ON THE TRAPS OF THE MESOZOIC SANDSTONE IN YORK AND ADAMS COUNTIES, PENNSYLVANIA.

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Chemical Properties.

All igneous rocks consist principally of compounds of some kind of feldspar (or Nepheline or Leucite) with pyroxene, hornblende, mica or quartz, and generally with some magnetite and other subordinate minerals. All these again may be divided into those poor in Silica or Basic, or those rich in Silica or Acidic.*

The average compositions of these two kinds of igneous rocks are :

	BASIC.		ACIDIC.	
	PER CENT.	AVERAGE.	PER CENT.	AVERAGE.
Silica.....	45–60	52	55–80	67
Alumina.. ..	10–25	17	10–15	12
Ferrous oxide Ferric oxide	1–25	13	1–15	8
Lime	1–15	8	0–8	4
Magnesia	1–12	7	0–4	2
Potash.....	1–9	5	1–11	6
Soda.....	1–7	4	2–8	5
Water.....	0–4	2	0–6	3

Taking these ideal average percentages of the constituent compounds of these two classes of rocks, throwing them into a more convenient form and neglecting small fractions, we have :

BASIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon.....	24.96	27.0	27
Aluminum	9.00	8.0	10
Iron from Fe_2O_3 say.....	4.5	2.0	
Iron from FeO say.....	5.0	1.5	10
Calcium	5.7	2.3	
Magnesium.....	4.3	2.7	
Potassium	4.1	0.8	
Sodium	2.9	1.0	
Hydrogen	0.2	1.8	
Total oxygen.....		47.1	

Of course it is understood that these figures represent no combination

* Rocks Classified and Described, by B. v. Cotta. Translated by H. Lawrence. London. Longmans, Green & Co., 1866.

of elements actually possible, and that the ratio of the Oxygen of the Silica to that of the protoxide and sesquioxide bases is only approximative to that of a mixture of minerals representing a mean of the highest and lowest percentages of those elements which are more commonly found in Basic igneous rocks.

The same remark applies equally to the next following class :

ACIDIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	32.16	34.84	34.84
Aluminum	6.38	5.62	6.82
Iron from Fe_2O_3 say	2.80	1.20	
Iron from FeO say	3.08	0.92	9.67
Calcium	2.86	1.14	
Magnesium	1.22	0.88	
Potassium	3.24	2.76	
Sodium	3.70	1.30	
Hydrogen	0.33	2.67	
Oxygen		51.33	

Bunsen's* classes were as follows :

	PYROXENIC.	TRACHYTIC.
Silica	48.47	76.67
Alumina, Ferric oxide	30.16	14.23
Lime	11.87	1.44
Magnesia	6.89	0.28
Soda	1.96	3.20
Potash	0.65	4.18
Total	100.00	100.00

Bringing them into the same form as the above, we have :

PYROXENIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	23.26	25.21	25.21
Aluminum (say 15 p. c. Al_2O_3)	7.95	7.05	11.60
Iron (say 15.16 p. c. Fe_2O_3)	10.61	4.55	
Calcium	8.47	3.40	6.69
Magnesium	4.22	2.67	
Sodium	1.45	0.51	
Potassium	0.54	0.11	
Oxygen		43.50	
Total acid and basic radicals	56.48		

* Pogg. Ann., 1851, Vol. LXXXIII.

TRACHYTIC.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	36.80	39.87	39 87
Aluminum (say 7 p. c. Al_2O_3)	3.71	3.28	5.45
Iron (say 7.23 Fe_2O_3)	5.06	2.17	
Calcium	1.03	0.41	2.06
Magnesium	0.17	0.11	
Sodium	2.37	0.83	
Potassium	3.47	0.71	
Oxygen		47.38	
Total acid and basic radicals	52.61		

In the Journal of Science and Arts, Vol. IX, March, 1875, is a paper by Mr. Geo. W. Hawes, on the Trap Rocks of the Connecticut Valley, in which a number of closely accordant analyses of dolerites are given, the specimens being selected from various localities in the Mesozoic Sandstone Belt of that State.

A Dolerite taken from a dyke known as West Rock, and standing west of New Haven, gave to Mr. Hawes the following results, which have been embodied in the form of the preceding hypothetical compositions.

ANALYSIS I, OF WEST ROCK.

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	24.86	26.94	27.02
Phosphorus	0.06	0.08	
Aluminum	7.55	6.65	7.72
Iron (from Fe_2O_3)	2.48	1.07	
Iron (from FeO)	6.36	1.90	8.58
Manganese (from MnO)	0.32	0.10	
Calcium	7.58	3.00	
Magnesium	4.67	2.96	
Sodium	1.59	0.56	
Potassium	0.32	0.06	
Ignition	0.63		
Oxygen		43.32	
Acid and basic radicals	56.42		

On comparing this analysis with the hypothetical composition of Cotta's Basic Igneous Rock, it will be observed that the Silicon (including under this head the small per cent. of P. present in West Rock), is almost the same in both, as also is the percentage of radicals in the pro toxide bases, while the per cent. of Oxygen of both protoxide and ses-

quioxides, and the per cent. of the radicals of the sesquioxide bases are somewhat less in the actual, than in the hypothetical analysis.

In tabular form the proportions would stand as follows :

	HYPOTHETICAL BASIC IGNEOUS ROCK.	WEST ROCK.
Silicon }	24.96	24.92
Oxygen }	27.00	27.02
Aluminum } }	13.50	10.03
Iron (from peroxide) } }		
Oxygen }	10.00	7.72
Radicals of protoxide bases }	22.20	20.84
Oxygen }	10.00	8.58

A mean of 40 analyses of Labradorite recorded in Dana's Mineralogy, is as follows :

	PER CENT.
Silica	53.09
Alumina	27.96
Ferric oxide	1.33
Magnesia	0.93
Lime	10.88
Soda	4.09
Potash	1.08
Water	0.84
Total	99.39

Or in the simple form :

	PER CENT.	OXYGEN.	OXYGEN RATIO.
Silicon	25.48	27.61	27.61
Aluminum	14.73	12.96 }	13.36
Iron (from Fe_2O_3)	0.93	0.40 }	
Magnesium	0.24	0.15 }	5.26
Calcium	7.77	3.11	
Sodium	3.03	1.06	
Potassium	0.98	0.19	
Hydrogen	0.09	0.75 }	

Mr. Hawes extracted enough crystals of pyroxene from one specimen of Connecticut trap to enable him to determine its constitution.

It bears the nearest resemblance to an Augite of the Rhone, analyzed by Klaproth :

	Si.	Al.	Fe.	Mn.	Ca.	Mg.	Ignition, Alkalies and Loss.	Total.
Connecticut pyroxene .	24.34	1.88	11.90	0.63	9.53	8.34	2.65	56.62
Oxygen.....	26.37	1.76	3.40	0.18	3.82	5.29		40.82
Augite (Rhone*).....	24.96	3.06	8.48	0.19	1.00	7.80	4.23	54.49
Oxygen.....	27.04	2.70	2.54	0.06	4.00	4.95		41.29

Assuming the pyroxene analyzed by Mr. Hawes to represent that constituting part of these traps, and assuming furthermore, the above average of 40 analysis of Labradorite as constituting the remaining part, we have the following comparative table, which is calculated by comparing the sum of the percentages of each element of the two minerals with double the percentage of the same element in West Rock.

PER CENT.

Elements.	Labradorite.	Augite.	West Rock.		
			Double Equivalent.	Deficient.	In Excess.
Si.	25.48	24.34	49.72	0.10	——
P.	——	——	0.12		0.12
Al_2^{vi}	14.78	1.88	15.10	1.51	——
Fe_2^{vi}	0.93	——	4.96	——	4.03
Fe'' & Mn''	——	12.53	13.36	——	0.83
Ca.	7.77	9.53	15.16	2.14	——
Mg.	0.24	8.34	9.34	——	0.76
Na.	3.03	1.65(?)	3.18	1.50(?)	——
K.	0.98	1.00(?)	0.64	1.34(?)	——

Of the constituents necessary to form a mixture of one molecule of each of the above mentioned minerals, there are in West Rock :

* Dana's Min., p. 218, II. 7.

CHEMICAL UNITS.

Elements.	Deficient.	In Excess.
Al_2^{vi}	0.165	——
Fe_2^{vi}	——	0.216
Fe″ & Mn″	——	0.030
Ca.	0.107	——
Mg.	——	0.063
Na.	0.065	——
K.	0.034	——
Sum.	0.371	0.309
Si.	0.014	——
P.	——	0.011

Supposing the basic radicals in excess to replace those deficient, there are wanting 0.062 (= 0.28 p. c.), and of the acid radicals 0.003 units (= 0.018 p c.) to fulfil theoretical requirements.

Or, to throw this into a rough practical form susceptible of easy comparison :

Double Equivalent of Constituents of West Rock.				
Si (P. &c.)	24.92 × 2		25.48	1 molecule Labradorite.
			24.34	1 " Augite.
	=	49.82	49.82	
Al_2^{vi} &c.	10.03 × 2		15.66	1 molecule Labradorite.
			1.88	1 " Augite.
	=	20.06	17.54	
Dyad and Monad Basic Radicals,	20.84 × 2		11.80	1 molecule Labradorite.
			30.40	1 " Augite.
	=	41.68	42.20	

A specimen of Dolerite was taken from Beeler's farm, 2 miles S. W. of York, York county, Pa., and submitted to Dr. F. A. Genth for analysis, which is as follows :

	PER CENT.			Oxygen.
Silicic acid	52.53	Silicon	24.51	28.02
Phosphoric acid	0.15	Phosphorus	0.06	28.24 — 0.10
Titanic acid	0.32	Titanium	0.19	— 0.12
Alumina	14.35	Aluminum	7.65	6.70
Ferric oxide	5.93	Iron (from Fe_2O_3)	4.15	8.48 — 1.78
Ferrous oxide	5.45	Iron (from FeO)	4.23	— 1.21
Manganous oxide	trace	Manganese	—	— — —
Magnesia	7.99	Magnesium	4.79	— 3.20
Lime	10.27	Calcium	7.33	8.00 — 2.94
Lithia	faintest trace.	Lithium	—	— —
Soda	1.87	Sodium	1.38	0.49
Potash	0.92	Potassium	0.76	— 0.16
Copper	trace.	Copper	—	— —
Sulphur	0.08	Sulphur	0.08	— —
Ignition	1.23			
Total	101.04			

These constituents in chemical units give:

Silicon	3.500	3.515
Titanium	0.015	
P ——	—	
Aluminum	0.834	2.050
Iron (from sesquioxide)	0.222	
Iron (from protoxide)	0.150	
Magnesium	0.399	
Calcium	0.366	
Sodium	0.060	
Potassium	0.019	
Difference		1.465

DOLERITE FROM BEELER'S.

Total units in rock	11.130
Chemical units of Si. and Ti.	3.515
" " of basic radicals	2.050
Excess of units of Silicon, &c.	1.465

(*Neglecting Sulphur*)

	CHEM. UNITS.
Total chemical units of oxygen	5.565
Excess of units of acid over basic radicals (= units of saturating oxygen)	1.465
Linking oxygen	4.100
= 32.80 p. c.	
Saturating Oxygen = 11.72 p. c.	

Hence the conclusion that 4.09 p. c. of this rock is Silicon combined as ortho-silicic acid, according to the formula $M'_4Si^{iv}O''_4$, and the remaining 20.51 per cent. exists in the form of the mono-meta acid, or as $M'_2Si^{iv}O''_3$.

The excess of the chemical units of Si. over those of the basic radicals, will also serve to explain the fact (mentioned to me by Mr. Hawes in reference to the Ct. Traps, but which I have not yet sufficiently verified in those from our own State), that in many cases free Silica is observed in them.

It may be added that the reduction of the analysis of these rocks to a form which gives the measure of chemical force employed in the composition of their constituent minerals, and in a single unit, *i. e.*, the ratio of the percentage weight by the equivalence to the atomic weight, seems a very convenient one to employ in discussing the questions here considered.

It is interesting to observe that while the analysis of the Connecticut Dolerite agrees very well with a mixture of one molecule of Labradorite to one of Pyroxene, that from Beeler's farm corresponds even more closely with a mixture of two molecules of Labradorite to one of Pyroxene. In this table the same analyses of Labradorite and Pyroxene are used as in the former case.

3 molecules of Beeler's dolerite.			
Si.	24.65 × 3		49.40 (24.7 × 2) 2 molecules of Labradorite.
			24.34 1 molecule, Pyroxene.
	=	73.95	73.74
Al^{vi}_2 &c.	11.81 × 3		32.40 (16.2 × 2) 2 molecules, Labradorite.
			1.88 1 molecule, Pyroxene.
	=	35.43	34.28
Dyad and Monad Basic Radicals,	18.45 × 3		23.60 (11.8 × 2) 2 molecules, Labradorite.
			30.40 1 molecule, Pyroxene.
	=	55.35	54.00

OPTICAL PROPERTIES.

Syenite (?) from Cemetery Hill, near Gettysburg, Adams Co., Pa.

Contains Feldspar, Hornblende and Magnetite, and some Biotite, with Quartz rarely. With a single Nicol's prism, the blades of Hornblende are fully dichroic. Both that and the feldspar are speckled and spotted.

Between two Nicol's prisms the Labradorite polarizes through blue, yellow, and lilac ; the Hornblende from white to brown and black ; and the Quartz, which is sparingly present, gives brilliant colors.

In the thick specimen examined under the microscope the feldspar differs from that of the equally thick specimens of dolerite in being more transparent and "icy"-looking, resembling Adularia, and here and there are seen small grains of a transparent mineral giving the rainbow colors of quartz.

The fine slice reveals the feldspar in a state not easily distinguishable and of weathered appearance, and also several objects, which from their colors, green and red, resemble small fragments of pyroxene. While therefore, there is no doubt of the occurrence of hornblende in sufficient quantity to give the character to this rock, the question as to its proper name will be remanded to future study.

Dolerite from Beeler's Farm, 2 Miles S. W. of York.

This slide at 275 diameters and between Nicol's prisms, shows an aggregate of irregular portions of crystals of pyroxene and Labradorite with the accompanying magnetite. The surfaces of the crystals are rough, but they do not seem to be so much affected by weathering as in that marked No. 3.

Dolerite (No. 3) from Beeler's Farm, 2 Miles S. W. of York.

The Labradorite and pyroxene of this specimen, under 275 diameters, appear in much the same condition as those of the slide from the Mumper dolerite. The blades of Labradorite are twinned and sometimes geniculated ; the two individuals polarizing alternately light and brown.

Certain parts of this slide are very rich in a fine rod-like crystal apparently uniaxial which may be set down with safety as apatite. A very large number of these little crystals is distributed throughout the whole mass.

Dolerite from Mumper Shaft, 1 Mile N. of Dillsburg, York Co., Pa.

The thin section (magnified 56.8 diameters) and with $\frac{1}{8}$ in. aperture, exhibits blades of Labradorite very finely and regularly striated, mixed together with yellowish green masses of pyroxene irregularly cleft and stippled on the surface like fish roe and containing magnetite, around which is to be seen a brownish-yellow stain due to its partial conversion into ferric hydrate. With appertures of $\frac{1}{2}$ in., $\frac{1}{4}$ in., and 3-16, the same appearances are manifest, but not so clearly.

With the Lieberkühn reflector the fragments of magnetite assume a partially metallic lustre.

With one Nicol's prism there is a faint appearance of dichroism in some isolated spots of some of the pyroxene crystals but in general there is no change.

Between two Nicol's prisms the pyroxene changes from green to pink (sometimes giving a transient spot of deep purple), and the irregular rifts in its mass are more plainly visible.

The Labradorite changes abruptly along the planes of twinning to light brown and pale greenish-blue from white. The striation is very apparent and polarization is usually complementary in two or three sections of the single blade.

The magnetite of course remains unchanged.

Between Nicol's prisms and magnified 275 diameters the outlines of the constituent crystals of this rock are very sharp, and the pyroxene in particular shows very brilliant shades of purple and green.

The cleavage is quite apparent, and the whole rock seems but little altered.

Dolerite from Logan's Shaft, 1 Mile N. of Dillsburg.

This slide resembles the others but is less decomposed and compounded of finer crystals than the others. It exhibits Labradorite, pyroxene and magnetite, besides acicular crystals which appear to be apatite.

Under 275 diameters the Labradorite and pyroxene have a rough appearance, as if covered with little bubbles, due perhaps, to incipient decomposition. A number of small needle-like apatite crystals are scattered through the mass.

The greater part of the Labradorite (which is twinned as usual) lacks sharpness of outline.

The photographs and zinc plates from the photo-zincograph process have been prepared by Mr. Anthony Wenderoth, of this city, to whom great credit is due for his skill in overcoming what have been hitherto considered insuperable difficulties. In the present state of photography it is impossible to make a picture from nature of the constituents of a complex rock of this kind, and at the same time to preserve the identity of each to the eye. Indeed the outlines of the separate minerals will blend more or less into each other when the colors are such as will affect the sensitized plate imperfectly. Another drawback is that yellow and red minerals photograph black, and the former being one element of the color of many pyroxenes, the black spots, which should indicate magnetite, are sometimes extended out of all reason, when the two last mentioned minerals occur together. Another evil is that the same mineral may, by reason of slightly differing thicknesses in different parts of the slide, assume totally different colors. And still another, is that part of the stippled effect is often due to the necessities of the process. Yet in spite of these disadvantages, some of which at least experience and patience will enable

us to overcome, these plates are among the most faithful representations of the facts as seen through the microscope which have yet appeared.

With suitable apparatus and after some prefatory trials, I have hopes of producing more perfect results, and of obtaining sharp level photographic outlines, which can be colored if necessary to correspond to five or six positions of the analyzer during its rotation.

[NOTE.—In connection with this paper a series of thin slices of Connecticut Traps, made by Mr. E. S. Dana, of Yale College, the Pennsylvania specimens referred to in the text, as also, photographs of maps of York County and Gettysburg, and the positive picture on glass of the slices of 136 diameter enlargement, were projected on the screen.]

EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1. This photograph was among the first made with an $\frac{8}{10}$ microscopic objective. A portion of the edge of the section was included in the field in order that the portion represented might be more easily recognized and studied under the table-microscope.

The enlargement is very nearly 34 diameters. The original is a dolerite (No. 3) containing pyroxene (*a*), magnetite (*b*), plagioclase (labradorite) (*c*), and some scattered needles of apatite (*d*).

The previous description of the dolerite No. 3 from Beeler's farm applies to this specimen.

FIG. 2. The negative of this print was made in polarized light and is another portion of Fig. 1, Pl. IV.

The object is a specimen of dolerite from Beeler's farm marked No. 4.

The rock is seen to be a confused mass of crystal fragments consisting of labradorite (*a*), pyroxene (*b*), and magnetite (*c*).

PLATE II.

FIG. 1. The negative of this print was taken with a $\frac{1}{5}$ microscopic objective, and the enlargement is about 136 diameters. The minerals constituting this rock, (which occurs on Cemetery Hill, Gettysburg, Adams County, Pa., and has been provisionally called Syenite,) are more or less weathered, as their rough appearance, caused by their numerous cavities, sufficiently shows.

a. Crystals of feldspar.

b. Hornblende.

c. Magnetite.

FIG. 2. This object is specimen 1 of dolerite from Beeler's farm, 2 miles S. W. of York, and is magnified 136 diameters.

a. Labradorite.

b. Pyroxene.

c. Magnetite.

The surfaces of both feldspar and pyroxene (and especially of the latter) are covered with small cavities.

Plate III.

Fig. 1. This is a dolerite from Logan's, a shaft contiguous to the Mumper shaft. Besides exhibiting the relations of the light-colored slabs of labradorite to each other, and the pyroxene which forms a matrix for them, there are two distinct apatite crystals reproduced in the print.

a. Labradorite.

b. Pyroxene.

c. Apatite.

Central black spot, Magnetite.

Fig. 2. Thin section of a dolerite from a shaft on Mumper's property about 1 mile N. of Dillsburg. The dyke of which this is a section cuts the ore bed at a short distance beneath the surface.

In this print there is a labradorite of unusual size, in which is imbedded a small mass (of pyroxene) (?) which appears black in this light. The striation of other labradorite crystals is distinctly seen, while the outlines of the magnetite crystals are unusually sharp.

a. Labradorite.

b. Pyroxene.

c. Magnetite.

Plate IV.

The figures in this plate were photographs of the same object but under different conditions of polarized light. Figs. 1 to 5 inclusive, were photographed in five different positions of the analyzer. A peculiar crystal of pyroxene which exhibits a median line differing in color from the body of the crystal was made the guide. The purpose of these experiments was to see whether means could not be discovered to discriminate between the effects of anactinic light and opacity, by the camera alone. The object was a thin section of a dolerite from Beeler's farm, 2 miles S. W. of York, marked No. 4.

Fig. 1. This pyroxene appears of a light color and with a dark core, which in turn contains an irregularly formed light-colored axis. The boundary between this crystal and the magnetite at its right hand extremity is sharply defined; and the division between this pyroxene and a neighboring fragment just below its lower edge is also evident.

Fig. 2. In this photograph polarizer and analyzer are in the same phase. The main crystal is still light-colored, but there is less definition about the middle part of its dark nucleus, a light band extending nearly across it at this place. The pyroxene lying below its lower edge, which was dark in Fig. 1, has now become light, and the line of division between the two crystals is nearly obliterated, except at one point where a small magnetite appears in relief against the light background. The angle of the analyzer was not determined.

In Fig. 3, the main crystal has become almost entirely black with a light core. The upper end now blends with the magnetite alongside of it, and the pyroxene on the lower side has become sensibly darker, but still leaves the small crystal of magnetite apparent. The angle of the analyzer was not determined.

In Fig. 4, with an angle of $\pm$ 135° from the first position, the appearance is nearly the same as in Fig. 1; and in Fig. 5 as in Fig. 3.

In Fig. 6, which was taken in the same position of the analyzer as Fig. 4, a new condition was introduced, viz.: a thin plate of selenite was interposed over the slide and between polarizer and analyzer. The effect is a general resemblance to Figs. 1, 2 and 4.

These attempts to utilize the art of micro-photography, for the delineation of the facts as seen through a microscope of moderate power, are yet crude and undoubtedly susceptible of very great improvement, and my only excuse for offering them to the Society in their present unfinished state, is the supreme importance of using every means in our power at the present time to illustrate the conditions of structure of these micro-crystalline (once crypto-crystalline, but now so no longer) igneous rocks; and the hope that the effort to enlist the pencil of the sun in these reproductions, however imperfect it may be in its beginning, may be ultimately successful.

It has not been attempted in this paper to specify *all* the constituents of these traps; to do this a further laborious study of many more slides would be necessary: but only to point out those of most frequent occurrence and of principal importance, which can be recognized in the photographic representations.

ON CREMATION AMONG THE DIGGER INDIANS.

By W. J. Hoffman, M. D.

(*Read before the American Philosophical Society, April* 16, 1875.)

In my last communication, I described, in part, the funeral ceremony of that sub-tribe of Pah-Utes inhabiting the vicinity of Spring Mountain, Nevada, and in looking over my notes made in 1871–2, I find that cremation was also practiced by the Digger Indians (Pah-Utes) living around Marysville, Cal. I would here state, that as far as I have been able to compare the language, or rather dialects, customs, beliefs, ethnology, etc., I am inclined to trace the various sub-tribes of Utes, Pah-Utes (including Diggers) and Gosh-Utes, to one common type. Their bands are scattered over an extent of country, from the northern interior portion of California, southward throughout that State to Owen's Lake, thence irregularly eastward into Utah and Colorado, making a distance between the two limits of about one thousand miles. The dialects are similar to a great extent, except where they have adopted many Spanish words, and these incorrectly pronounced.