ART. XII.—*Note on the "Chloritic formation" on the western border of the New Haven Region;* by JAMES D. DANA.

THE rocks of the hilly region west of the New Haven plain are, for nine miles westward, metamorphic slates, and beyond this distance mostly gneiss. Immediately adjoining the region there is what Percival has called a "chloritic formation," the area trending about north-northeast; then on the west of this, with the same trend, (2) a hydromica slate, but little removed from argillite, becoming slightly garnetiferous toward the western limit; next (3) a glossy garnetiferous mica slate, containing some beds of gray semi-crystalline limestone; next (4) at Derby, common gneiss and coarse porphyritic gneiss. These rocks are involved in one system of folds, and are throughout conformable in bedding.

The rock of the "chloritic formation" varies much in texture and composition in passing from the Sound northward. Near Savin Rock, on the Sound, it is a chloritic hydromica slate. The gray and slightly silvery surface is more or less blotched and lined with the olive-green of chlorite, and the rock has in the mass in general a greenish tint. The slaty structure is usually perfect, and yet some layers fail of it. Grains of magnetite are common, and, less so, those of pyrite.

* Ann. der Ch. und Ph., clxvii, p. 41.

This slaty variety of the rock continues with little change for a mile and a half north. Beyond, the massive layers increase in extent. At the deep Derby railroad cut, two miles north of Savin Rock, the massive variety constitutes more than half of the rock exposed in the sections; and it is not all in separate beds; for thick beds that are slaty in one part are in others for many rods massive, and it is impossible to separate the massive from the slaty by any stratigraphical planes.

This massive rock is commonly without a trace of bedding; at the same time, it is variously and extensively jointed, so that it affords only deceptive indications of strike or dip. It varies in color from greenish gray to dark olive-green and blackish gray. Some of it is almost cryptocrystalline; but in general the texture is fine granular. Part of it is porphyritic with small crystals of a whitish feldspar.

Between this Derby cut and "Maltby Park," a mile and three quarters west of north, this massive rock constitutes nearly all the outcrops; and in some places the porphyritic variety is pale greenish gray, from the thickly crowded feldspar crystals.

Over Maltby Park the rock is again slaty and silvery, often with blotches of chlorite—a chloritic hydromica slate—as at Savin Rock; yet with enough of both the ordinary and porphyritic *massive* kinds among the slaty layers to exhibit its close relation to the rocks farther south. The slate occasionally has the chlorite in large lenticular concretions, and now and then is light gray and contains crystals of pyroxene. In some places, especially along seams, it is epidotic. Veins and seams of quartz are numerous. In the slate there are interrupted beds of limestone. Part of the limestone contains serpentine and is a handsome verd-antique marble; and with the serpentine there are often grayish green cleavable pyroxene (sahlite), asbestus and chromic iron.

A mile farther north, or five miles from Savin Rock, (west of Westville), the rock is almost wholly a dark green chlorite slate—the micaceous part absent.

The rocks in the course of the five to six miles are—in recapitulation—commencing at the Sound:

For 1½ miles, chloritic hydromica slate, little of it massive.
1½ to 2¼ miles, chloritic hydromica slate, much of it massive.
2¼ to 4 miles, massive chloritic rock with little of it slaty.
4 to 4¾ miles, chloritic hydromica slate, very little of the rock massive.
4¾ to 6 miles, mostly dark green chlorite slate.

It is to be noted that throughout the formation the slaty and massive portions are so associated, sometimes as alternating

beds, sometimes as parts of the same beds, that *their common metamorphic origin* cannot be questioned—a point that I have studied for years.

The resemblances of the massive rock to trap was long since noticed by Professor Silliman, who, in a paper on the geology of New Haven and its vicinity, published in 1811 in Bruce's Mineralogical Journal, called it "primitive greenstone." In fact, the similarity in external aspect is so close that hand specimens from some portions of it would without question be pronounced trap—that is, doleryte, diabase, or melaphyre—by the most experienced lithologists.

In 1872, an incomplete analysis of the feldspar in the pale grayish green porphyritic rock, outcropping just south of Maltby Park, was made, by Mr. Edward S. Dana. The amount of silica afforded by the feldspar having been found to be but 45 per cent, the conclusion suggested was that the rock consisted largely of labradorite, and that it was probably essentially identical with part of the trap of the Connecticut valley dikes. In view of the presence of chlorite, I hence regarded the compact rock of the region as a metamorphic diabase; and it is the rock specially referred to under that name in the last edition of my Manual of Geology.

Still, the analysis, besides being incomplete, was not satisfactory because the feldspar crystals, although of the normal hardness, were granular in texture, without good cleavage, suggesting that they might possibly have undergone a partial alteration. On account of Mr. Dana's departure for Europe, he was compelled to leave the investigation he had begun unfinished; and so it has remained until this summer, when it was taken up, at my request, by the skillful analyst connected with the mineralogical department of the Sheffield Scientific School of Yale College, Mr. George W. Hawes. His results prove that the rocks are in fact *metamorphic doleryte*, *metamorphic diabase*, and *metamorphic melaphyre;* the first two, labradorite rocks, and the last an oligoclase variety. To distinguish these metamorphic rocks from the igneous of the same composition, they are named, on my suggestion, *metadoleryte*, *metadiabase*, and *metamelaphyre*. The examples are part of a long series of rock species which have representatives both among igneous (or intrusive) and metamorphic rocks. Other kinds are *dioryte* and *metadioryte*, *syenyte* and *metasyenyte*, *felsyte* and *metafelsyte*, etc.

We have here the important geological fact that labradorite is a prominent constituent of certain metamorphic rocks which have the aspect of much dioryte, and which are probably of Lower Silurian origin.* The labradorite—a lime-and-soda feld-

* On the question of their age I have collected many facts and propose before long to publish.

spar—must have been a result of the metamorphic process. And its formation was probably favored by two conditions in the original mud-beds so changed; (1) the presence of a comparatively small percentage of silica, or not over 50 per cent; and (2) the presence of much disseminated carbonate of lime probably derived mainly from pulverized fossils. The fact that the chloritic formation contains two or more beds of limestone is reason for supposing that the mud elsewhere may have been more or less calcareous. The oligoclase of the metamelaphyre required for its formation only that the mud should contain a little more silica and soda and less lime.

The terms *doleryte* and *diabase* are here retained for the *igneous* rocks which have been so called—*diabase* being applied to the chloritic variety of doleryte.* Some German works on Lithology restrict the term doleryte to dolerytes not older than the Tertiary, and call the other kinds, whether chloritic or not, diabase. But this is giving different names to the same compound; and it is making geological age—a criterion fortunately never considered in the naming of other rocks—override difference of mineral composition.