.35
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	100.48

It has been recently shown by Knop* that the melanite crystals from several localities in the Kaiserstuhlgebirge and also from Frascati contain from three to seven per cent of titanitic acid. In view of this fact special tests were made for titanitic acid in the progress of the analysis; they served, however, only

* A. Knop, *Zeitschrift für Krystallographie*, i, 58, 1877.

to prove its absence. The magnetite was also tested qualitatively for titanitic acid, but none was discovered.

The associated minerals deserve also a few words of description. The *magnetite* stands first in order of abundance. It appears in the form of brilliant octahedrons, scattered sometimes thickly, sometimes sparsely, over the surface of the rock; it uniformly underlies the garnet where they occur together. The octahedrons of magnetite are sometimes unmodified, but generally the solid angles are replaced with the planes of the form 3-3, and the edges beveled with those of the form 2-2; an *m-n* form is also common, but with planes so rounded as not to admit of determination. The development of the last form occasionally produces irregular bullet-shaped crystals. The octahedral faces are brilliant, the others dull.

The *pyroxene* occurs in minute dark-green crystals, destitute of luster; they are crowded together on the surface of the rock. These crystals are strictly pseudomorphs after pyroxene, for though having unquestionably its form, they are so soft as to be easily cut with a knife, and in the powder have all the appearance of chlorite.

The *apatite* occurs in very minute prismatic crystals of a yellowish-green color. They are most common on and among the crystals of pyroxene. They are more numerous, however, than would appear at first glance, since a careful examination shows that they interpenetrate the garnet crystals in great numbers. The crusts of garnet particularly, which are apparently perfectly homogeneous, are found when broken up to be penetrated in every direction with these minute apatite needles. In this respect the garnets resemble those of the Kaiserstuhl described by Knop.

Finally, the *calcite* is found in crusts, and in rhombohedral crystals, covering the other minerals and also the surface of the rock itself. This calcite is very common not only at the point to which the garnets and their associates are confined, but also at many other places, so that it may not have any essential paragenetic relation to them.

All the above minerals are here true secondary products deposited on the columnar surface of the trap, and probably in the following order: magnetite, pyroxene, apatite, garnet, calcite. It will be noticed too, that, of the species which have been mentioned, the magnetite, pyroxene and apatite, are all original constituents of the rock itself, so that it can hardly be questioned that it has furnished immediately the material out of which these later minerals have been formed. The other essential ingredient of the rock, the triclinic feldspar, must have furnished the lime to the garnet and probably to the calcite; the excess of silica above that needed by the garnet, and also the alkalis have disappeared entirely.

Garnets from Mill Rock.

The other garnet locality is at the west end of Mill Rock. In appearance and in method of occurrence the garnets here found are a decided contrast to those that have been just described. They occur on the line of contact between the trap and the adjoining sandstone, and probably owe their origin to the metamorphic action of the heat of the erupted rock. They are found best in seams and little cavities in the trap, where they are implanted as isolated crystals upon an earlier deposit of quartz crystals. Occasional garnets of indistinct crystalline form but presumably of similar origin occur on the surfaces of the sandstone adjoining; scales of hematite produced by metamorphic action are common on the same surfaces.

The garnets in the trap only are distinctly crystallized; the crystals are highly complex and interesting. They appear at first sight to be dodecahedrons, but further examination shows that each dodecahedral plane is replaced by the four planes of a very obtuse hexoctahedron, having the symbol $64 \frac{6}{8} \frac{4}{3}$; the other forms occurring with this are: $2\cdot2$, $\frac{7}{2}\cdot\frac{7}{2}$, and H . The adjoining figure shows the habit of the crystals. The following angles were measured to determine these forms.

For $\frac{7}{2}\cdot\frac{7}{2} \wedge \frac{7}{2}\cdot\frac{7}{2}$ (over H) = $136^\circ 15'$, required $135^\circ 59' 48''$.

“ “ “ adjacent (edge B) = $149^\circ 16'$, required $149^\circ 16' 38''$.

For $64 \frac{6}{8} \frac{4}{3}$ edge B = $178^\circ 15'$, required $178^\circ 5'$.

“ “ “ C = $178^\circ 56'$, “ $179^\circ 6'$.

Of the above enumerated forms, the basal plane (H) is quite rare with this species, the tetragonal tris-octahedron $\frac{7}{2}\cdot\frac{7}{2}$ is new, though it has been observed on fluorite, and also by Klein (as a hemihedral form) on sphalerite; and the hexoctahedron $64 \frac{6}{8} \frac{4}{3}$ has been observed only on the *topazolite* from Piedmont (Quenstedt), though the related form $i \frac{6}{8} \frac{4}{3}$ was found by Webbsky on the transparent garnets of Jordansmühl, Silesia.

The Mill Rock garnets have a wine-yellow color, and a brilliant luster. The material available was much too scanty to admit of any chemical examination, but in view of their similarity of form and color, they may safely be referred to the variety *topazolite*.

In addition to the crystallized quartz upon which the garnets are implanted, the only other associated mineral is one occurring very sparingly in silky hair-like fibres. It was impossible to obtain enough for even a blowpipe examination, so that its character remains undetermined.