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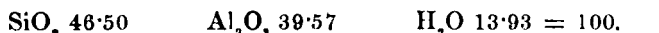
solution, including the eccentricity of the center of polarization, the inclination of the axis of polarization to the plane of reference, besides such corrections as may arise from refraction, or diffraction or photography. The importance of the problem will certainly justify us in trying to take good photographs of the streamers at the future eclipses.

ART. II.—*Newtonite and Rectorite—two new minerals of the Kaolinite Group*; by R. N. BRACKETT and J. FRANCIS WILLIAMS.

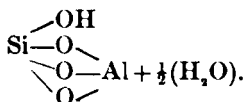
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THE object of the following paper is to briefly describe two hydrous silicates of alumina, which we have every reason to believe have not before been observed, and to call attention to the relation of these new compounds to other members of the group.

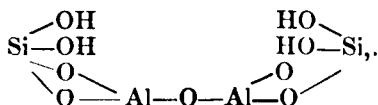
As is well known and generally admitted the commonest substance of this class, kaolin, or when crystallized called kaolinite, approaches the composition represented by the formula $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, and has the percentage composition:



Considering half of the water basic or as water of constitution and dividing the formula by two, the constitution of kaolinite may be represented as follows:*



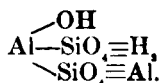
As there is reason to think that all the water represented in the original formula should be regarded as water of constitution, the formula would become:



or writing this in the form suggested by F. W. Clarke in his paper on the Structure of the Natural Silicates,† the following formula is obtained:

* Kaolinite is thus regarded as a derivative of normal silicic acid $Si(OH)_4$, analogous to a similar compound $Al_2O_3 \cdot 2SiO_2 \cdot 3H_2O$ mentioned by Remsen. Inorganic Chemistry by Ira Remsen. American Science Series—Advanced Course. New York: Henry Holt & Company, 1889, p. 576.

† Bulletin of the U. S. Geological Survey, No. 60, Washington, 1890, p. 16.



Either of these formulas suggests the possibility of the existence of other hydrous silicates of alumina closely related to kaolinite, and indeed differing from it only in the presence of a larger or smaller proportion of water, while the relation of the silica to the alumina remains constant.

It is readily seen that three other hydrous silicates of alumina may be derived by eliminating one molecule, or introducing respectively one and two molecules of water into the formula, and that thus the following series would be formed :

Formulas.	Percentage composition.		
	Al ₂ O ₃	SiO ₂	H ₂ O
(1) Al ₂ O ₃ . 2SiO ₂ . H ₂ O	42·52	49·99	7·49
(2) Al ₂ O ₃ . 2SiO ₂ . 2H ₂ O	39·57	46·50	13·93
(3) Al ₂ O ₃ . 2SiO ₂ . 3H ₂ O	36·98	43·47	19·55
(4) Al ₂ O ₃ . 2SiO ₂ . 4H ₂ O	34·72	40·82	24·46

Of this series of four theoretically possible hydrous silicates of alumina only one, No. 2 of the series, ordinary kaolin, has been described, so far as we have been able to find in the literature at our command. From many of the published analyses of halloysite, this mineral might be supposed to correspond with No. 4 of the series, but, as will be shown below, this correspondence is only apparent.

This series will be designated as the *Kaolinite Series*,* and will include the *Kaolinite Group*, which was first established by J. D. Dana in 1858 † under the name of the *Halloysite Group*, but was afterwards called the Kaolinite Group by the same author. ‡ The object of forming such a series is to classify if possible the already existing members of the kaolinite group, most, if not all of which will be found to fall under kaolinite; and at the same time to have a definite place into which to put any new minerals of this class which, like rectorite and newtonite, may from time to time be found, and which would at present hardly be classed under kaolinite itself if their water of constitution was properly determined. It is the hope of the authors to be able in a future paper to show the true chemical composition and microscopic structure of many minerals now existing as members of the kaolinite group; and to assign them to their proper place in the above-mentioned series, by rede-

* The word *series* is not used here in the sense in which it is generally applied in the natural sciences, but as it is employed in mathematics to describe a sequence of similar terms which bear some definite relation to each other.

† This Journal, II., vol. xxvi, p. 361, 1858

‡ System of Mineralogy, J. D. Dana, 5th edition, 1868.

termining their water of constitution under the conditions mentioned below.

Since kaolin approaches the composition represented by the formula ascribed to it only when it has been dried at about 110° C., and from the facts mentioned below regarding halloysite, we propose to consider the whole series as based upon analyses of material dried at 110° C. or thereabouts.

Considering the series in this way, at least one and probably two hydrous silicates of alumina lately analyzed in the laboratory of the Geological Survey of Arkansas fall into this series. One of these corresponds to No. 4 and the other possibly to No. 1 of the series.

Newtonite.

The first compound which will be described, and that which suggested the series given above, is found on Sneed's Creek in the northern part of Newton county (16 N., 23 W., section 1), in the State of Arkansas. At this place a mineral claim was laid and a shaft opened in 1889 by Mr. W. S. Allen of Harrison, Ark. The rocks of the region are for the most part sandstones and shales of the Barren Coal Measures, while the opening itself seems to penetrate some of the limestones of the Lower Carboniferous series. At a depth of eight feet this form of kaolin was found imbedded in a dark gray clay, through which it is scattered in lumps which vary from a few ounces to forty pounds in weight. Iron and a little manganese are also said to occur in the opening. Samples of the material were kindly furnished the Geological Survey of Arkansas by Mr. Allen, the proprietor of the claim.

On account of its occurrence in Newton county we propose the name *Newtonite* for this, the fourth member of the Kaolinite Series.

Newtonite is a pure white, soft, compact, homogeneous substance, and both chemical analysis and microscopic examination show it to be a remarkably pure substance. It is infusible before the blowpipe, and when in the form of a powder it has a specific gravity of 2.37. It is only slightly attacked by boiling concentrated hydrochloric acid, but boiling concentrated sulphuric acid decomposes it almost completely, with a separation of silica. It is also decomposed by a boiling saturated solution of caustic potash with the formation of a compound insoluble in water but easily soluble in cold dilute hydrochloric acid. (See below.)

Quantitative chemical analyses of newtonite gave the following results :

	I.	II.
SiO ₂	38·86	40·22
Al ₂ O ₃	35·20	35·27
Loss on ignition	23·69	22·89
Fe ₂ O ₃	0·21	0·21
CaO.....	0·31	0·54
MgO.....	trace	trace
K ₂ O)	1·73*	0·99
Na ₂ O {		0·73
	100·00	100·85
Water at 110°–115° C. ..	5·53	5·44

If the impurities be disregarded and the silica, alumina and loss on ignition in analysis I be recalculated to 100 per cent, and the same be done in analysis II, after first bringing the whole to 100 per cent, the following figures are obtained:

	Ia.	Iia.	Theory for Al ₂ O ₃ ·2SiO ₂ ·4H ₂ O.
SiO ₂	39·76	40·88	40·82
Al ₂ O ₃	36·01	35·85	34·72
Loss on ignition..	24·23	23·27	24·46
	100·00	100·00	100·00

Although this compound closely resembles ordinary kaolin in its chemical properties, it shows thus a marked difference in composition, by containing for the same amount of silica and alumina double the quantity of water usually found in kaolin.

That an apparent similarity exists between newtonite and halloysite when a comparison is instituted between the analysis of newtonite calculated on the material dried at 110° and the published analyses of halloysite where it is not stated whether the calculations are made on the air-dried material or that dried at the above-mentioned temperature, is shown in the following table:

	Newtonite.		Halloysite (Indianaite.)	
	Ia.	Iia.	III.	IV.
SiO ₂	39·76	40·882	39·35	38·90
Al ₂ O ₃	36·01	35·851	36·35	37·40
Loss on ignition ..	24·23	23·267	22·90	23·60
	100·00	100·00	98·60	99·90
			·40 CaO	
			99·00	

Analysis III is of a soft and IV of a hard, white variety of halloysite called indianait.† H. Pemberton, Jr., who made

* Alkalies by difference.

† Report of the Geological Survey of Indiana, 8th, 9th and 10th Annual Reports (1876–1878), p. 156. See also Sixth Annual Report (1874), p. 15.

these analyses, kindly furnished the information that the calculations are made on the *air-dried material*, and that in analysis III, 8.68 per cent of the loss on ignition is given off at about 110° C.

If analyses Ia and IIa be calculated to the air-dried material the difference between them and the published analyses of halloysite is clearly shown, as is evident from a consideration of the following table :

	Ib.	IIb.	Halloysite.
SiO ₂	36.83	37.96	39.35
Al ₂ O ₃	33.42	33.34	36.35
Loss on ignition	24.22	23.26	14.22
Water at 110°-115° C. ...	5.53	5.44	8.68 (at 100° C.)
	100.00	100.00	98.60

If it be assumed that the 8.68 per cent of water in halloysite is partly hygroscopic and partly water of crystallization, this mineral would have the composition of kaolinite containing one molecule of water of crystallization. Judging from the newtonite analyses Ib and IIb, this substance would, under like circumstances, have one molecule of water of crystallization, but would be represented by the formula Al₂O₃ . 2SiO₂ . 4H₂O+aq, while the composition of halloysite would be expressed by the formula Al₂O₃ . 2SiO₂ . 2H₂O+aq.

Ordinary kaolin usually contains less than one per cent of loosely combined water. Hydrous silicates of alumina have, however, been analyzed in this laboratory, which have given off as much as five per cent of water at 110° C., but which differ from ordinary kaolin in no other respect, and it is probable that differences in origin and occurrence will account for these varying amounts of *loosely combined water*.

A thin section of newtonite under the microscope when viewed only with low powers appears as a perfectly amorphous substance but when magnified to four or five hundred diameters it shows that it is entirely made up of minute rhombs or squares. The largest of these are not more than 0.005^{mm} ($\frac{1}{200}$ of an inch) on an edge, while the smallest appear to be about half that size. Sometimes they seem to form perfect squares but in the majority of cases the acute angles have values ranging from 88° to 89°, as nearly as could be measured. There appear between these minute figures blank spaces where nothing can at first be seen, but by sinking the microscope tube somewhat, so as to focus a little lower down, an entirely new set of rhombs is discovered, while those above go out of focus. At first sight all the rhombs appear as squares and show small indistinct lines running from their corners toward the center, giving the appearance of the hopper-shaped crystals of salt.

In addition to this there is a white rim about the edges which gives them the appearance of being higher than the rest of the surface. The cause of this is, however, not due to any marking or relief on the surface but probably to internal reflections whose origin it is hard to detect.

In polarized light the rhombs extinguish sharply parallel to their diagonals, thus showing that they are faces of some anisotropic material and not, as might be supposed, sections of cubes which had been cut more or less obliquely.

If these rhombs and squares are sections of rhombohedrons then one would expect to find also plane triangles corresponding to sections perpendicular to the principal axis. This, however, is not the case and only in a very few instances have any triangular forms been found and even then they are very indistinct and appear to be not in the upper surface of the plate but somewhat lower down. It is probable that in making sections of this material the individual crystals are not cut, but are either rubbed away entirely, or are left undisturbed, so that what are seen under the microscope are not sections but crystal faces. By means of a selenite plate the positions of the axes of greatest and least elasticity were determined, and were found to lie respectively parallel to the shorter and longer diagonals of the rhomb.

By powdering some of the material and allowing it to settle out from water, similar rhombohedral crystals were obtained.

Rectorite.

The second hydrous silicate of alumina, which is also to be regarded as new, is found in the Blue Mountain mining district in Marble Township, Garland county, 2 North, 19 West, section 27, about 24 miles nearly north of Hot Springs. It occurs in deposits which are very narrow near the surface but increase to the thickness of a foot or more in descending nine feet. Several such deposits have been found. The wall rock is sandstone probably of Lower Silurian age. Specimens of this mineral have been furnished by Messrs. Ware and Arnold of Hot Springs, who are interested in developing the deposit.

We propose the name *Rectorite* for this, the first member of the Kaolinite Series, in honor of Hon. E. W. Rector, of Hot Springs, Ark., who originated and has so unceasingly supported in the State Legislature the bills providing for the Geological Survey of Arkansas.

Rectorite, when pure, is a soft, white mineral occurring in large leaves or plates and resembling very closely in form that variety of asbestos known as "mountain leather," and at the same time having somewhat the soapy appearance of steatite. Parts of it are often pure white, while other portions are

stained with hydrous oxide of iron and present a reddish-brown appearance. The sheets tear apart easily and are very flexible and perfectly non-elastic. Some specimens of this mineral have been obtained through the kindness of Mr. Charles F. Brown, of Hot Springs, in which fine doubly terminated quartz crystals are imbedded. Some of the latter are at least one and a half inches in length and when surrounded by the rectorite form very beautiful and striking specimens. The hardness of rectorite is less than that of talc—say 0.5—although this is difficult to estimate exactly. When heated in the flame of a Bunsen burner it loses water and becomes brittle. It is infusible before the blowpipe. Its behavior when treated with sulphuric acid and caustic potash will be explained below.

Two quantitative chemical analyses gave the following percentage composition calculated on the material dried at 110° C.:

	V.	VI.
SiO ₂	52.72	52.88
Al ₂ O ₃	36.60	35.51
Fe ₂ O ₃)	0.25	0.25
CaO)	0.45	0.45
MgO) once determined	0.51	0.51
K ₂ O)	0.26	0.26
Na ₂ O)	2.83	2.83
Loss on ignition	7.76	7.72
<hr style="width: 50%; margin: 0 auto;"/>		
Total	101.38	100.41
Water at 110° C.	8.78	8.33

If these analyses be brought to 100 per cent, then all save silica, alumina, and loss on ignition be disregarded and the analyses again calculated to 100 per cent, the following figures result:

	Va.	Via.	Theoretical for Al ₂ O ₃ . 2SiO ₂ . H ₂ O.
SiO ₂	54.32	55.01	49.99
Al ₂ O ₃	37.69	36.96	42.52
Loss on ignition	7.99	8.03	7.49
<hr style="width: 30%; margin: 0 auto;"/>			
	100.00	100.00	100.00

If the calculations be made on the air-dried material the following figures are obtained:

	Vib.
SiO ₂	50.18
Al ₂ O ₃	33.72
Loss on ignition	7.32
Water at 110°-115° C.	8.78
<hr style="width: 50%; margin: 0 auto;"/>	
	100.00

If the water given off at 110° – 115° C. be regarded mainly as water of crystallization it is evident that it corresponds to one molecule, and the compound would have the formula $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot \text{H}_2\text{O} + aq$.

Under the microscope a cleavage plate usually shows a few spots where it is evident that only one plate is included in the thickness, while the most of the section is made up of two or more plates lying one over another. In the single plate there is one comparatively distinct system of parallel lines in the direction of which a sharp extinction takes place. There is usually also a much less distinct system of lines which lie at nearly right angles to the first.* In the thicker portions of the plate two or more such pairs of line systems are often found superimposed one upon the other. In such cases the extinction parallel to either system is very indistinct.

The index of refraction is low—lower than that of Canada balsam—and the peculiar structure of the plates gives to the thin section, especially when viewed without the microscope, a peculiar undulating and glistening appearance.

In convergent polarized light, the simple plates show a strong double refraction, and give very beautiful biaxial interference figures. The acute bisectrix appears to stand perpendicular to the cleavage plane.† The angle between the hyperbolas varies much in size, in some cases being not more than 5° , and in others approaching nearer to 15° or 20° . The rings about the axes join each other forming ellipses so that the determination of the dispersion of the axes and bisectrix is uncertain. It appears, however, as if the angle for red were greater than that for blue, $\rho > v$. Dispersion of the bisectrix appears to be wanting. The fact that in many cases two plates lie one over the other gives rise to apparent optical anomalies which are, however, only caused by this superimposition. Thus in some cases beautiful examples of what is known as the "optical spectacles" (Optische Brillen) may be observed.

Among the inclusions of foreign material which appear in this substance may be mentioned the following: The hydrous oxide of iron, which has already been noted, appears in small round masses or globules, which are for the most part deposited between the individual plates of which the mass is made up. Some member of the pyroxene or amphibole group has also been observed lying in the cleavage planes.

These impurities occur in sufficiently large quantities to exert a decided influence over the results of the chemical

* 86° and 88° have been measured.

† A plate cut at right angles to the cleavage plane seemed to show extinction parallel and perpendicular to that plane, but owing to the wavy form of the plate it was impossible to determine it accurately.

analyses so that the discrepancy between them and the calculated formula may well be ascribed to this cause. There was, however, no mineral detected which would account for the relatively large amount of alkali shown by the analysis, and it is possible that the soda should be considered as replacing some of the water and be brought into the formula. Further investigation will probably throw some light on this point.

In view of the relatively large quantities of quartz of both macroscopic and microscopic dimensions, which have been observed intermixed with the rectorite, it may be allowable to consider the excess of silica found in the analyses as due principally to this cause. By recalculating the analysis after deducting just enough silica to bring that constituent down to the theoretical amount, the following percentages are obtained :

	Vc.	Vlc.	Theoretical for Al ₂ O ₃ . 2SiO ₂ . H ₂ O.
SiO ₂	49.99	49.99	49.99
Al ₂ O ₃	41.26	41.08	42.52
H ₂ O	8.75	8.93	7.49
Total	100.00	100.00	100.00

In order to determine whether or not the soda found in the analyses really belonged to the rectorite, the following experiment was made. The mineral, in small flakes, was digested with concentrated hydrochloric acid for two hours on a sand bath. It was then washed and filtered, and the residue was boiled with sodic carbonate in order to remove any separated silica. The remaining substance was then washed with water, hydrochloric acid, and again with water, and was finally heated before the blast lamp. A portion of this dried and purified material was then analyzed with the following result :

	VII.
SiO ₂	57.10
Al ₂ O ₃	40.53
Sum	97.63
Impurities (undetermined)	2.37
Total	100.00

It appears from this that about half of the alkaline impurities were removed, but that the silica and alumina had approximately the same relative values as before. If the theoretical amount of water be introduced into this analysis, and the silica be diminished as in the preceding case, the analysis then expresses very nearly the theoretical composition.

Many points of similarity appear between rectorite and kaolinite, but in view of the peculiarity of the form which it assumes, and on account of its chemical composition, it is probable that it should be considered as a separate mineral.

In confirmation of the above opinion the statements of two manufacturers of ceramics to whom specimens of rectorite were sent for firing may be quoted.

Homer Laughlin, Esq., of East Liverpool, Ohio, writes: "The sample of what you call kaolinite, sent me, was duly received, and carefully examined and tested under fire. The mineral is neither kaolin nor kaolinite, but just what it should be called I am unable to say, never in all my experience having seen any mineral of its kind. Unlike kaolin it will not dissolve* in water. It burns a white color and becomes very vitreous and strong. It cannot be finished with a smooth face or skin, but roughs up like a blotting pad. It is certainly a very interesting and curious mineral, but I can think of no use for it in ceramic manufacture unless it could, after careful experiments, be made into novel ornaments."

Messrs. Oliphant & Company of the Delaware Pottery, Trenton, New Jersey, write: "Your sample of kaolinite came out of the kiln to-day, and would say that we are unable to make any report upon it. We do not know just what it is, therefore cannot say anything about its quality or market value."

It appears therefore from the above that its physical properties when subjected to heat do not correspond to those of kaolin.

Experiments were made in the laboratory on the relative solubility of newtonite and rectorite, and at the same time upon some specimens of true kaolin in the following manner:

The fine powder of the various substances was boiled with 10^{cc} of concentrated sulphuric acid for five minutes, after having been digested with it for three hours on a sand bath. It was then diluted, decanted, treated with a strong solution of potassium carbonate, washed with water and hydrochloric acid, filtered and weighed. In all the cases, the results were very similar, so much so in fact that no characteristic differences could be detected.

When treated with caustic potash the results were somewhat different in the different cases. Powder from each specimen was boiled with 10^{cc} of a saturated solution of caustic potash for 20 minutes, diluted, filtered, washed and treated with dilute hydrochloric acid. The white flocculent residue which remained after the treatment of the powder with caustic potash

* Mr. Laughlin does not mean dissolve in the chemical sense of the word, but disintegrate into a fine powder which remains partly in suspension.

dissolved readily in cold dilute hydrochloric acid in all cases except that of rectorite. In order to dissolve the residue from the latter it was necessary to use much stronger acid and even then the solution was not complete. The composition of this residue has not yet been determined.

From the foregoing facts and considerations, it is probable that three members out of the possible four, making up the above described series, are known, and the present status of the Kaolinite Series may therefore be concisely stated as follows:

KAOLINITE SERIES

- | | | |
|--|---|------------------|
| 1. Rectorite | $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot \text{H}_2\text{O} + \text{aq.}$ | Monoclinic (?). |
| 2. Kaolinite and members
of the Kaolinite Group | $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O} + \text{aq.}$ | Monoclinic or 0. |
| 3. | $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 3\text{H}_2\text{O}$ | |
| 4. Newtonite | $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 4\text{H}_2\text{O} + \text{aq.}$ | Rhombohedral. |

In the case of other hydrous silicates of alumina, as well as of magnesia and other bases, similar homologous series could be formed, which would tend toward a more systematic arrangement of the species than now exists.

Chem. and Petrog. Laboratory of the Geol. Survey of Arkansas, Dec., 1890.

ART. III.—*On the Intensity of Sound.*—II. *The Energy used by Organ Pipes*; by CHARLES K. WEAD.

[Read in abstract at the Philadelphia meeting of the American Association, 1884.]

In a former paper* the case of a vibrating tuning fork has been considered as an important example of sounding bodies that gradually expend the store of energy originally imparted to them. We have now to consider one of the class that can store up little or no energy, viz: an organ pipe; and have therefore to determine, not the rate of loss as with the fork and piano string, but the rate at which energy is supplied to the system from without. The experimental problem is very simple, and it seems strange that it has not been completely worked out.

The literature of the subject is very slight. Lord Rayleigh,† in an oft-quoted experiment, measured the pressure and volume of air supplied to a whistle of 2740 d. v., and so found the rate of consumption of energy. Several years earlier Mr. Bosanquet in a very interesting and valuable paper‡ discussed the relative amount of energy supplied to the several pipes of an

* This Journal, xxvi, 177, Sept., 1883.

† Phil. Mag., xlv, 1872.

‡ Proc. Roy. Soc., xxvi, 248.