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no difficulty in condensing the volatilized sulphuric acid, which can be used over again. This process is easier, on a laboratory-scale, than the soda carbonate method, which is about as follows:

Bauxite is fused with carbonate of soda in a reverberatory furnace. The fused mass is lixiviated with water, which dissolves aluminate of soda, which is decanted off. The solution of aluminate of soda is decomposed by carbonic acid gas, which forms carbonate of soda, which remains in solution, and the alumina hydrate is precipitated. This alumina hydrate is afterwards washed repeatedly with water, dried, and calcined at a red-heat for a considerable time, anhydrous alumina being the result.

UINTAITE, ALBERTITE, GRAHAMITE, AND ASPHALTUM DESCRIBED AND COMPARED, WITH OBSERVATIONS ON BITUMEN AND ITS COMPOUNDS.

BY WM. P. BLAKE, NEW HAVEN, CONN.

(Washington Meeting, February, 1890.)

I HAVE not before had the honor of offering to the Institute a communication on the subject of the variety of asphaltum which I described as uintahite; but several disconnected notices of it have appeared in the *Transactions*, and much additional information regarding it and its relations to other varieties of the asphalt group has been gathered together.

Dr. Henry Wurtz has also discussed the nature of uintaite, and has endeavored to show that it should be considered a variety of grahamite.*

We have also had an interesting paper upon "Asphalt and its Uses," from Captain F. V. Greene,† containing much important technical information and a scheme of classification of the varieties of bitumen and of bituminous compounds.

The object of the present paper is to bring the substance of these disconnected notices together; to present some additional facts; to revise the name uintahite; to compare the substance with the allied bitumens or asphalts, known as albertite and grahamite; and fur-

* *Engineering and Mining Journal*, August 10, 1889, xlviii., 114.
† *Trans.*, xvii., 355, October, 1888.

ther to give a general view of the classification and nomenclature of this class of bodies.

Historians record the use of asphalt in the most ancient structures of which we have any knowledge. The Babylonians used it as a cementing substance for their bricks, and according to Brongniart applied it hot. The cradle of the Babylonian Moses was cemented with it. Xenophon, four hundred years before Christ, describes the wall of Media as built of burnt bricks laid in asphalt.* The Scriptures record the use of bitumen in the building of the ark and in the construction of the tower of Babel.

The Latin word *asphaltum* is believed to be derived from the Greek word Ασφαλτος, *asphaltos*, which in turn is considered to be of Phœnician origin. It was used by Homer, and probably in its Latin form gave the name Asphaltites to the lake in Palestine, now known as the Dead Sea, and anciently as the source of bitumen, called *bitumen judaicum*.

Pliny describes this bitumen, which he says at certain seasons of the year is found floating upon Lake Asphaltites, as a "substance which is peculiarly tenacious and adheres to everything it touches."† In the more formal description‡ he considers it as nearly approaching the nature of sulphur, which in some places assumes the form of slime and in others that of an earth. He also describes, under the name of *maltha*, an inflammable mud from the Euphrates.§ This name, which has been generally given to the soft viscid and semi-fluid bitumens, is derived, according to Dana, from the Greek word meaning soft wax, and sometimes a mixture of wax and pitch. Pliny also used the word *pissasphaltus*, derived from Πισσασφαλτος (Dioscorides ‖), meaning pitch-asphalt.

Hill, the translator, in the last century, of Theophrastus's "*History of Stones*," thinks that this ancient writer, the pupil of Aristotle, about three hundred years before Christ, referred to asphaltum when he described certain "brittle stones," as he terms them, which became, "as it were, burning coals when put into a fire and emitted, troublesome and disagreeable smell."¶ This description would, however, refer equally well, or better, to coal, and is so applied by Dana.

It will be noted that Pliny describes the bitumen of the Dead Sea as a viscous body, and in another part of his *Natural History*

* *Anabasis*, Book II., iv., § 12. † *Natural History*, Book vii., § 13.
‡ Book XXXV., § 51. § Book II., § 108. ‖ *Dana's Mineralogy*, 5th edit., 728.
¶ *History of Stones*, Section XXIII., and notes by Hill.

he describes how it may be cut asunder by a string if dipped in a peculiar bloody menstruum. In contrast with this idea of a viscid body the following is from Bergman, of Sweden, who, in 1784, gave an interesting description of bitumen. He said:

"The asphalte, or bitumen of Judea, so named because it is found upon the waters of the Lake Asphaltide, in Judea, is a bitumen, solid, black, brittle, brilliant in its fracture, which is vitreous; its black color is really a brownish red, since a thin flake held between the eye and the light appears red. It floats upon water, and in the fire it burns, giving off the odor of amber. When it is very pure it burns with a clear flame without leaving any residue; when impure, it leaves carbon or a scoria."*

This description is more nearly in accord with the characters of pure solid asphalt than any other I have found in the writings of the mineralogists of the last century.

Bergman also describes naphtha, petroleum, maltha and pissasphalte as examples of the gradation of the fluid bitumen into the solid forms of asphalt and of jet, this last being regarded by him as only a more solid bitumen. He also made a distinction between these bituminous substances and bitumen in combination with earthy substances.

Le Sage, in 1777,† had given nearly the same classification of bitumens, placing in sequence, naphtha, petroleum, mineral pitch, maltha and asphalt, or bitumen of Judea, and regarded them all as originating from fluid petroleum. He quotes Wallerius‡ to the same effect.

Wallerius, in 1778, grouped the bitumens under the general head of "Inflammable Substances," placing them in the following order: bitumen, naphtha, petroleum, maltha, asphalte, bituminous earth, stone-coal, jet. Woltersdorff, 1748, under the head of "Bitumens," made two classes—the fluid and the solid—placing petroleum in the first, and amber, succin, mountain pitch and sulphur in the second.

Brongniart, in 1807, under the heading of "Bitumen," credited to Haüy, wrote: "*Les variétés de cette espèce sont la plupart peu distinctes et passent de l' une à l' autre par des nuances insensibles.*"§

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* *Manuel du Minéralogiste ou Sciagraphie du Règne Minéral.* Par M. Torbern Bergman. Traduite et augmentée de notes par M. Mongez. Paris, MDCCLXXXIV.

† Le Sage, *Élémens de Minéralogie*, i., 101–103. 1777.

‡ *Elucet asphaltum nihil aliud esse quam vel petroleum coagulum vel maltham inspissatam.—System. Minéralogie*, ii., 96.

§ *Traité Élémentaire de Minéralogie*, ii., 19–29.

These varieties are there described in the following order: naphtha, petroleum, maltha, asphalte.

These views of the derivation of this group of hydrocarbons have been followed by most mineralogical writers of this century.

Boussingault, in 1837,* made a special investigation of the composition of asphalt, taking the viscid bitumen of Bechelbronn for his experiments. He found it only slightly acted on by alcohol; the liquid assuming a yellow color when aided by heat, but in sulphuric ether it was easily dissolved. At a temperature of 230° C., in an oil-bath, he separated an oily liquid to which he gave the name *pétrolène*, regarding it as the liquid constituent of bitumens, which, mingled in varying quantities with a solid substance, *asphaltène*, forms the bitumens of different degrees of fluidity. He describes asphaltene as brilliant black in color and luster, with a conchoidal fracture, and heavier than water. Towards a temperature of 300° C., it becomes soft and elastic. It begins to decompose before it melts, and burns like the resins, leaving an abundance of coke.

Boussingault takes the asphalte of Caxitambo, Peru, first brought into notice by Humboldt, as a type of the asphalts, and describes it as having such a large conchoidal fracture and such a brilliant luster and black color that it might be supposed to be obsidian. It has a specific gravity of 1.68. It is difficult to dissolve in petrolene or in the thick oils.

In further support of the opinion of the mixture of the two substances, petrolene and asphaltene, Boussingault says that it is always possible to thicken a soft bitumen by volatilizing the liquid portion by heat. This is done by the Indians of Payta to gain the consistence of bitumen needed for paying their boats.

Dr. T. Sterry Hunt, in 1862, regarded the bitumens and asphalts as intermediate links in the series of substances between solid coal and fluid petroleum. He says: "Anthracite, or nearly pure carbon, on the one hand, and petroleum, or carbon with a maximum of hydrogen on the other, represent the two extremes of the process of which bituminous coals and asphalts are intermediate terms." And in regard to their origin or formation, he says:

"Although we have seen that the solid asphalts, which differ from petroleum in containing less hydrogen and a portion of oxygen, have in most cases been directly formed from organic matters by a process analogous to that which yields coal and petroleum; it appears that the latter body, like other hydrocarbons, may gradually undergo an

* *Ann. de Ch. et de Phys.* (II.), lxiv., p. 141–151.

oxidizing process, which by removing hydrogen and adding oxygen, at last converts the liquid into substances having the characters of asphalt, of coal, or even of anthracite."

In describing further the occurrence of hard, black, brittle hydrocarbons in fissures of rocks of the Quebec group in Canada, he says: "The mode of occurrence of these matters shows that they have once been in a liquid state, and, as the limestones of this group are in many parts distinctly bituminous, there can be little doubt that the liquid carbonaceous matter was bitumen which has since been slowly oxidized, indurated and converted into these insoluble, infusible coaly and anthracitic bodies."*

Daubrée, writing in 1868,† said that we might include under the general name of bitumens, carbonaceous bodies of varied nature, from petroleum to viscous bitumen, or maltha; sometimes, also, called pissasphalte; and even include that which is solid at ordinary temperatures, to which the name asphalt is reserved.

Beckwith's description of bitumen (asphalt) is as follows:

From whatever source derived, superior bitumen exhibits the following properties: Its *color* is brilliant black with a reddish tinge. The reddish tinge augments when bitumen is softened and drawn into threads. The *fracture* is conchoidal at a low temperature. Below 50° (F.) it is solid and brittle; from 50° to 70° it is elastic and begins to soften; from 70° to 90° it becomes soft and pasty; from 90° to 100° viscous; and at 110° or 120° it melts. Its specific gravity is 1.025. The odor is empyreumatic and free from the noxious smell of coal-tar.

The more modern and comparatively recent attempts at a scientific classification of the bitumens and hydrocarbons generally are based upon their chemical composition. Thus Prof. Dana in the fifth edition of his *Mineralogy* places the hydrocarbons in five groups: 1. Simple; 2. Oxygenated; 3. Acid oxygenated; 4. Salts of organic acids; 5. Nitrogenous; but is obliged to place asphaltum and mineral coal in an appendix to the series.

I now pass to a consideration of the three substances which, under the names of albertite, grahamite, and uintaite, are generally known, and may be considered as the best examples we now have of pure asphalt on a large scale. In regard to albertite, however,

* *Contributions to the Chemical and Geological History of Bitumens and of Pyroschists*, by T. Sterry Hunt, M.A., F.R.S., *American Journal of Science* [II.], xxxv., 164, March, 1863.

† *Substances Minérales.*

there was, at the time of its discovery, a great difference of opinion amongst mineralogists and chemists as to its true nature, whether it should be classed amongst the coals or with the bitumens and asphalts.

ALBERTITE.

The name, albertite, is credited to Robb, but it was described by Dr. Charles M. Wetherill, in 1852, as a new variety of asphalt.* He was emphatic in his opinion, "that the substance is not coal, nor any variety of coal, but a true and new variety of asphalt." He describes it as brilliant jet-black in color, of high resinous luster; fracture perfectly conchoidal and brilliant; hardness between 1 and 2; density, 1.097; brown color on extremely thin edges. Held in the flame of a candle in such manner as to prevent as much as possible the action of oxygen, it gave evidence of incipient fusion, and adhered to paper when placed in contact with it. He obtained 44.35 per cent. of coke. It was found to be less soluble than Egyptian asphalt, and to bear a great analogy to the asphalt from Caxitambo, as described by Boussingault, the density of which was 1.08.

Melan-asphalt (albertite), analyzed by Wetherill, gave him, in comparison with Cuban asphalt (the ash being subtracted and the oxygen and nitrogen united):

	Cuban asphalt.	Melan-asphalt.
Carbon,	82.670	86.123
Hydrogen,	9.141	8.971
Oxygen and nitrogen,	8.189	4.906

The late Richard C. Taylor was also emphatic in his opinion that this substance should be regarded as asphaltum, and not as coal. He says:

"Like the *chapapote* of Cuba, the New Brunswick mineral has been commonly spoken of as a species of coal, and has been shipped and sold at the ports of the United States and Nova Scotia under that denomination. . . . . After a sufficient investigation of the mine, and of the geological circumstances under which it occurs, there appear to exist no grounds for denominating the mineral contents by any other name than *asphaltum*."†

Mr. Taylor further says, that it has neither a true roof nor floor. It has no overlying or underlying fire clay; no conform-

* *On a New Variety of Asphalt (Melan-Asphalt).* By Charles M. Wetherill, Ph.D. *Trans. Am. Phil. Soc.*, July 16, 1852. 353.

† *Proceedings Amer. Phil. Soc.*, v. 241 (read January 16, 1852).

able lamination, as in coal or coal-seams, instead of which the divisional planes are arranged transversely, *i.e.*, at right angles to the sides of the vein. It occupies a line of dislocation. It throws off smaller branches which, in places, reunite with the principal vein.

Prof. Charles H. Hitchcock* also regarded the mineral as asphalt, and for the following reasons:

1. The Albert "coal" occurs in true cutting veins, not in sedimentary beds like ordinary coal.

2. The "coal" was originally in a liquid state; was injected into vertical fissures, and subsequently hardened into a substance resembling jet.

3. The Albert coal must be classed with the asphaltic and bituminous veins found in the Quebec group in Canada.

But Dr. Dawson† held a different view, and describes albertite as a coal, or a variety of jet, while at the end he admits that its composition may be nearly that of asphaltene. He says:

"This substance, unfortunately, became a subject of litigation; and as one point in dispute was whether it should be called coal or asphaltum, scientific gentlemen were summoned from the United States as witnesses, and the most discordant opinions were given, both as to the name of the mineral and its geological age. This was not to be wondered at in the circumstances, for the substance was really a new mineral, intermediate between the most bituminous coals and the asphalts. . . . . Some, in all sincerity, called the mineral coal, others asphalt."

Dr. Dawson thought, that in its general characters, with the exception of the color of the powder, it agrees more nearly with the finer varieties of jet, or pitch coal, than with any other substance. Finally, he says: "If we compare albertite, as it has been named by persons not desirous of committing themselves, with the substances most nearly allied to it, we can scarcely avoid arriving at the following conclusions: In its behavior in the fire, chemical composition and electrical properties, the substance is nearly allied to jet, from which, however, it differs in its extreme brittleness, its greater uniformity of texture and more perfect luster and fracture, and also in its black streak; a character which also separates it from ordinary bituminous coal, and all the varieties of asphaltum. Its nearest analogue in this last particular is Lesmahagow coal. Its luster and fracture remarkably assimilate it to the finer varieties of asphalt;

* C. H. Hitchcock, *American Journal of Science*, II., xxxix, 267, May, 1865.

† Dr. J. W. Dawson, F.G.S., *Acadian Geology*, Edinburgh, 1855, p. 198.

but its streak, mode of combustion, and chemical composition effectually separate it from them. On the whole, the above considerations, in connection with a number of experiments made by Jackson, Hayes and others, and published in the reports on the mineral, place the substance at the head of the pitch coals, or jets, as the purest variety of that species of bituminous coal. It has, however, some claims to be viewed as a distinct mineral species, intermediate between coals and asphalts, and I suspect that its chemical composition may approach to that of asphaltene, the coaly ingredient of the asphalts."

The following description is compiled chiefly from Dr. Dawson's paper:

Structure.—It is free from mineral charcoal and lines of impure coal or earthy matter. It is, however, divided into prismatic pieces by a great number of smooth divisional planes proceeding from wall to wall. Both at the roof and floor it gives distinct evidence of a former pasty or fluid condition, being injected into the most minute fissures of the containing rocks. It seems to occupy a fissure along the anticlinal bend of the strata.

Fracture conchoidal. Brittle, and disposed to fly into fragments.

Color.—The substance has externally an appearance not dissimilar from the ordinary asphalt of commerce in its purest forms. Its color and its powder, or streak, on porcelain, are black, and it is perfectly opaque. My trials show, that while the powder is very dark-colored, it has a shade of brown.

Hardness.—3 nearly (=1 to 2 according to Dana), of Mohs's scale.

Specific Gravity.—1.08 to 1.11, according to Jackson and Hayes.

Fusibility.—In the flame of a spirit lamp it intumesces and emits jets of gas, but does not melt like asphalt. In a close tube, however, it can be melted with some intumescence.

It emits a bituminous odor, and when rubbed becomes electric.

Its deportment with solvents is not given by Dr. Dawson, but according to Dana there is only a trace soluble in alcohol, 4 per cent. in ether, and 30 per cent. in oil of turpentine.

Composition.—Comparative trials were made of its composition and that of a specimen of jet from Whitby, with the following result:

	Albertite.	Jet.
Water,	0.4	1.5
Volatile combustible matter,	57.2	57.1
Coke,	42.4	41.4
	100.0	100.0
Ash in coke,	0.27	4.0

The analyses by Wetherill have already been given (p. 568) and compare closely with the analyses of uintaite and some of the coals.

Grahamite.

Grahamite, another allied mineral, was first described and named by Dr. Henry Wurtz, in 1869,* from observations made in 1865. This substance was found in a vein some four feet wide in Ritchie county, West Virginia, and it is now exhausted.

I condense and rearrange the chief physical characteristics of grahamite from Dr. Wurtz's descriptions.

Structure.—The structure as shown in mass in the vein is marked by four distinct divisional planes having general parallelism with the walls. The portions next to the walls are coarsely granular with irregular cuboidal jointed cleavage. The next adjoining layers, from 15 to 16 inches in thickness, were highly columnar, with the columns at right angles to the walls. The center of the vein, averaging about 18 inches in thickness, is more compact and massive, and less lustrous in fracture than the other portions. It is described as "clearly *resinoid* in fracture and luster." Fracture subconchoidal, the outer portions of the dike or vein being brittle, fragile, glossy in fracture, breaking partly into small cuboidal fragments, and partly into pencillate fragments, described by Lesley as "pencil-cleavage."

Color.—Streak and powder, dark chocolate-brown.

Hardness.—Not stated.

Specific Gravity.—1.145.

Fusibility.—When heated above 400 degrees Fahrenheit, it softens and undergoes pasty fusion, becomes plastic and may be moulded and can be drawn out into threads. "It endures a temperature far above that of the fusing point of asphalts." Decrepitates and behaves very much like a caking coal.

Solubility.—Indifferent to all acids except strong sulphuric (oil of vitriol) which is colored brown by it. Alkalies do not act on it. Alcohol does not dissolve it. Partially soluble in gasoline and ether; coal-tar benzole and oil of turpentine gradually dissolve most of it. Chloroform and bisulphide of carbon dissolve it rapidly.

Gesner† and others claimed that this mineral was identical with albertite. Professor Lesley considered it to be a mineral pitch or inspissated petroleum, but Dr. Wurtz combated this view and considered the mineral as neither coal, asphaltum nor albertite.

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* *Proceedings American Association for Advancement of Science*, 1869, vol. xviii, 124.

† *Gesner on Coal-Oils, Petroleum*, etc., p. 27.

In the description of grahamite by Dr. Wurtz, he refers, at the end, to the discovery of a dike-like formation some years before in Colorado, consisting of a substance resembling albertite, and which he determined as grahamite. This, possibly, came from the Uintah region, and may have been similar to, or identical with, the substance I have called uintaite.

Dr. Wurtz also directs attention to the fact, of which I was not aware when my paper was written, that Prof. S. F. Peckham, as Special Agent of the U. S. Census of 1880, reported the occurrence in Utah of veins of a substance resembling the grahamite found in West Virginia.*

Professor J. P. Lesley describes a vein of asphaltum in Wood county, Virginia, which makes a straight course for two-thirds of a mile. Outcrop, 4 feet 10 inches thick, and also 2 feet 6 inches. A shaft had been sunk 34 feet on the vein, which continued of the same thickness, "the asphaltum being filled in, pure and clean," in what "was once, no doubt, an open fissure."†

Dr. J. P. Kimball‡ has referred to grahamite, the asphaltic mineral of the Cristo mine, near Tampico, Mexico. It occurs filling a fissure, and has a "distinct cleavage, a jointed structure as well as columnar partings in the deposits," thus closely resembling the structure of the grahamite of Ritchie, West Virginia. Gravity, 1.156 to 1.167 and 1.176; volatile matter, 57 to 62.14 per cent.; ash, 3 to 5.8 per cent. It was regarded both by Dr. Kimball and by Mr. Wm. Wallace, of Glasgow, not as a coal, but as belonging to the bitumens.

UINTAITE.

The principal facts regarding the brilliant solid asphalt from Uintah county, Utah, to which I gave the name *uintahite*, were first published in the *Engineering and Mining Journal*,§ and later were quoted in our *Transactions*, in connection with a paper by Mr. Jos. M. Locke, on "Gilsonite or Uintahite,"‖ in which he gave the results of chemical analyses, and a still later paper,¶ by Dr. R. W. Raymond, on a "Specimen of Gilsonite from Uintah County."

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* Census Reports, vol. x., p. 20. † *Proceedings Amer. Phil. Soc.*, ix., 185, 1863.

‡ On a Deposit of Grahamite known as the Cristo Coal Mine, etc. New York, May, 1876.

§ Uintahite. A New Variety of Asphaltum from the Uintah Mountains, Utah.—*Engineering and Mining Journal*, December 26, 1885, xl., 431.

‖ *Trans.*, xvi., 162. ¶ *Trans*, xvii., 113.

Since these descriptions and notices of uintaite, it has ceased to be a mineralogical curiosity and has become the basis of a considerable trade and industry. The anticipations of its utility in the arts have been more than realized. The deposit has been opened and worked, and companies have been organized to introduce and utilize the article, which is recognized as a superior form of asphaltum.

The first company was formed in Salt Lake City, and the shipments by it for the year 1889, up to the month of September, are reported as aggregating 3,000,000 pounds = 1500 tons. Since then the new company, organized in St. Louis, has shipped 1,200,000 pounds, making a total of 4,200,000 pounds for the year 1889.

The mines are in Uintah Valley, near Fort Duchesne, about 100 miles from Price, a station on the Rio Grande and Western railway. The vein was located as the "Carbon Lode," and was found to be upon one corner of the Uintah Indian Reservation, and special legislation was necessary to have it segregated. The vein is described as a regular fissure, cutting across the country for 12,000 feet, or more, in length, and from 3 to 4 feet thick. It has been opened by fourteen shafts or pits, aggregating 700 feet in depth. The surface-portions of the mineral are fissured and cracked by weathering, are more or less contaminated with sand and earthy matters, and are regarded as of second quality, while the portions below are compact and pure.

In regard to the occurrence we have also the statement of Mr. Wigglesworth, Chief Engineer of the Colorado and Utah Midland Railway,* that it is found about three miles east of Fort Duchesne, near the line between the Uintah and Uncompahgre Indian reservations, in a vein from three to five feet thick, nearly vertical, cutting through nearly horizontal beds of sandstone. Its course can be followed by the eye for a considerable distance on the ridges. Prof. E. W. Claypole writes that it has been followed for about two miles and traced downwards for about 100 feet, still retaining its thickness.†

I am also informed by a correspondent of the discovery of another vein, about 33 inches thick, which has been traced for the length of three locations, or 4500 feet.

Other localities are cited by Mr. Wigglesworth in the paper to which reference has been made.

* Note on a Specimen of Gilsonite from Uintah County, Utah, by R. W. Raymond, *Trans.*, xvii., 113.

† *American Geologist*, December, 1889, iv., 6, 386.

Structure.—The pure mineral, so obtained, breaks with a large conchoidal fracture, of which it presents perhaps the very best typical examples. As Boussingault observed respecting the chapapote asphalt, it might at a distance be mistaken for blocks of obsidian. There is no trace of structure. It appears to break with equal facility in any direction, in this respect differing from albertite in its columnar condition, and from the so-called pencillate structure of portions of the grahamite vein. It should, however, be remembered that we have not had as yet any description, in detail, of the appearance of uintaite in the vein. It is very brittle and is easily crushed to powder.

Color.—Black, brilliant and lustrous; streak and powder a rich dark-brown with a shade of red. It is lighter in color than the streak of albertite, which approaches black.

Hardness, 2 to 2½, not appreciably different from albertite.

Specific Gravity.—1.065 to 1.070.

Fusibility.—Disregarding any possible change of composition, when heated, uintaite may be said to fuse readily in the flame of a candle. Its deportment is like that of sealing-wax or shellac. It can be used in the same way, and takes a sharp impression from a seal. It is plastic while warm, but is not sticky and adhesive. It can be repeatedly melted and cooled without any apparent change of composition, though doubtless losing its more volatile portions when heated.

In my original description of uintaite I pointed out that it differed from albertite and from grahamite in its easy fusibility. No direct comparison of the substances was then made, but the descriptions cited in Dana's *Mineralogy* were taken. It is there stated that albertite differs from ordinary asphaltum by its very imperfect fusion when heated, and that in the flame of a candle it shows incipient fusion. Grahamite is stated by Dr. Wurtz to melt only imperfectly and with a decomposition of the surface, but in this state the interior may be drawn into long threads.

Since then comparison has been made directly with a specimen of albertite obtained many years ago, but which was not accessible when the uintaite was described. This albertite, to my surprise, appears to be nearly as fusible as uintaite, and the two substances do not so greatly differ in this respect as, from the descriptions of albertite, I was led to believe. Fragments of each placed in a glass tube and warmed over a candle fuse quietly, flow in a smooth rounded mass, and by turning the tube each substance coats the

sides and fills the tube, and on cooling, each hardens to its original condition. There is no appearance of decomposition, and no distillate of oil. The odor becomes stronger, but there is no sensible change of substance.

Albertite and uintaite may thus be said to be equally fusible. Both become rounded smoothly on the edges when brought near the flame of a candle, but their deportment is somewhat different. Albertite at once gives off a slight vapor which is very inflammable and takes fire before contact of the fused surface with the flame, while uintaite does not take fire until brought into the edge of the flame. The odors given off by the two substances are different.

There would seem to be some misapprehension of what constitutes fusibility in these substances, for in addition to the opposite statements already given, Mr. Locke, in his paper upon uintaite, says: "Heat softens gilsonite without melting it."* I can only surmise in this instance he referred to some artificial mixture or possibly an impure uintaite containing earthy substances.

Solubility.—Uintaite readily dissolves in melted wax, in ozocerite, in spermaceti, stearine, etc., and in crude petroleum. Spirit of turpentine, aided by heat, readily dissolves it. Under the trade name of gilsonite, it is now largely used for the manufacture of varnishes. Thus Locke has pointed out that this substance, mixed with turpentine, in the proportion of 1 pound of gilsonite to 5 pints of turpentine, and heated, gives an excellent japanning varnish.†

Uintaite, like albertite and grahamite, is not readily attacked or dissolved by alcohol. The heavy oils, fat, wax and ozocerite unite with it freely.

Composition.—Since the original publication of my description, two or more analyses have been made, and are here brought together. Analysis I., by Messrs. Fristol and Lawver;‡ II., by Prof. T. M. Drown;§ to which I have added for comparison an analysis III., of torbanite, calculated without the ash:

	I.	II.	III. (Torbanite.)
Carbon,	78.43	80.88	80.39
Hydrogen,	10.20	9.76	11.17
Nitrogen,	2.27	3.30	1.32
Oxygen,	8.70	6.05	7.12
Ash,	.40	0.01	

* *Trans.*, xvi., 164.
† *Trans.*, xvi., 165.
‡ *Trans.*, xvi., 163.
§ *Trans.*, xvii, 114.

A modification of the original name uintahite to uintite has been suggested by the Secretary, Dr. Raymond,* as a more agreeable form, and I am happy to adopt it so far as to drop the h, making the name uintaite, and to use this in preference to uintahite, especially as it is now not uncommon to contract the Indian name Uintah to Uinta. There appears, also, to be a preference in some places for the name gilsonite, after S. H. Gilson, of Salt Lake, who first brought this mineral into commercial notice, and made some insulating compounds from it, to which, I understand, his name was attached rather as a commercial trade name than as a purely mineralogical or scientific one. While desiring to recognize Mr. Gilson's great service to industry in bringing this substance into use, it seemed to me best to attach a name indicative of the source of the material. The name, gilsonite, has also been registered by the St. Louis company as a trade-mark, and this would interfere with its free and unrestricted use for the same substance if found, or mined, or worked by others.

Dr. Henry Wurtz, in August last, sought to show that uintaite should be considered as a variety of grahamite,† comparing it especially with the glossy variety. There is no doubt of the close alliance of these two minerals; yet there are differences, besides the difference of locality, sufficient to make a separate designation desirable. The points of difference between grahamite and uintaite are probably as great as between grahamite and albertite, and if uintaite should be merged in grahamite, both should disappear in albertite, and that, in turn, into a more comprehensive name, asphaltite, giving to the ancient name, asphaltum, or asphaltites, the common termination in *ite*, to conform to mineralogical usage.

In this view, the three minerals, albertite, grahamite and uintaite, from widely separated localities, would be regarded as the best examples, or types, of the species including the hard glance-pitch and the hard bitumen from Lake Asphaltites, so well described by Bergman.

If similarity, or correspondence of the chemical composition of the three substances, is to be taken as evidence of their identity, then they might equally be regarded as varieties of boghead, or Scotch cannel coal, for, according to the analyses cited (computed without the ash), the composition is nearly the same. We see at once that chemical an-

* *Trans.*, xvi., 162, foot-note.

† *Engineering and Mining Journal*, xlviii., 114.

alysis fails to indicate the peculiar physical characteristics of these substances, and this suggests that the classification of these and other hydrocarbons, in detail, should be based upon their physical characteristics rather than upon their composition, or their derivatives, the nature of which may be varied according to the processes used for their extraction. If these substances are, as supposed, mechanical mixtures, an endless number of species or varieties might be instituted upon the differences of composition.

Bituminous Compounds.

Besides the series of fluid, semi-fluid, and solid bitumens, all of them in a nearly pure condition, we have extensive natural formations of mechanical mixtures of bitumen with limestone, sand, and earthy matters, constituting a class of substances which have important technical uses. Of these, probably the best known is the asphaltic limestone of the Jura mountains, described by Beckwith as "asphaltic rock," and by General Gilmore as "bituminous limestone, called asphaltic rock."

Asphaltic rock, such as is extensively used in Paris for street-paving, is obtained chiefly from Val-de-Travers, in Switzerland, and from Seyssel, in France. It is a bituminous limestone of natural formation, composed of pure (in a commercial sense) carbonate of lime, impregnated with bitumen. Its color is dark chocolate, nearly black; fracture—finely-grained, granular, without cleavage or structure-planes. At a low temperature it is brittle, and breaks like common limestone. At a temperature of 140° or 160° it begins to disintegrate and crumble into powder, and at the temperature of boiling water to 280° the disintegration is complete; it is then a mass of powder. If, in this powdered condition, it is pressed into moulds, or tamped upon a hard surface, such as a roadway, it becomes hard and solid upon cooling, retaining the form given to it, and, in the case of a roadway, presents a monolithic surface, tough and hard, and to a great degree impervious to water and moisture.

The composition varies generally from 7 to 8 per cent. (Beckwith) 10 to 11 per cent. (Greene) of bitumen, and from 93 to 92 per cent. of limestone. Beckwith says that the rock may be uniformly impregnated, but if it contains less than 6 per cent. of bitumen it is too poor to be worked. The rock may also appear rich in bitumen but contain elements of clay, which, not being impregnated like the carbonate of lime, destroy the homogeneity of the formation. "The

fissures seen in sidewalks are often attributable to this cause, but the presence of clay is easily detected."*

In 1853, I observed in California a very interesting formation of rocks impregnated with bitumen, one of the most remarkable being a compact siliceous stratum, probably infusorial silica, but charged with bitumen. Similar strata were seen near Monterey.†

There are also extensive deposits of viscous bitumen mingled with sand in California, and also in Kentucky and in other localities.

These mechanical aggregations of lime and bitumen and of sand and bitumen are sometimes described, or carelessly referred to, as "bitumen" or "asphalt," but this is entirely in a trade sense, and is inaccurate, and is not justifiable if accurate reference is intended.

Classification of Bitumen and Asphalt.

The subject of classification and nomenclature, and the usage of authorities for centuries, as herein given in some detail, is more important to us when we consider that the existing classification has only recently been the basis of a discussion in the *Transactions*, and that somewhat diverse views and interests are involved in the use of different terms applied to the same compounds.

I refer to the interesting paper by Capt. F. V. Greene, on "Asphalt and its Uses,"‡ and to the discussion of the classification by Mr. W. H. Delano, of London.

The nomenclature in Paris in 1867, from a practical, not mineralogical, standpoint, is stated by Beckwith as "asphalt" or "asphaltic rock" as applied only to a species of limestone impregnated with bitumen, and "mastic of asphalt," an artificial composition formed of the first reduced to powder and mixed with a small quantity of bitumen.

The classification of bituminous substances by Mr. Leon Malo, the consulting engineer of the *Compagnie Générale des Asphalte de France*, and author of a treatise§ upon asphalt and bitumen, is evidently intended for the grouping chiefly of the various natural and artificial compounds of bitumen, rather than for the bitumens or asphalts in their pure state. It is a grouping for technical purposes

* *Report on Asphalt and Bitumen, etc.*, by Arthur Beckwith, C.E., Washington. 1868. *Reports of Paris Exposition*, 1867, vol. iv.

† *Report Geological Reconnaisance, California*, 1855, pp. 178, 182.

‡ *Trans.*, xvii., 357, 373.

§ *Guide Pratique pour la fabrication et l'application de l'asphalte et des bitumes, par Léon Malo, Paris*, 1877, p. 3.

under the general title of "Bitumen," but a grouping in which the purer forms of bitumen, such as glance-pitch or asphaltum, albertite, grahamite and uintaite have no place or mention. This tabular grouping is as follows:

Tableau Synoptique des Matières Bitumineuses.

Bitume.

- 1° à l'état libre:
  - liquide
    - huile de naphte.
    - pètrole de Gabian, de Baku, d'Amerique, etc.
    - diverses huiles de schiste.
  - visqueux
    - fontaine de Poix (Auvergne).
    - bitume provenant du lavage des sables bitumineux.
    - brais de gaz.
- 2° mélange à une gangue terreuse:
  - bitume terreux du Mexique.
  - " de Cuba.
  - " de l'île de la Trinidad.
- 3° mélange à une gangue quartzeuse:
  - sable bitumineux de Pyrimont-Seyssel.
  - " de Clermont.
  - " de Bastennes, etc.
- 4° imprégnant des schistes:
  - schistes bitumineux d'Autun.
  - " de Buxieres-la-Gaur (Algier).
  - " du Dauphiné, etc.
- 5° imprégnant des calcaires (asphaltes):
  - asphalte de Seyssel.
  - " du Val-de-Travers.
  - " de Lobsann.
  - " de Chavaroche.
  - " de Clermont, etc.

Reference may be made to the paper of Capt. Greene for a modified form of this classification, in which the solid forms of bitumen are added, thus making a just and needed recognition of asphaltum, and of its separation from the asphaltic limestone. He, however, uses the name bitumen in a generic and comprehensive way to cover and include the whole series of bituminous or asphaltic compounds, both pure and mechanically mixed, giving the name asphalt only to the pure mineral known as asphalt. Mr. Delano prefers to use the name asphalt in a commercial way for the asphaltic limestone, such as is used for paving in Paris. He gives, however,* the following nomenclature as existing in Europe for the past five and twenty years:

1. Asphalt-rock (bituminous limestone).
2. Compressed asphalt for roadways.
3. Asphalt-mastic.
4. Gritted asphalt-mastic.
5. Refined bitumen.

* *Trans.*, xvii., 374.

This is clearly technical rather than scientific, yet in the first definition there is the recognition that accuracy requires a distinction to be made between asphalt *per se* and asphalt mixed with rock. Careless use of the terms, and the tendency to abbreviate, have doubtless led to the too frequent substitution of the word asphalt for asphalt-rock, rock-asphalt or asphaltic rock, all of which are in use by authorities. Mr. Delano occasionally uses the word asphalt simply when referring to the asphalt-rock. Beckwith sometimes uses the single word asphalt to denote asphaltic rock, and he also describes pure asphalt as bitumen.

We have seen, by the authorities cited in the first portion of this paper, that the use of the word bitumen is generic rather than special, and also that it is synonymous with asphaltum, both of these words being applied to the series of pure or nearly pure substances, ranging from the fluid petroleum to solid asphaltum, but the name asphalt being generally reserved for the solid forms. The various natural and artificial mixtures of bitumen or of asphalt are not grouped with the pure minerals.

The use of the name bitumen for the whole series has the sanction of authority and long usage, but it is not sufficiently comprehensive for our present knowledge of the variety of substances grouped under the more exact designation of hydrocarbons.

The classification proposed by Captain Greene is a step in advance of that given by Malo, but it is objectionable in grouping the free or pure bitumens with the various mechanically-formed rock-mixtures under the one general term, bitumen, which should be applied only to the varieties of pure and unmixed bitumens, while the other substances, into which a variable portion of bitumen enters as a constituent, may be better grouped and called by the name of bituminous compounds.

It is also undesirable to involve the subject of classification with any theory of origin as is done in the definition of bitumen, which is called, "the generic name for the entire class of hydrocarbons resulting from the distillation of coal, or other substances from which coal has been formed."* It is better to group the substances as we find them without regard to their origin; and I would confine the term to natural products, and exclude all artificial products, such as coal-tar and mastic, unless for purely commercial or technical purposes.

Capt. Greene is in error in saying that "native mineral tar, or viscous bitumen, has only been found in such limited quantities,

* *Trans.*, xvii., 357.

and has been so little used, that it has received no specific name."* As we have seen, the names maltha, brea, and pissasphalt, were applied to the viscous bitumens by the early writers, by Boussingault and others.

From the most remote antiquity to our own time, the native bitumens have been classified and described chiefly by their external and physical characters. They have generally been grouped according to their degrees of fluidity, plasticity, and hardness, and not by their chemical composition beyond the general fact of their being hydrocarbons, the exception being the modern but unsuccessful attempts to secure a purely chemical classification.

The incursions of modern chemistry, which have revolutionized mineralogy as a branch of natural history, have here found an open field; and organic chemistry appears to have taken possession of this department of the science, and promises to absorb it in a cloud of organic derivatives from the protean elements. In the hands of the chemist familiar substances are transformed beyond recognition, and if we attempt to follow the chemists alone, we are soon lost in the mazes of organic chemistry.

Educts vary with the materials and processes used; and, beyond a certain narrow limit, a classification based upon the possible educts cannot be satisfactory. Ultimate analysis fails to give any correct idea of the characteristics and properties of these substances. Polymerism confounds us, and formulas mislead even the few chemists whose lives are devoted to their comprehension.

For practical technical purposes, at least, it is sufficient to follow the old system, and group these substances as they appear to our senses, without the aid of the tortures of the furnace and the retort. Following these views, the following classification of the hydrocarbons is suggested. It is followed by a tabular grouping of the natural and artificial bituminous compounds or mixtures.

* *Trans.*, xvii., 357.

Tabular Classification of Hydrocarbons.

Hydrocarbons.	Bituminous	Gaseous, ...	Marsh gas. "Natural gas."
		Fluid, ...	Naphtha. Petroleum.
		Viscous (Malthite),	Maltha. Mineral Tar. Brea. Chapapote.
		Elastic, ...	Elaterite. Wurtzilite.
		Solid — Asphaltite,	Albertite. Grahamite. Uintaite.
		Solid — Coal, . .	Bituminous coal. Semi-bituminous coal. Anthracite coal.
	Resinous, ...		Succinite (amber). Copalite. Ambrite, etc.
	Cereous, ...		Ozocerite. Hatchettite, etc.
	Crystalline, ...		Fichtelite. Hartite, etc.

Tabular Classification, or Grouping, of Natural and Artificial Bituminous Compounds.

Bituminous Compounds.	Natural.	Mixed with limestone— "Asphaltic limestone."	Seyssel, Val de Travers, Lobsan, Illinois and other localities.
		Mixed with silica and sand— "Asphaltic sand."	California, Kentucky, Utah and other localities. "Bituminous silica."
		Mixed with earthy matter— "Asphaltic earth."	Trinidad, Cuba, California, Utah.
		Bituminous schists, . . .	Canada, California, Kentucky, Virginia and other localities.
	Artificial.	Fluid, ...	Thick oils from the distillation of Petroleum. "Residuum."
		Viscous, ...	Gas-tar. Pitch.
		Solid, ...	Refined Trinidad asphaltic earth. Mastic of asphaltite. Gritted asphaltic mastic. Paving compounds.

AVALANCHES.

BY B. E. FERNOW, WASHINGTON, D. C.

(Colorado Meeting, June, 1889.)

MINING interests in the Western mountains are very seriously affected by the danger to property and life from destructive snow-slides and avalanches. This is a danger which the miner has largely brought upon himself by an improvident stripping of the timber from the mountain slopes, and, therefore, he might be expected to take an interest in the reforestation of the areas thus devastated.

A canvass was lately undertaken by the writer to ascertain approximately the extent of the damage suffered from this source, but the difficulty of obtaining reliable data has proved too great to permit, as yet, even an approximation. So much, however, is certain: that the loss of life is considerable, and that much property is destroyed almost every winter. True, neither the number of avalanches, nor their destructiveness, nor the amount of loss compares with what Switzerland experiences. This is due not only to the greater precipitousness of the Alps and to different climatic conditions, but also to the fact that in Switzerland a larger number of settlements is exposed to these dangers.

A very complete and interesting official report on the very numerous and destructive avalanches occurring in Switzerland during the season of 1887–1888 has just been published as a contribution to the inquiry, whether and how these dangers can be averted.

Peculiar weather-conditions, in addition to heavy falls of snow, were the reasons for the frequency of the phenomenon during that winter. This report records 1094 avalanches, by which 850 houses were destroyed or severely damaged; 84 persons and 752 cattle were buried; traffic on railroads and on highways was greatly interrupted, and the damage to personal property alone was valued at over $100,000. One of these snow-masses covered about half an acre, with a cone 250 feet in height. During the same year in Tyrol the number of avalanches was 2647. Of these 1355 run over permanent beds; that is, they recur annually, so that they are