

*J. L. Seaman Cr.*

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CONDUCTED BY  
**PROFESSORS B. SILLIMAN AND JAMES D. DANA,**

IN CONNECTION WITH  
**PROFESSORS ASA GRAY, AND WOLCOTT GIBBS,**  
OF CAMBRIDGE,

AND  
**PROFESSORS S. W. JOHNSON, GEO. J. BRUSH, AND**  
**H. A. NEWTON, OF NEW HAVEN.**

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the distillation of a mixture of light and heavy oils, and is also due to the superiority of the results given by Mr. Warren's process over those obtained by ordinary fractional distillation.

Prof. Silliman notices the fact that when 485 cc. were distilled from 1000 cc., the mercury suddenly arose from  $320^{\circ}$  to  $370^{\circ}$  C. This remarkable phenomenon clearly indicates that when nearly 500 cc. or 50 per cent had passed into vapor, 485 cc. of which had passed into the receiver, the more dense oils remaining in the retort required a higher degree of heat for their distillation. This phenomenon would no doubt be observed, during the distillation of a mixture of equal parts of refined Pennsylvania petroleum, and a dense oil like that of the Cañada Laga, yielding a distillate, 90 per cent of which distills at a temperature at or above the boiling point of mercury.

It will also be observed, that by Warren's process the Cañada Laga oil yields 11.5 per cent of sp. gr. .810 or  $43^{\circ}$  B, and that by the same process the oil examined by him yielded about 55 per cent of the same grade, or 50 per cent plus 5 per cent. I obtained by the ordinary process 93.75 per cent of distillate, a very large amount, the loss being 6.25 per cent. Prof. Silliman obtained 96 per cent, or 50 per cent plus 46 per cent, the loss being 4 per cent, or a little more than half that which I experienced. However these are mere coincidences, striking though they may be.

The foregoing details have been gathered from the results of a large number of experiments, made both in California and in the Eastern states, for the purpose of ascertaining the commercial value of California bitumens. They are offered for the purpose of correcting, what I am confident is an error, and to assist in the dissemination of reliable information respecting California Petroleums.

Providence, R. I., March 6th, 1867.

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ART. XXXIX.—*Contributions from the Sheffield Laboratory of Yale College.*—XIV. *On Kaolinite and Pholerite;* by S. W. JOHNSON and JOHN M. BLAKE.

THE study of certain minerals termed pholerite, nacrite, steinmark, and kaolin, leads to the conclusion that a number of substances which are included under these various designations must be classed together and constituted into a mineral species in virtue of possessing chemical and physical properties which admit of precise definition. This species must have a new or unappropriated name, and we propose for it that of Kaolinite, in allusion to the material which furnishes it most commonly and abundantly.

The chemical composition of this mineral was first deduced by Forchhammer from the analysis of a number of kaolins. It is represented by the formula  $4\text{Si}3\text{H}16\text{H}$ , or by  $2\text{Si}3\text{H}2\text{H}$ . The *per cent* proportions vary considerably according to the atomic weights employed in the calculation. In the table that follows, p. 358, are given the percentages reckoned on the atomic weights adopted by Gmelin (Handbook, English ed.), by Rammelsberg (Handbuch d. Mineralchemie), and by Fresenius (Quantitative Analysis, 4th ed.).

Of the substances which have come under our notice, having the above composition, the most striking is the so-called nacrite, from the Einigkeit mine at Brand, near Freiberg, Saxony. It is described by Breithaupt (Berg. u. Hüt. Zeit., No. 40, 1865) as occurring "in snow-white or yellowish six-sided tabular crystals in fan-shaped or reniform aggregates, and having pearly luster passing into adamantine. Sp. gr. 2.63." The analysis of this mineral made by Richard Müller appeared in Dana's 9th Supplement, and is quoted below.

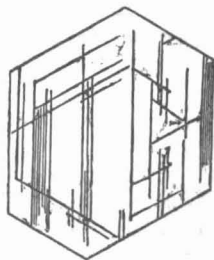
DesCloizeaux, in the Supplement to his Manuel de Minéralogie, p. 549, remarks concerning this mineral as follows: "There has been recently discovered in Saxony a pholerite, at first called *nacrite*, which occurs in large macled hexagonal plates. These plates are composed of six triangular sectors, whose boundaries, though quite vague, nevertheless give indications of composition parallel to the faces of a right rhombic prism approximating the angles  $120^\circ$  and  $60^\circ$ . They cleave easily in the direction of the base of this prism; their interior structure is fibrous, and their surfaces are slightly undulated. Notwithstanding the plates are transparent when sufficiently thin, their action on a polarized beam of parallel rays is very irregular. In convergent light there are seen in each sector the hyperbolas which indicate two diverging optical axes whose plane is normal to the side situated upon the hexagonal contour and is consequently parallel to the principal diagonal of the base of the fundamental prism. The bisectrix is negative and evidently normal to the plane of cleavage. The dispersion of the axes is feeble: at  $45^\circ$  from the plane of polarization it is shown by the symmetrical distribution of the colors about the two hyperbolas, and the separation of the axes is greater for the red rays than for the violet," &c.

Our observations, made on a specimen in the cabinet of Professor Brush, are as follows. The crystals occur in hemispherical groups of about 4 mm. in diameter. These groups have a radiated structure, as is evident from their cleaving into quite thin wedge-shaped laminæ. The laminæ themselves appear to have a radiate structure at right angles to that indicated by the cleavage, for, when viewed by polarized light, dark shades of color branch out irregularly from near the center of the thin

edge of the wedge, and these rotate with considerable uniformity as the plane of polarization is changed. When magnified, the surfaces of the laminæ are seen to be striated in three directions. These striæ intersect at angles of  $60^\circ$  and  $120^\circ$ . The microscopic structure under polarized light gives evidence that the ultimate plates of these groups are twin or compound crystals. In a section ground thin, parallel to the cleavage direction, crystals were seen superposed, the outline of one corresponding to the striæ of another, while, optically, they did not correspond. The portions of crystals thus distinguished by polarized light, were often elongated three or four diameters, and this elongation had the same relation to the plane of polarization as observed in the mineral from Summit Hill to be described presently. Sections of the groups often give an approximately hexagonal outline. The plates of this mineral are flexible, non-elastic, and have a soft, soapy feel.

The white pearly luster of the "nacrite" appears to be due to strata of air included between the separate crystalline plates composing a mass. It, as well as the crystals presently to be noticed from Summit Hill, exhibits the colors of pearl. This can be seen under the microscope by reflected light. If perpendicular illumination be not used, an oblique position of a plate on the slide is most favorable to reflect the light into the instrument and bring out the color. This iridescence may be due either to the fine striæ upon the crystal or to the colors of thin plates of cleavage. As a comparative test, quite thin blown glass, when crushed into a mass, was found to give the pearly luster perfectly, without at the same time exhibiting color; while the thinnest glass in the same condition showed both in a high degree.

A second substance in possession of Prof. Brush was received from Prof. W. T. Roepper, of Bethlehem, Pa., and was found in a cavity in a coal seam at Summit Hill, Carbon Co., Pa. It bore the label Pholerite. It is a brown scaly powder, which on digestion in hydrochloric acid gives up oxyd of iron to that solvent and becomes nearly white. It has a pearly luster and soapy feel. Magnified fifty diameters, the substance appears made up, for the most part, of well defined crystalline plates. The average size of the plates is  $\cdot 003$  of an inch, the largest are  $\cdot 005$  of an inch in breadth; they are in general extremely thin. They have, as nearly as the mode of measurement employed would show, the angles of perfect hexagons,  $120^\circ$  (see figure). The method used was to draw them upon paper under the camera lucida,



Kaolinite.—Scale 300 diams.

with the aid of a straight edge, to a scale of 650 diameters, and to measure the angles of the drawings with the hand goniometer. Many of these tables are elongated in a direction parallel to one of the sides of the hexagon, sometimes to two diameters. They are striated, and the principal striæ concur with this elongation.

Besides these extremely thin and isolated hexagonal plates, the substance contains prismatic aggregates of similar plates. These aggregates have all degrees of thickness, amounting in some instances to .003 of an inch. Some of them are obviously homogeneous crystals, composed of closely parallel laminæ perfectly resembling in their aspect prisms of mica. When viewed laterally they are often quite transparent and have deep transverse striæ, which indicate perfect basal cleavage. In other cases the structure of these prisms is less compact and symmetrical; the plates being loosely combined and somewhat separated from each other on one side of the prism.

The longer tables, when seen in polarized light, cease to show a difference of shade on the field, or of tint with the use of selenite, when the plane of polarization of the analyzer is parallel with or at right angles to the axis of elongation. The same occurred with crystals on edge, when the plane of polarization was perpendicular or parallel to the cleavage plane.

The thicker plates, when not in the positions just mentioned, have very evident effect on the polarized beam. This indicates a considerable separation of the optical axes. Like the laminæ of "nacrite," the crystals of this substance exhibit, when properly illuminated, the colors of pearl. When ignited, the substance is seen to increase in bulk, and the microscope shows this to be the result of the exfoliation of the crystals due to the expulsion of their water of combination. This mineral differs from the so-called "nacrite" in not being macled. Some fragments from the exterior of the groups of nacrite crystals resemble this "pholerite" closely, showing evident hexagonal outlines and striæ with the angles  $120^\circ$  and  $60^\circ$ . We found the specific gravity of the purified mineral to be 2.59. An analysis made on 442 milligrams by fusion with carbonate of soda gave the following results:

Silica,	-	-	-	-	-	45.93
Alumina, and trace of oxyd of iron,	-	-	-	-	-	39.81
Water,	-	-	-	-	-	14.02
						99.76

The substance described as pholerite by Dr. F. A. Genth (this Jour., [2], xxviii, 251) is of similar character and occurrence. It was found in coal mines at Tamaqua, Pa., in scales of a yellowish white color, which became white on treatment with dilute hydrochloric acid, and at Pottsville, Pa., in snow-white scales of

a pearly luster. Dr. Genth remarks that under the microscope the scales appear to be clinorhombic. His analysis of this substance, after purification by hydrochloric acid, is given below.

The first mention of a crystalline substance with the composition of Forchhammer's kaolin that we have been able to find is by Wöhler, who describes, under the name steinmark, a pale yellow coherent mass which is converted by dilute hydrochloric acid, with solution of a little oxyd of iron, into a white shining powder. (Ann. d. Ch. u. Ph., lxxx, 122.) With help of a lens, Wöhler found it to consist of "shining laminæ, which, when magnified 200 diameters, were seen to be transparent and to consist in part of rhomboidal tables. Before treatment with dilute hydrochloric acid the mass had an earthy fracture which assumed luster by rubbing, an unctuous feel, and adhered strongly to the tongue. Sp. gr. 2.6." The locality was Schneckenstein, Saxony. The analysis by Prof. W. S. Clark, now of Amherst College, is given below.

In response to our application, Prof. Clark has kindly favored us with a fragment of this substance. We observed that it requires to be acted on with hot concentrated hydrochloric acid for some time before falling to a white powder. Microscopic examination of the substance thus purified confirmed our anticipation of its close physical resemblance to the minerals already noticed. It consists of plates and bundles of plates, the largest being .001 of an inch or less in breadth, and when sufficiently magnified has a great similarity to the kaolinite from Summit Hill. The angles of the plates, as well as of the striæ which they exhibit, approximate  $120^\circ$ . Under a high power the striæ are seen to be formed by the edges of superposed and conformable plates; some loosely aggregated bundles resembled those to be noticed presently, as occurring in the kaolinite from near Richmond, Va. [See note on a subsequent page.]

In 1859, Knop analyzed a mineral of the same composition from Zeisigwald near Chemnitz, consisting of microscopic sharp rhombic plates. (Jahresbericht der Chem., 1859, p. 789.)

Stolba has also published an analysis (see below) of a substance occurring in the coal mines of Schlan, Bohemia, in the form of brilliant white scales, which is obviously kaolinite. (Jour. für prakt. Ch., xciv, 116.)

In his Manuel de Minéralogie, DesCloizeaux, in describing pholerite, remarks, p. 190: "a variety from Lodève, in somewhat contorted scales, exhibits under the polarizing microscope, indications of two quite divergent systems of axes, of which the negative bisectrix is almost normal to the plane of the laminæ; the interior structure otherwise appears highly irregular." This "variety" is the mineral analyzed by Pisani from the same locality (Comptes Rendus, liii, 1072, also Dana's 10th Supplement),

and the words of DesCloizeaux, above quoted, appear to be the first recorded optical observations on kaolinite. Pisani's analysis is given in the subjoined table.

Kaolin is described by nearly all writers as an opaque amorphous substance. Some have mentioned it to contain minute transparent plates, but have supposed them to be sheets of mica or other admixture. We have examined microscopically twenty specimens of kaolin, pipe- and fire-clay. Most of these are of unknown origin. In them all is found a greater or less proportion of transparent plates, and in the most of them these plates are abundant, evidently constituting the bulk of the substance. The kaolin from Diendorf (Bodenmais), Bavaria, is perhaps the most finely divided of all the white clays we have studied. When dusted dry upon a glass slide it appears to consist chiefly of masses of a white substance that are opaque or nearly so in transmitted light, but, when fully illuminated above and below, have the translucent aspect of snow in the lump. Interspersed among these masses may be seen extremely minute transparent plates of irregular rounded outline. When brought into water the masses are almost entirely resolved into similar transparent plates, most of which are not more than  $\cdot 0001$  of an inch in breadth. This description applies to all the finer plastic clays. Even the dark-colored Stourbridge clay is made up in large part of transparent laminae, as is a compact sedimentary brownish-gray pipe-clay from Table mountain, Tuolumne Co., Cal. The same is true of the blue fire-clay from Mt. Savage, Md., the white clays of Brandon, Vt., Perth Amboy, N. J., Reading, Pa., Chester Co., Pa., Long Island, and various other white and colored clays from unknown localities. On several specimens of kaolin, especially on one collected at one of the hematite mines at Beekmann, N. Y., we have observed pearly glistening surfaces on the interior of cavities. Viewed in reflected light, by the microscope, these surfaces were seen to be covered with minute scaly crystals, or crystalline aggregates, which, however, revealed no regular outlines.

A white, pulverulent substance, having much the appearance of powdered starch or wheat flour, found near Richmond, Va., was recently analyzed by Mr. Burton in the Sheffield Laboratory. Its composition agrees with Forchhammer's formula (see below), and under the microscope it is seen to be made up for the most part of transparent plates  $\cdot 001$  of an inch or less in breadth, and of prismoidal bundles, obviously composed of loosely aggregated plates, similar to those found in the kaolinite from Summit Hill. These bundles are usually curved, and their length is often several times greater than their breadth. The bundles are fan-shaped in some instances, and the plates are rarely parallel to each other. The edges of these bundles are frequently presented

and in this position they have the greatest effect upon polarized light. They have least influence on the polarized beam when the plane of polarization is perpendicular or parallel to the plates in this position. The separate plates are of broken and irregular outline. Grains of quartz are intermingled.

In four other specimens of kaolin from unknown (probably European) localities, similar prismatic bundles were observed. The bundles were usually curved and irregular; in some instances their length was four or five times their breadth. One of these four kaolins contained hexagonal plates that could be made out with ease under a one-fourth inch objective. Two others, when rubbed between the fingers, assumed a distinct pearly luster; and after this treatment, by which the prismatic crystals were broken up, microscopic examination revealed abundance of hexagonal plates.

Prof. Brush has called our attention to a specimen of fluor from Zinnwald on which occurs a white powdery substance that passes for kaolin. It consists entirely of perfectly definite hexagonal tables averaging .0005 of an inch in diameter, which are usually thin but sometimes are aggregated into short prisms.

The kaolin, pseudomorphous after prosopite, from Altenberg, Saxony, the analysis of which by Richter (Pogg., xc, 315) is given below, though compact in texture, is found by microscopic examination to be made up also of hexagonal plates and bundles of plates.

The plasticity of clay is a physical character, and appears to have a close connection with the fineness of the particles. The kaolinite of Summit Hill, consisting chiefly of crystal-plates averaging .003 of an inch in diameter, is destitute of this quality. The nearly pure kaolinite from Richmond, Va., occurring mostly in bundles of much smaller dimensions, the largest being but .001 of an inch in diameter, is scarcely plastic. The four kaolins of unknown origin which we have described as also consisting largely of prismoid crystals are scarcely plastic, though when rubbed between the fingers they become more soapy to the feel. So too the crystallized kaolinite accompanying fluor from Zinnwald is a scarcely coherent uniplastic substance.

The more finely divided fire-clay from Long Island, is more "fat," while the Bodenmais porcelain earth and other clays, in which the bundles are absent and the plates are extremely small, are highly plastic. So, too, the Summit Hill crystals, when triturated in an agate mortar, yield a powder which, when breathed upon, acquires the argillaceous odor, under the microscope perfectly resembles the finer kaolins, and in the wet state is highly plastic and sticky.

Sommaruga has published analyses of two Passau kaolins,



employed in the imperial porcelain manufacture at Vienna, one of which is "fat" and the other "short." The composition of the two is almost identical (see Chem. Centralblatt, 1865, p. 268), and the different degree of plasticity is thus evidently connected with their state of division.

It is possible also that the plasticity of a clay is related to the form of the plates of kaolinite, perhaps to their thickness, but this is a subject that requires further investigation. Our observations indicate that the impurer sedimentary clays are the most plastic. Some of these are perhaps not so fine as "shorter" kaolins. The plasticity may be, therefore, in part due to the impurities.

In the subjoined table are given the analyses of various crystallized kaolinites which have been previously referred to.

*Analyses of crystallized Kaolinite.*

	Si	Al	H	Other ingredients.
Kaolinite (Nacrite), Freiberg, Saxony, R. Müller,	47.74	39.48	14.07	....
" (Pholerite), Summit Hill, Pa., S. W. Johnson,	45.93	39.81	14.02	....
" ( " ), Tamaqua, Pa., F. A. Genth,	46.98	39.65	13.69	0.17
" (Kaolin), Richmond, Va., B. S. Burton,	48.56*	35.61	12.88	2.95
" (Steinmark), Schneckenstein, Saxony, W. S. Clark,	46.76	35.59	13.42	0.94
" (Kaolin), Zeisigwald, Sax., A. Knop,	49.91	35.23	14.86†	....
" ( " ), Altenberg, " R. Richter,	45.63	39.89	13.70	0.60
" (Pholerite), Lodève, France, Pisani,	47.00	39.40	14.40	....
" ( " ), Schlau, Bohemia, Stolba,	47.93	36.78	15.29	....
Calculation after Gmelin (Si=15, Al=13.7) requires,	47.19	39.12	13.69	....
" " Rammelsberg (Si=14.8, Al=13.68) requires,	47.05	39.21	13.74	....
" " Fresenius (Dumas) (Si=14, Al=13.75) requires,	46.33	39.76	13.90	....

We find more than thirty analyses of clays, kaolins, and steinmarks, which obviously agree with the formula above given. Some of these analyses appear to have been made on the kaolin as it occurs in nature; others, however, were made on the washed kaolin as prepared for the porcelain manufacture; and in still other cases, as in Forchhammer's investigations, the clay was first exhausted with hydrochloric acid and the analysis was performed on the residue, allowance being made for quartz and substances insoluble in sulphuric acid.

It is obvious then that the basis of many kaolins and clays is a soft, white, transparent, infusible mineral, which crystallizes in forms probably belonging to the trimetric system, has a density of 2.6, when crystallized has usually a pearly luster, is insoluble in dilute hydrochloric acid, and in most of its forms is difficultly decomposed by hot concentrated hydrochloric acid, but is resolvable by hot oil of vitriol and dissolves completely in strong solutions of caustic alkalis. In chemical composition

\* Including some quartz.

† By difference.

it agrees with the formula deduced by Forchhammer from his analyses of porcelain clays, viz.,  $3\text{Al}_2\text{Si}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$ .

This substance is not the nacrite of Vauquelin or Thomson, which contained at the most but one per cent of water. It is not the pholerite of Guillemin, as we shall presently see. The old terms kaolin, steinmark and lithomarge have been so loosely applied that they do not define it.

The massive yellow steinmark from Rochlitz has the composition of kaolinite, but with a portion of the alumina replaced by sesquioxyd of iron. Klaproth's analysis (Chemische Abhandlungen, vi, 287) is as follows:

Silica,	-	-	-	45.25
Alumina,	-	-	-	36.50
Sesquioxyd of iron,	-	-	-	2.75
Water,	-	-	-	14.00
Potash,	-	-	-	<i>trace.</i>
				98.50

Digested in hot concentrated hydrochloric acid it is scarcely acted upon, but retains its yellow color without falling to powder, as we have observed with a specimen in Professor Brush's cabinet.

The steinmark from Buchberg, analyzed by Zellner, that from Rumpelsberg examined by Rammelsberg (Ramm. Handbuch, p. 576), that from Saszka analyzed by v. Hauer (Jahresbericht der Chem., 1856, 860), and the *severite* of the latter (Ramm., Handbuch, p. 1012), are evidently impure indurated kaolinite.\*

Brongniart and Malaguti have investigated a large number of kaolins, and some of the results of their analyses have led to the adoption of the formula  $\text{Al}_2\text{Si}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$  (or  $2\text{Al}_2\text{Si}_2\text{O}_7 \cdot 4\text{H}_2\text{O}$ ). But of the 31 analyses by B. and M. but four agree to the above formulæ within 1 per cent of silica, but six within 2 per cent, and but nine within 3 per cent. (See Dana's Min., 4th ed., vol. ii, pp. 249-50.)

Furthermore, the data from which this formula has been proposed, were not derived from the original analyses of the clay, but from these analyses "corrected" by deducting from the total silica (exclusive of quartz), the loss suffered by boiling the kao-

\* Halloysite cannot be confounded with kaolinite although it is another hydrate of the same silicate of alumina that exists in the latter. Its formula is  $4\text{Si}_2\text{Al}_2\text{O}_7 \cdot 12\text{H}_2\text{O}$ , or  $2\text{Si}_2\text{Al}_2\text{O}_7 \cdot 4\text{H}_2\text{O}$ . The specimens of this mineral from Guatequé analyzed by Boussingault, and those from Houscha and Anglar examined by Berthier, lost one-half their water (8-9 per cent) on drying at  $212^\circ$ , and thus acquired the formula of kaolinite. It cannot be assumed that this loss was due to hygroscopic water, for many substances when dried at  $212^\circ$ , or below that temperature, lose a part or all their crystal water. Thus selenite loses about three-fourths of its water at  $212^\circ$ . The quantity is not, however, definite. Halloysite is of much inferior density (sp. gr.=1) to kaolinite, is more easily decomposable by acids, and is without doubt a fairly characterized species.

lin for one and a half minutes with a five per cent solution of caustic potash, this loss being assumed to be accidental hydrated silica. This mode of correction is obviously of no value. On the one hand, the caustic potash might dissolve the kaolinite itself from the more finely divided specimens. Berthier and Rammelsberg have both observed the solution of kaolin in strong potash ley. On the other hand, treatment for so short a time would scarcely suffice to remove all the free silica from a kaolin that contains a large proportion of that substance, if our analytical experience enable us to judge. Again, the analyses appear to have been intended in the first place for technical purposes, and were made, not on specimens selected with reference to their purity, but on the clays in bulk employed in the porcelain manufacture. It is plain that they are not adapted to throw light on the chemical composition of the basis of kaolin. Least of all do they give evidence of the existence of the compound  $\text{AlSi}_2\text{H}$  in the generality of clays.

We have been able to find but two analyses of kaolin made by Forchhammer's method that lead to this formula. On the other hand, eighteen of Malaguti's uncorrected analyses agree with Forchhammer's formula, and eight of them as closely as those of the crystallized varieties whose composition is given in our table above. It would be strange if, out of all the kaolins that have been studied some should not be nearly pure, except so far as containing fragments of quartz and other minerals insoluble in sulphuric acid. We find thirty kaolins agreeing with Forchhammer's formula and but two with Malaguti's.

The composition of the base of a material so heterogeneous as kaolin is likely to be, cannot in any case be deduced from analyses made on material not evidently pure, no matter how numerous they may be. But the fact that the composition of a substance whose purity cannot be ascertained by mechanical or optical means, agrees with that of another of like origin and occurrence seen to be homogeneous by the help of the microscope, is demonstration that the first is unmixed with foreign matters.

*Pholerite.*—That other crystallized hydrous silicates of alumina, infusible, insoluble in hydrochloric but decomposable by sulphuric acid, may exist in clays or may form the basis of clays is not at all improbable. In 1825 Guillemin first described, under the name pholerite, a pure white, pearly substance, occurring in the form of small convex scales, soft and friable to the touch, adherent to the tongue, and giving with water a plastic mass. (*Ann. des Mines*, xi, 489.)

In 1851 Prof. J. L. Smith published analyses of two minerals, one from Naxos, associated with emerylite, and another from Schemnitz, associated with diaspore, which he considered identical in composition with pholerite. (*This Journal*, [2], xi, 58.)

In 1859 Prof. A. Knop published an analysis of a substance found at Niederrabenstein near Chemnitz, the purest forms of which were white bolus-like masses, seen under the microscope to be aggregates of crystalline scales. This claystone (*felsittuff*) Knop referred to pholerite. (*Jahrbuch für Min.*, 1859.)

The steinmark from Georgesstollen, examined by Dumenil, that from Schlackenwald (of radiate structure) analyzed by Rammelsberg, and the Tuesite of Scotland, analyzed by Thomson and by Richardson (*Ramm. Handbuch*, p. 576), approach Guillemin's mineral in composition, or lie between it and kaolinite.

In the subjoined table is given the composition of these minerals and the percentages required by Guillemin's formula, which is the one that has been deduced from Malaguti's analyses of kaolin, viz.,  $\text{Al Si } 2\text{H}$ .

	Si	Al	H	Other substances.
Calculated, from Dumas' equivalents,	39.30	44.98	15.71	
"    by Guillemin,*	40.75	43.89	15.36	
Pholerite, Fins, Guillemin,	42.92	42.08	15.00	
"    "    "    "	41.65	43.35	15.00	
"    Naxos, J. L. Smith,	44.41	41.20	13.14	1.31
"    Schemnitz, "	42.45	42.81	12.92	
"    Chemnitz, A. Knop,	39.34	45.90	14.76	
Steinmark, Georgrstollen, Dumenil,	43.00	40.25	15.50	0.95
"    Schlackenwald, Rammelsberg,	43.46	41.48	13.49	1.57
Tuesite, Scotland, Thompson,	44.30	40.40	13.50	1.25
"    "    Richardson,	43.80	40.10	14.21	2.13

The correspondence between the calculation and the analytical results is not strikingly close. It is evident that most of the substances analyzed were not homogeneous, and future investigations must decide the yet open question, whether these pholerites are not really impure kaolinite.

It is to be desired that mineralogists having specimens of these pholerites in their possession, should take measures to decide this point by a study of their physical properties, and by instituting new analyses on material properly purified or shown by the microscope to be homogeneous.

New Haven, Conn., March, 1867.

\* This calculation by Guillemin is erroneously given by several writers as a third analysis of pholerite from Rive-de-Gier. Guillemin mentions the occurrence of pholerite at Rive-de-Gier, but made no analysis of the substance from that locality.