On a New Substance resembling Dopplerite from a Peat Bog at Scranton. By Henry Carvill Lewis, Professor of Mineralogy in the Academy of Natural Sciences of Philadelphia.

(*Read before the American Philosophical Society, December 2, 1881.*)

In the course of an excavation for a new court-house at Scranton, Pa., made last July, a very interesting substance was discovered, specimens of which were sent to the writer at that time for investigation. The excavation cut through a peat bog, and it was at the bottom of this bog, some 25 feet from the surface of the ground, that the substance here referred to was found.

It appears that formerly there had been a lake or swamp at this place, which with the extension of the town had been filled up. Below eight feet of cinder and other rubbish there is a bed of peat 10–12 feet in thickness. The peat is said to be a good fuel after drying. Beneath the peat is a deposit of "swamp muck" or carbonaceous mud, which dries to a hard compact gray mass, burning with difficulty. In this "muck" are numerous plant remains and occasional seeds.

The whole deposit rests upon glacial till or "hardpan," and is therefore of post-glacial origin.

Scranton is in the glaciated portion of the State, and the peat bog found here is one of the many which owe their origin to glacial causes. These peat bogs have been formed, for the most part, in former swamps or lakes caused by the damming up of streams by ridges of drift deposited at the time of the melting of the glacier.

Near the bottom of the Scranton peat bog are irregular veins filled with a black jelly-like substance, elastic to the touch. The veins of this substance, which are confined to the muck above described, vary in width from a mere stain to between two and three inches, and make all angles with the horizon, being frequently nearly perpendicular.

The substance, as thus found, has the following properties: When first taken from the ground it is jelly-like in consistency, breaking with a conchoidal fracture, and having a hardness of less than 1. Immediately on exposure to the air it becomes tougher and more elastic, resembling India rubber. It may be preserved in this condition if kept in alcohol. The substance is black by reflected light. When a thin slice cut by a knife is examined under the microscope it appears brownish-red by transmitted light, and is nearly homogeneous in character.

Occasional seeds occur in this substance as well as in the surrounding peaty matter. In general appearance they resemble the seeds of certain Cyperaceæ. Under the microscope their surface is seen to be curiously marked with irregular wavy outlines. Professor J. T. Rothrock has been kind enough to make some sections of these seeds and reports concerning them that they have the characters of spores of one of the higher cryptogams, probably *Marsilia*. He states that Marsilia is a bog plant which is found during later geological time, and that the general shape and size of

its fruit corresponds with that of the specimens under examination. The outer coat is made up of outwardly pointing prismatic columns, the extremities of which gives the peculiar wavy appearance seen on the surface of these *peat seeds*. Yet since the interior bag and its contents can be reduced neither to an embryo nor to the interior structure of the Marsilia, it is not possible to assign these seeds definitely to that species. No other recognizable organisms have been noticed in the substance here described.

The black jelly is tasteless and odorless. If placed in the flame of a Bunsen burner before drying, it burns slowly and without flame. It is almost insoluble in water, alcohol or ether, but is almost completely dissolved in caustic potash; and from the dark-brown solution thus formed may be precipitated in reddish-brown flocculent masses by the addition of an acid.

After exposure to the air until completely dry, the substance becomes brittle, and nearly as hard as coal. In this condition it resembles jet or some of the varieties of lignite, and might readily be mistaken for those substances. It acquires a hardness of 2.5, and has the brilliant resinous lustre, and conchoidal fracture of true coal.

It has a specific gravity of 1.032. It is jet black in the mass, but in powder is dark-brown. It now burns with a clear yellow flame. Soaking in water will not soften it appreciably. In the closed tube it gives off water, and abundance of brown oil and empyreumatic vapors. The latter are in the form of a white smoke which can be lighted at the end of the tube.

In solubility it is like the undried substance. Hot alcohol dissolves a small portion, and forms a pale yellow solution. On treatment with caustic potash it dissolves completely, with the exception of an extremely slight residue of impurities. It will dissolve even in the cold. This test serves to distinguish the dried substance from brown coal or lignite, which are but partially soluble in alkalies.

A very slight trace of ammonia is given off on heating with caustic potash. By dissolving in a standard solution of alkali and titrating with standard acid, it is found that the substance has an acid reaction. It is therefore either an organic acid or a mixture of such acids.

The physical characters of this substance are closely allied to *Dopplerite*, but its chemical composition, as will be seen from its analysis, prove it to be an undescribed substance.

Mr. John M. Stinson, of the Second Geological Survey of Pennsylvania, has, at the request of the writer, kindly made the following analysis. The substance was carefully separated from the surrounding earthy material, and dried at 212° F. before analysis. Carbon and hydrogen were determined in duplicate, the two determinations closely agreeing:

Carbon	28.989
Hydrogen	5.172
Nitrogen	2.456
Oxygen	56.983
Ash	6.400
	100.

Approximate analysis of the dry separated material gave :

Volatile matter	72.190
Fixed carbon	21.410
Ash	6.400
	100.

Subtracting the amount of ash from the first analysis, we have :

C	30.971
H	5.526
O + N	63.503
	100.

From this we may deduce the empirical formula $C_{10}H_{22}O_{16}$. This formula would yield the calculated composition :

C	30.15
H	5.53
O + N	64.32
	100.

In giving the above formula, it is by no means assumed that it represents a simple mineral substance. It is merely a convenient expression of its composition. It is probable that the substance here described is a complex organic acid containing water. The nitrogen may possibly exist as ammonia. The small amount of carbon and the excess of hydrogen distinguish this substance from other organic acids. By the subtraction of NH_4O, and one or more parts of H_2O from the formula, it may be more closely allied to some of the organic acids which form Humic acid, the formula of which is so variously given by different authors. The determination of the true formula of the acid here analyzed, can only be determined after the formation of an organic salt with lead or silver. The absence of any exact knowledge concerning the composition of the organic acids existing in humus, as recently shown by Julien,* renders it difficult to express definitely the chemical relations of the substance under discussion.

The relation which it bears to its nearest ally, Dopplerite, may best be seen after a review of the facts as yet gathered about that curious mineral.

The mineral known by that name, and generally regarded as allied to Humic acid, was first found in a peat-bog near Aussee, Austria, at a depth of 6 to 8 feet below the surface. It was a black gelatinous substance, known by the peat-cutters as "*Moder-substanz,*" which after exposure to the air became at first elastic and afterwards brittle, assuming the lustre of coal. Döppler drew attention to this substance in a paper entitled "On a re-

* Proc. A. A. A. S., 1876 p. 311.

markable gelatinous substance discovered in Austria," read before the Vienna Academy in 1849,* and stated that it was nearly insoluble in water, alcohol and ether, but almost entirely dissolved by caustic potash.

Having been referred to Haidinger and Schrötter for further examination, it was fully described and named by them a week later. Schrötter† found its composition to be (after drying at 212° F.):

C.....	48.06	or without ash	
H.....	4.93	C.....	51.63
O.....	40.07	H.....	5.34
N.....	1.03	O + N...	43.03
Ash.....	5.86		

Haidinger named the substance and described its physical properties. He stated the observation of Löwe that it burned without flame, and that of Ettinghausen that it contained recognizable vegatable organisms.

In 1858, Gümbel‡ announced that a substance very similar to Dopplerite occurred in a peat-bed near Berchtesgaden, Bavaria. Like the substance from Scranton, a black jelly-like substance was found as irregular and sometimes nearly vertical veins of varying, but slight thickness, in the lower part of the peat. It was known as Peat-Pitch-Coal. It was very slightly soluble in alcohol, giving it a pale yellow color, but was almost completely soluble in alkali. Unlike the original Dopplerite, it burned with a yellow flame. Gümbel indicated the chemical changes which converted wood into peat, and showed that Dopplerite had the same composition as peat, and was in fact a truly homogeneous peat.

In 1863, Dopplerite was discovered in a peat-bog at Obburg, Switzerland, and was described by Kauffmann, who in an important paper§ showed that it had the same physical properties and chemical composition as the Dopplerite of Aussee.

It occurred in a black peat at a depth of 12 to 14 feet, in layers sometimes a foot in thickness. Except in burning without flame, its physical properties were nearly identical with the Scranton substance. The air-dried Dopplerite lost 19.7 per cent. of water at a heat of 110° C., and according to Muhlberg had the following composition:

C.....	52.2
H.....	5.9
O + N.....	35.7
Ash.....	5.2
	100.

By dissolving in caustic potash, precipitating by acid, and then analyzing the dried precipitate, a similar composition was obtained. Kauffmann

*Sitzunsb. d. k. Acad. d. Wiss. Wien, 1849, Vol. i, p. 239.
†Loc. cit. p. 286.
‡Neues Jahr., f. Min., 1858, p. 278.
§Jahr., d. k. k. Geol. Reich, Wien. 1865, Vol. xv, p. 283.

concludes that Dopplerite consists of one or more of the humous acids, and shows that the portion of peat soluble in alkali is identical with Dopplerite, and that compact peat contains minute black particles of Dopplerite. Peat is therefore a mixture of Dopplerite with partially decomposed plant remains; while Dopplerite itself may be regarded as a homogeneous peat in which all organisms have been decomposed. He shows that in different peats the proportion of Dopplerite, or part soluble in alkali, increases with the age of the peat, while the contrary is the case with mineral coal. Thus while in a recent peat but 25–30 per cent. was soluble, in an old compact peat, the proportion was 77 per cent. On the other hand, the solubility of coal, decreases with its age, as shown in the following table, where the figures represent the degree of solubility in alkali:

(Dopplerite)	(100)
"Slate coal," a woody lignite, Diluvial	75
Brown coal	42
"Pitch coal," Upper Miocene	10
" Lower "	5
Bituminous coal, Eocene	2.3
" " Carboniferous	trace.
Anthracite	0

He concludes that in the formation of coal from peat, the first step of the process is the formation of Dopplerite, and the second the gradual transformation of the latter into a material less soluble in alkali, and richer in carbon.

Several other European localities for Dopplerite have more recently been discovered.

A substance resembling Dopplerite in the peat of Hägnetswyll, St. Gall, Switzerland, mentioned by Deicke,* burns with flame, and is regarded by Kenngott as having characters more nearly approaching those of Pyropissite or Melanchyme. It possibly is more analogous to the substance from Scranton.

Dopplerite has not as yet been discovered in America. While the substance described in the present paper more nearly resembles Dopplerite than any other known mineral, it differs, as already shown, both in composition and in its behavior when burning.

A distinguishing feature of the Scranton mineral is its very low percentage of carbon. Dopplerite has almost the precise composition of peat, and peat, as is well known, contains more carbon than is contained in wood. Yet the Scranton mineral contains even less carbon than is contained in wood.† The empirical formula of the Scranton mineral gives

*Neues Jahr. f. Nim., 1858, p. 663.

†The composition of peat is about:

C	H	O + N	Ash.
61	6	33	= 100

The average composition of wood is:

C	H	O + N	Ash.
49.6	6.1	43.1	1.2 = 100

v. Coal, its History and Uses. Thorpe, etc., p. 165.

a larger amount of hydrogen than is expressed in the formulas of any similar substance.*

The first printed notice of this substance was given by Mr. T. Cooper.† A week later Mr. C. A. Ashburner, contributed to the same Journal the following analysis made by Mr. J. M. Stinson:

Water at 212°.....	66.758
Volatile matter.....	9.826
Fixed carbon	4.012
Ash.....	19.404
	100.

Mr. Stinson informs the writer that this analysis was made upon a sample consisting of a mixture of peat, muck, and the jelly-like substance, and that as no attempt was made to separate the latter, the analysis is not of scientific value.

Special interest is attached to the substance here described as being perhaps an intermediate product between peat and coal. While the quaternary lignites illustrate the transformation of wood with coal, this substance illustrates a similar change from peat. As by the investigations of Kauffman, it was shown that the formation of Dopplerite preceded that of any of the varieties of coal, so in the present case we have perhaps a yet earlier stage.

The characters of the Scranton mineral entitle it to a distinctive place among the hydrocarbons of natural origin. It has been the custom among mineralogists to regard these substances, as mineral species. In view, however, of the objection to adding new mineral species whose distinctive characters are made prominent only by analysis, the writer believes that it would be more advisable to combine those already described under generic names, and to regard the minerals included in such genera as varieties.

In the present case we have to do with a black jelly-like substance derived from vegetable decomposition, which with a different composition and with somewhat different physical properties has been found in similar geological conditions in several parts of Europe. It is therefore suggested that all of these substances be combined under one generic name. The name "*Phytocollite*" (*φυτόν, κόλλα*) signifying "plant-jelly," would include all jelly-like substances formed by the decomposition of plant matter. Dopplerite would then be regarded as one of its varieties, the mineral described by Diecke would be another, and the mineral from Scranton yet another.

* The formula of Dopplerite has been given as:

C_{40}	H_{25}	O_{25}	(Gmelin);
C_{16}	H_{10}	O_{10}	(Descloiseaux);
C_{10}	H_6	O_5	(Dana).

† Engineering and Mining Journal, Aug. 13, 1881.