ART. XXXII.—*On a great dyke of Foyaite or Elæolite-syenite, cutting the Hudson River Shales in Northwestern New Jersey;* by BEN. K. EMERSON.

IN the Geology of New Jersey by Professor G. H. Cook, 1868, p. 144, an extensive dyke, "on the eastern slope of the Blue Mountain," is described as follows from the manuscript notes of Mr. E. Hauesser, assistant on the earlier geological survey under Dr. Kitchell: "On the slope of the Blue Mountain between Beemersville and Libertyville, a dyke of porphyritic hypersthene rock has been intruded between the slate and conglomerate. It runs from a point one and a half miles northwest of Libertyville, without interruption, to its termination, which is one and one-fifth miles northwest of Beemersville. It is about a quarter of a mile wide, and is a little tortuous in its course, but its general bearing is northeast and southwest. The rock of the northeastern part consists usually of a coarsely granular aggregate of labradorite and hypersthene, associated occasionally with hornblende, mica, sphene, tourmaline and quartz. The labradorite occurs in imperfect crystals, and in distinctly cleavable masses; it is of a gray color and a pearly luster. The hypersthene is of a greenish black color, of a bright metallic luster; it occurs in small and slender crystals more or less perfect.

"At the southwestern extremity the dyke presents a peculiar and striking appearance. It does not occupy a long and high hill, with nearly perpendicular slopes, like the northeastern part, but, owing to a powerful and rapid disintegration, it has

crumbled into loose pieces and into a fine sand, which form a range of low hills with gentle slopes, and which, seen from a distance, look exactly like hills of sand or drift.

"The dyke here consists of a rather coarsely granular aggregate of labradorite, sphene, mica, quartz, pyroxene and iron pyrites. The sphene is of a brown to yellowish brown color, of an adamantine luster, and occurs in small, more or less perfect, crystals, in such quantity as to form one of the principal constituents of the rock.

"The iron pyrites is profusely disseminated throughout the rock, and causes the rapid decomposition.

"There is usually a marked difference between the middle of the dyke and the margins, the material being distinctly crystalline at the middle while it is compact at the surface. The dyke is traversed by joints and by some small veins, and it also sends out veins into the contiguous rocks.

"The slate has been altered for a distance of three thousand feet from the southeastern border of the dyke.

"Very near the dyke the rock is so much changed that the stratification cannot be determined, but farther off, though the rock is much changed, the marks of stratification are still plain, and the rock has the usual northwesterly dip."

Being fresh from a study of the wonderful "Cortland series," under the kind guidance of Professor Dana, my attention was immediately attracted by the description above of a great dyke of hypersthenic rock which crumbled readily into hills of coarse sand, and had exerted such powerful metamorphic influence upon the soft Hudson River rocks, and I visited the locality in the hope that it might throw some light upon the complexities of the Cortland region. Leaving the railroad at Deckertown just above Franklin Furnace, the drive of six miles was over a hilly country of soft crumbling shales. More than half a mile from the dyke its influence was manifest, the shales having changed into a dark gray compact mass, breaking into wedge-shaped pieces bounded on all sides by slickensides. Nearer at hand the shales are baked into a complete hornstone of a black color, breaking with the perfect conchoidal fracture of flint, and cut into small fragments by numerous joints. Where the road over the mountain leaves the road which skirts the mountain on the east, at the house of Mr. D. B. Roloson, this is seen in great perfection on the hillside, and in the orchard above this gentleman's house, a band of limestone occurs—a dark gray fine grained rock, which might be easily mistaken for a fine-grained diorite. It has, however, the rusty corroded surface of a siliceous limestone. Scales of biotite are disseminated in it in considerable abundance, and the rock is so rich in magnetite that the coarse powder is readily

taken up by the magnet. Microscopically the rock is a crystalline-granular aggregate of calcite and magnetite.

A few rods farther south, and just behind the house in the orchard, occurs a large mass, apparently a bowlder, of a fine-grained brown-black eruptive rock, which is so filled with small angular fragments of the same siliceous limestone, that these latter make more than half its mass. They are gray, compact and horny, and contain in abundance minute cubes of pyrite arranged with some regularity parallel to the surface of the broken fragments. There also occur in the mass of the trap small fragments of quartz manifestly enclosures, and small aggregations of white grains of calcite so mixed in with scales of biotite that they seem to be the result of fusion and crystallization in the mass, rather than of subsequent decomposition. Examined under the microscope, the trap was found to be thoroughly impregnated with calcite, and, when treated with acid, effervescence appeared in every part. Besides the large scales of mica visible to the eye, more minute scales of the same red mica and grains of magnetite were scattered throughout the slide in a colorless ground, interrupted here and there by quite large square and hexagonal sections of nepheline, which gelatinized slowly under the microscope after the effervescence of the calcite had ceased. Rarely a broad rounded mass of fibrous green hornblende, decomposed nearly to the center, appeared. I was not able to discover the exact relation of this rock to the main dyke, but it was probably an offshoot therefrom, as it occurs only a few rods from the latter in the midst of the region of most active metamorphism.

Going north about a mile from the house of Mr. Roloson along the road skirting the mountain on the east to a point where the woods are cleared away and a single great oak stands by the roadside, one ascends the first slope of the ridge which rises about eighty feet like a terrace scarp, and comes out upon a broad level made up of the metamorphosed slates from which the great dyke rises at the west to form the crest of the mountain, and stretches away several miles to north and south. Toward the front of this terrace-like plain, and about thirty rods from the nearest outcrop of the dyke, a layer of the shale is altered to a tough gray rock broken by numerous fissures which has much the appearance of a claystone porphyry. In a ground mass, quite felsitic in appearance, are imbedded opaque white Carlsbad twins of orthoclase, sharply defined and six to eight millimeters in length, small rhombs of calcite and cubes of pyrite now changed mostly to limonite, and in a single instance a quite large crystal of dark green chlorite. The ground mass is resolved under the microscope into an aggregate of extremely fine scales of muscovite of irregular outline.

While the calcites are limpid, the orthoclase crystals, opaque white by reflected light, are of deep reddish brown by transmitted light, and this color, which is caused by the abundance of a very fine red dust, is spread uniformly over every portion of every crystal, except in one slide where they are quite fresh, and enclose in considerable number small perfect spheres of a deep brown to black color, which seem to be some hydrocarbon compound which has been included in the forming crystal in a liquid state. This black carbonaceous matter is scattered here and there through the mass, and it is sometimes aggregated in the midst of a brownish substance in such a manner as to suggest an incipient stage in the formation of chiastolite crystals. All the rest of the micaceous ground-mass is mottled by a great number of very minute, stout, rod-like forms, four to six times longer than broad, and quite uniform in size and distribution, though not always regular in shape, being often rounded, pointed, or ravelled out at one or both ends. They are nearly opaque but resolvable (×800) in the thinnest places into a congeries of red scales. The specimen contains a single large crystal of a dark green chlorite, visible to the eye, and these minute forms may have resulted from the decomposition of a similar mineral, but it seems to be rather an early stage in the growth of some ferruginous mineral like ottrelite.

On crossing the high terrace-like buttress of thoroughly metamorphosed rocks, here, perhaps forty rods wide, one comes upon the sharp slope of the great ridge formed by the dyke itself. The contact of the dyke and the enclosing rock was nowhere to be seen. Where it was first met with in place, a little way up the slope, the foyaite bears no resemblance to the compact trap-like rock from near Roloson's, described above. It is completely granitic in texture, of medium grain, and of a grayish flesh color, deriving this color mainly from the elæolite which is its principal constituent. The latter is so abundant that a small piece of the rock treated with hydrochloric acid changed into a thick jelly, in which only a small quantity of black ægirite remained undissolved. The hand specimens which I got from this portion of the dyke contain certainly 90 per cent of elæolite. The mineral possesses the usual greasy luster, is granular massive, yet shows under the lens everywhere incomplete crystalline outlines.

The component next in importance is ægirite, which appears in black elongated crystals up to 3^{mm} in length, upon which I was able to measure the angle of the prism 92° 47′. The mineral fuses with somewhat greater difficulty than the Norwegian ægirite, and tinges the flame yellow. The surface of many of the crystals is brightly iridescent, as is sometimes the case with the arfvedsonite from Kangerdluarsuk, and the crystals

can be seen toward the surface of the rock to be changed for a part or the whole of their length into a greenish black, fibrous, hornblendic mineral apparently arfvedsonite.

The third constituent, orthoclase, occurs in elongated Carlsbad twins up to 30^{mm} in length; in a single instance three crystals are twinned together. They are of brilliant luster, and of the same flesh color as the elæolite in the fresh rock, while toward the surface they are whitened, and there closely resemble the feldspar of the Brevig zircon-syenite. They are scattered in the rock somewhat distantly, so that in three sections no feldspar appeared. The crystals enclose rounded masses of elæolite as well as crystals of ægirite, often so thickly crowded as to give the feldspar a pegmatitic appearance.

Titanite occurs in minute crystals quite abundantly. The maximum length is about 1^{mm}. It is of bright reddish yellow color, transparent, and of adamantine luster, and is always well crystallized in both complex and simple forms, with the faces often brightly iridescent. No trace of triclinic feldspar or of hypersthene could be found.

High up along the crest of the ridge, perhaps fifty rods west of the point where the specimens were obtained which furnished the material for the above description and for microscopical study, the rock is much coarser grained, more loosely granular and decomposed, falling readily to a mass of coarse grains under the hammer.

The proportion of elæolite is here much less, and the only additional mineral found in this coarser variety was a glossy black mica, which gives all the blowpipe reactions of astrophyllite, but it may be a biotite containing much manganese.

Under the microscope by far the greater portion of the section is elæolite, with scattered crystals of ægirite and titanite. The elæolite presents itself in three forms, quite distinctly demarked: (*a*) as distinct crystals, stout hexagonal prisms with end faces, of much the same appearance and properties as in the more modern nepheline rocks. These crystals are rare. The cleavage is more perfect and delicate than in the remainder of the elæolite in which they are embedded, and as a result they are only slightly decomposed. They are quite free from enclosures. The second form (*b*) appears in somewhat larger, aggregated, and more imperfect crystals, in which the basal, prismatic and pyramidal cleavages are ruder and more open, and the crystals much more decomposed. Flakes of a green hornblendic mineral, probably arfvedsonite, appear as enclosures parallel to the three cleavages. Finally it occurs (*c*) filling up the interstices of the other two forms like the quartz of a granite, and swarming with minute acicular microlites, especially in the recesses made by neighboring crystals of earlier formation. This portion has a less distinct cleavage and is less decomposed.

The freshest ægirite shows six-sided cross-sections (*I*, *i-i*,) remarkably regular both in form and cleavage, the latter being in straight equidistant lines carried generally clear across the crystal, and thus differing widely from that of augite. It is red brown with much depth of color in cross-sections, blackish brown in longitudinal plates, free from enclosures, and without trace of fibrous structure. Both in lengthwise and cross sections it absorbs the light with a single Nicol's so strongly that at the point of extinction it becomes jet black. The pleochroism is also very marked, ranging from charcoal brown to deep emerald green. In other crystals, starting from one end, the color in ordinary light changes gradually from dark brown into a bright green, and corresponding with this change of color the mineral becomes quite suddenly fibrous, and filled with minute grains of magnetite, which are wanting in the unchanged portion. The changed portion has all the microscopic peculiarities of a fibrous hornblende. In longitudinal sections of the ægirite a cleavage parallel to *O* appears, and in one instance occurred a well terminated arrow-headed twin—twinning plane *i-i*. Its crystals often radiate from or enclose a crystal of titanite.

The titanite appears in wine-yellow, limpid, much fissured, cross-sections, distinctly pleochroic, rough of surface, never sinking to the smallest dimensions, or containing any enclosures. Besides ægirite the microlites often radiate from it. Beautifully distinct twins occur with the twinning plane *O*, and with crossed Nicols the light is extinguished at 33° on either side of this plane.

Sodalite occurs rarely in wholly apolar patches irregularly bounded by the other constituents, and showing rude dodecahedral cleavage.

The order of crystallization of these minerals is interesting. The titanite is plainly the first formed, and had reached its limit before the appearance of the other constituents, except perhaps the first form (*a*) of the elæolite. These are almost without enclosures of any kind. Next the second portion of the elæolite (*b*) crystallized out, and during the time of its formation the hornblendic mineral, which is included in it in scales, as well as the ægirite which radiated from the earlier formed titanite, appeared. This green hornblendic mineral as it is synchronous with the ægirite and as it is found in the most decomposed portion of the elæolite, I take to be arfvedsonite paramorph after the ægirite.

Toward the close of this period the orthoclase, which encloses the imperfect crystals of the elæolite and the ægirite, separated out, and all these minerals share the same freedom from microlites, a great swarm of which is included in the third form of

the elæolite (*c*) which has taken its shape entirely from the preceding minerals and which thus closed the series.

Out on the plateau of metamorphic rock I picked up a curious mass not in place, which showed a contact of foyaite on foyaite of different age. The older was coarser grained than I found it elsewhere and richer in orthoclase, being largely made up of crystals 25–30^{mm} long, distributed porphyritically in a fine-grained rusty ground containing pyrite. The newer rock, resting on this, has a rudely columnar structure at right angles to the plane of contact, resembling somewhat the gypsum crusts from salt vats.

The columns of which this layer consists are elongate imperfect crystals of orthoclase and elæolite and bundles slightly radiated of a greenish black hornblendic mineral. Small tufts and spheres of the latter are also scattered through the mass, together with some dark purple fluor and much pyrite.

Under the microscope distinct crystals of elæolite appeared and the hornblende needles were contracted, like the handle of a dumb-bell as they passed through such a crystal, showing that the hornblende had here commenced its crystallization first and that the two minerals had thereafter increased together.

The hornblende crystals are now in an advanced stage of decomposition, being resolvable into an aggregate of short interrupted fibers and so impregnated with scales of "ferrite" as to be often quite opaque, and the same material has also often gathered on the needles in large masses like the warts on a plum twig. Only rarely in unchanged non-fibrous portions of green color could the angle of extinction of hornblende be measured. The feldspar was orthoclase with no indication of the presence of microcline.

The aphanitic and the granitic varieties of the rock described above are connected by intermediate grades of fine grain in which occur segregations in size and shape like a hen's egg, composed of coarse granular orthoclase, ægirite, pyrite and fluor.

Decomposition has everywhere affected the superficial portions of the dyke, and at the summit where the rock is coarsest, extended quite deeply, but without the formation of any zeolitic minerals.

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