

ART. XIII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXXVII.—*The Rocks of the "Chloritic formation" on the Western Border of the New Haven region ;* by GEORGE W. HAWES.

THE rocks which compose the ridge fronting the New Haven plain on the west, in the town of Woodbridge and Orange, and which have been described in the foregoing article by Professor Dana, bear, as he states, a close resemblance to the trap rocks of the Connecticut Valley. It hence becomes interesting to ascertain whether the similarity is sustained by their chemical composition and mineral constituents.

As in the case of the trap, these rocks are of different kinds. *First*, dark-colored crystalline rocks very similar in color, texture, fracture, and specific gravity, to the undecomposed dolerites of this region; and *second*, rocks which are more or less green and appear to be chloritic, very closely resembling the diabase. The latter kind has its porphyritic varieties. Besides these there is a *third* kind which contains a higher percentage of silica, and has the composition of melaphyre.

I. *Metadolerite*.—A specimen collected from an outcrop about a mile south of Maltby Park (on what was formerly Mr.

* On the origin of this chloritic condition of part of the trap of the Connecticut valley—the part distinguished here as diabase—see this Journal III, vi, 104, 1873; also Mr. G. W. Hawes, *ibid.*, ix, 191, 1875.

Stoeckel's farm) was selected for analysis. It was crystalline-granular in texture; and it would be hard to detect by the eye any difference between it and many kinds of doleryte which are found in this region. The analysis shows that in chemical composition also it is very nearly the same. An analysis of a specimen of true igneous doleryte, from the trap ridge called West Rock, in New Haven, is placed beside it for comparison.

METADOLERYTE, FROM STOECKEL'S FARM.

	I.	II.	Mean.	Doleryte, from West Rock.
Silica	50.40	50.32	50.36	51.78
Alumina	14.43	14.71	14.57	14.20
Ferric oxide	2.48	2.47	2.48	3.59
Ferrous oxide	8.28	8.35	8.31	8.25
Manganous oxide	.43	.49	.46	.44
Lime	11.15	11.11	11.13	10.70
Magnesia	7.65	7.59	7.62	7.63
Soda	3.01	3.08	3.04	2.14
Potash .....	.43	.44	.44	.39
Titanic acid	1.65	1.74	1.70	
Chromic oxide....	<i>tr.</i>	<i>tr.</i>	<i>tr.</i>	P ₂ O ₅ .... .14
Ignition .....	.74	.83	.78	.63
	100.65	101.13	100.89	99.89
Specific gravity			3.04	3.03

The close resemblance between the igneous and the metamorphic rock will be noticed; they differ from one another less than do the different varieties of doleryte. Moreover, observations made upon thin sections indicate that the rock is composed of pyroxene, a triclinic feldspar, and a black opaque mineral which the analysis shows to be titanite. The pyroxene is a dark-green variety, but clear and undecomposed. If we assume that the pyroxene of this rock is of the same composition as that of the New Haven dolerytes,* the magnesia indicates that it contains 55 per cent of this ingredient, which being subtracted along with 3 per cent of titanite iron, leaves 41 per cent of a mineral, the oxygen ratio of which is very near to 1:3:6—proof that the feldspar is labradorite. Hence, the physical appearance, the chemical composition, and the proportion between the mineral constituents all show a very close resemblance to doleryte. The name of *metadoleryte* seems therefore to be particularly appropriate for this rock.

2. *Metadiabase*—The chloritic variety, which has been referred to, resembles diabase in appearance as closely as the preceding kind does doleryte. There are, however, wider limits of variation in texture and in the proportion between the mineral constituents than is noticed in diabase; for the rock is sometimes uniformly crystalline, and sometimes coarsely

* See this Journal, III, ix, page 187.

porphyritic. As would be supposed, there are no amygdaloidal cavities or geodes either in the mass or in microscopic sections. The analysis was made upon a specimen collected at the Derby railroad cut where there is a fine display of these rocks. The specimen was uniform in texture and of a light-green color.

METADIABASE, FROM THE DERBY RAILROAD CUT.

	I.	I.	Mean.
Silica	48·25	48·15	48·20
Alumina	14·22	14·01	14·12
Ferric oxide	1·95	2·05	2·00
Ferrous oxide	7·39	7·43	7·41
Manganous oxide ...	1·30	1·19	1·24
Lime	11·53	11·47	11·50
Magnesia	8·26	8·11	8·19
Soda	2·63	2·56	2·60
Potash	·24	·23	·23
Titanic acid	1·61	1·55	1·58
Water	2·11	2·29	2·20
	99·49	99·04	99·27
Specific gravity.....			3·02

The analysis, taken with the observations made upon thin sections, shows that the rock is a mixture of pyroxene, chlorite, labradorite, and titanite iron, which are the constituents of diabase; and hence this metamorphic rock is appropriately distinguished by the name *metadiabase*. The absence of carbonate of lime is noticeable, showing that in this case the chlorite was formed simultaneously with the pyroxene, and not at the expense of the pyroxene, as in the case of the diabase of the trap dikes of the Connecticut valley, which always contains carbonate of lime as one result of the change. This rock in places contains pyrite, which is also frequent in trap.

PORPHYRITIC METADIABASE; SOUTH OF MALTBY PARK.

	I.	II.	Mean.	Diabase of Salton-stall Ridge.
Silica.....	48·57	48·65	48·61	49·28
Alumina	17·78	17·85	17·81	15·92
Ferric oxide.....	·35	·16	·25	1·91
Ferrous oxide	8·44	8·48	8·46	10·20
Manganous oxide..	·20	·20	·20	·37
Lime	11·17	11·14	11·16	7·44
Magnesia	7·78	7·74	7·76	5·99
Soda	2·73	2·82	2·77	3·40
Potash	·47	·47	·47	·72
Titanic acid.....	1·35	1·35	1·35	CO ₂ 1·14
Water.....	1·60	1·65	1·63	3·90
	100·44	100·51	100·47	100·27
Specific gravity.....			3·01	2·86

There are varieties of this rock intermediate between these two, some specimens of which are beautifully porphyritic. In some kinds the feldspar is free from impurities; but in those varieties which are very feldspathic, and the feldspar crystals largest, these crystals are quite impure from the envelopment of chlorite. The porphyritic rock, from an outcrop near the Orange road, just south of Maltby Park, containing clear crystals of feldspar, was analyzed, and the result is given on the preceding page. An analysis of the diabase of Saltonstall Lake, from my former paper, is added for comparison.

This porphyritic rock is composed of the same minerals as the more compact varieties, for all of the ingredients can be easily recognized under the microscope. The possible presence of anorthite in the rock is suggested by the following analysis of some large grains of feldspar taken from an adjoining rock: SiO_2 45.52, Al_2O_3 29.84, MgO 2.35, CaO 15.99, NaO 1.61, KO .37, ignition 2.38 = 98.06. This analysis was made by Mr. E. S. Dana some years since, but he states that the microscopic examination, and the analysis itself, show that the grains were very impure crystals of a triclinic feldspar, and as all the calculations upon the analyses point to the presence of labradorite, we cannot assume that any of the rocks which have been analyzed contain anorthite, though it is very likely to exist in the rocks of the series, since a constant composition in the feldspar could not be expected in the different layers of a rock made up of shifting sediments.

3. *Metamelaphyre*—a specimen taken from an outcrop on Stöckel's farm is so fine grained as to appear nearly cryptocrystalline; it is broken into angular fragments like some of our trap rocks, and in fact resembles some compact trap so closely as to make it impossible to distinguish it by the eye alone. Its analysis afforded the following results:

METAMELAPHYRE, FROM STÖCKEL'S FARM.

	I.	II.	Mean.
Silica	55.03	55.10	55.07
Alumina	14.38	13.98	14.18
Ferric oxide	7.15	7.25	7.20
Ferrous oxide	1.85	1.99	1.92
Manganous oxide .....	.30	.30	.30
Lime	9.05	9.01	9.03
Magnesia	6.02	5.94	5.98
Soda	4.08	4.14	4.11
Potash .....	.38	.37	.37
Titanic acid	1.56	1.56	1.56
Water .....	.68	.75	.72
	<hr/> 100.48	<hr/> 100.39	<hr/> 100.44
Specific gravity			2.99

If we assume that the pyroxene of this rock has the same composition as that of No. 1, we calculate, from the magnesia that it contains, 44 per cent of this ingredient; then, deducting three per cent of titanitic iron, we have left a remainder of 53 per cent, which has very exactly the ratio and composition of oligoclase. This mineral constitution appears to be justified by the microscopic examination, since no free quartz or other mineral can be detected. If we restrict the use of the term melaphyre, as it is done in some recent works on lithology, to a mixture of oligoclase and pyroxene, with some titanitic iron, the rock here analyzed is melaphyre in composition as well as appearance; and being a metamorphic rock, it is *metamelaphyre*.

We thus have representatives of the larger part of the pyroxenic igneous rocks, in positions which show conclusively that they are of metamorphic origin. The fact that metamorphic action can produce rocks exactly like the igneous in external aspect and chemical constituents is of great interest in the study of rocks.