SOME NOTES ON THE BLACK SLATE OR GENESEE SHALE, OF NEW ALBANY, IND.

BY HANS DUDEN.

The great uncertainty existing among scientists about the age of the New Albany black slate has induced me to study with interest this formation. The few facts I observed during the years 1894 and 1895 more than paid me for the time and labor spent, and I hope that the following will help to give a better understanding of this Devonian formation.

The black slate is well exposed in all water courses near New Albany and can be best studied along the Ohio River, beginning at the mouth of Silver Creek and continuing five miles below town; also along the Silver Creek bed, from a mile above Blackiston's mill down to its mouth, and in a good many places along Falling-run Creek. The deep bed, cut by the waters of Silver Creek into the slate, offers, perhaps, the best exposure, and reaches in many places to a depth of eighty feet. Tho total depth of the slate, according to Dr. Clapp's borings, is 104 feet at the foot of the knobs.* I also refer to Mr. Cubberly's paper† in which he gives the thickness of the slates at Salem at 103 feet as revealed by the drill.

The slate has a black to bluish gray color when freshly broken, but changes, after being exposed to the air, to light gray or drab. It becomes brittle and splits into thin laminæ and at the same time a whitish or yellowish salt weathers out, sometimes several feet in thickness, and forms the so-called "copperas banks."

The year 1895, with extremely low water during the summer months, was very suitable for my investigation. When coming from Jeffersonville, along the dry Ohio bed, the Corniferous limestone formation stops very suddenly about 200 feet above the mouth of Silver Creek and the black slate begins without any intermediate change. The careful observer will at once notice two different systems of cuts perpendicular to the layers of the stratum. One set of joints runs nearly from north to south and is more prominent with openings of two to three inches at the surface. The other system of joints is less marked and the slits run from west northwest to east southeast. The origin of the regular jointed structure is still doubtful; some believe it to be caused by shrinkage during the drying process, others, by the uplifting of the strata, and Prof.

*Geolog.cal Report of Indiana, 1873, page 158.

†Eighteenth Report, Ind. Geol. Surv., 1893, 219, Table XV.

King thinks it to be a physical phenomenon and terms it a crystalline polarity depending on the secular variation of the magnetic meridian.

At many exposures of the black slate the jointed structure causes it to break in the above mentioned joints and the waters have worn the slate so that from a distance it resembles fortifications.

The lamination of the slate is caused by pressure. Tyndall long ago demonstrated that homogeneous, fine grained bodies under high pressure become of a slaty cleavage. The finer the grains, the thinner the laminæ, even material like paraffine, wax and so on, represent a scaly structure when taken from a hydraulic press.

Pyritic iron is evenly distributed throughout the whole formation as roundish concretions, as well as in particles in the form of dust, visible only with a microscope. Cubical, as well as needle-shaped crystals, are found, while some of the concretions have a radiated structure.

CHEMICAL COMPOSITION.

To give a full explanation of the "black slate" we have to consider also the chemical composition of the formation. Plainly spoken, it is sand in the form of very fine grains, cemented together by ferric sulphide, and this mixture is evenly saturated with the residues of plants (and perhaps animals) in the form of carbon and bitumen.

The following are the results of analyses of the slate taken from different localities near New Albany:

I.

Water expelled at 100° C	0.50
Volatile organic matters	14.16
Fixed carbon	9.30
Silica	50.53
*Pyritic iron and alumina	25.30
Calcium oxide	0.09
Magnesium oxide	0.12
	100.00

II.

Water expelled at 100° C., during four hours		0.56
Volatile organic matters	14.30	23.60
Fixed organic matters	9.30	
Silicates insoluble in HCl		65.43
Ferric oxide		8.32
Calcium oxide		0.09
Magnesium oxide		0.12
Sulphur		2.08
		100.00

*The amount of pyrite and alumina changes considerably in different layers. This piece had 10.367 per cent. iron pyrite and 14.933 per cent. alumina.

The sand in such a fine condition is certainly a marine deposit The sea waters always contain a small amount of sulphate of lime and magnesia, which reacts on the iron oxide of the sea bottom. The resulting ferrous sulphate was reduced to ferric sulphide (pyrite) by the decaying organic matters, and we therefore find it very often replacing fossils. The carbon of the slate is so thoroughly intermingled with the sand that we can not explain it otherwise than by the theory that the organisms of this sea were deposited with the mud. Dittmar's Report on the Composition of Ocean Waters (1884), from seventy-seven complete analyses of different sea waters, gives as an average composition 6.410 per cent. of sulphuric acid in ocean water salts. These are the results of an extensive investigation made on H. M. S. Challenger. The high percentage of sulphuric acid fully explains the origin of the enormous quantities of pyritic iron contained in this slaty Devonian formation. The nodular as well as the fine grained pyrite (iron disulphide) had their origin in the above explained way, and it is my opinion that soft-bodied shell-less mollusks were totally replaced by the cubical crystallized or radiated iron disulphide. By observing a piece of the slate under a microscope with good light, one is astonished to find the piece glittering with the dust of this iron ore. When we expose this rock to the oxidizing influence of air and rain, the water and oxygen combine with the pyritic iron according to the following formula:

$$FeS_2 + 8\,H_2O + 7\,O = FeSO_4 + 7\,H_2O + H_2SO_4.$$

Pyrite + 8 water + 7 oxygen = iron sulphate (copperas) + 7 water + sulphuric acid.

The water-soluble iron sulphate is leached out by drainage water, and the free sulphuric acid reacts on the sand forming with silicate of alumina, aluminium sulphate, both of which salts occur in the so-called copperas banks of Silver Creek in considerable amounts. The free sulphuric acid has also a tendency to oxidize to carbonaceous matter of the slate, and the result is a light gray or drab-colored disintegrated mud. The oxidizing process has changed the bodies to their original forms, namely, sand and iron sulphate, the carbon being lost by oxidation.

An analysis of the salt weathered out on Silver Creek gave the following result:

Water expelled at 100° C	8.20
Water expelled by ignition	45.06
Iron oxide	20.54
Sulphuric acid	24.70
Matter insoluble in water, admixed slate	1.50
	100.00

We take up next the last and most interesting constituent, the carbon, which has already been mentioned as being the reducing agent which brings about the change of the sulphate of iron into the disulphide.

When a covered crucible filled with freshly pulverized slate (passed through a sieve of eighty meshes to the inch) is subjected to a Bunsen burner a great part of the carbon goes off in the form of inflammable vapors. On taking off the lid an asphalt like coating covers it on the inside. The residue which represents the fixed carbon is changed in color into a blue-black. By repeating the same experiment without any cover and giving the crucible a somewhat inclined position, stirring from time to time with platinum wire, all the carbon is oxydized and the light colored silicate remains.

In trying to extract the volatile components of the slate by solvents I did not succeed. Ether, alcohol, benzine, benzole, coal oil, chloroform, all gave the same negative result.

Dry, destructive distillation produces a blackish looking oil, an ammoniacal water and gas of high illuminating properties. This oil contains chiefly bodies of the paraffine series, and yields by redistillation and refining hard paraffine as well as fluid paraffine oils fit for many industrial uses.

The tendency of application of high temperature on organic substances is to break them up into their elements. Dry, destructive distillation produces complex compounds by rearrangements of the atoms before complete dissociation is reached. The degree of temperature employed is of importance, each elevation resulting in new compounds not possible at a lower temperature. It is, therefore, possible to obtain very different results by applying different temperatures during the distilling process. When the slates are thrown into a red-hot iron still and kept red hot, the greater part of the products of distillation will consist of gas. By applying a heat of perhaps 600° F. under atmospheric pressure a considerable amount of oil is obtained, and by distilling at twenty-four inches vacuum at 400° F. all the hard paraffine goes into the condenser unchanged without "cracking," as it is termed.

Hunt, in his chemical and geological essays, gives an analysis of black pyroschist equivalent to the Genesee from Bosanquet on Lake Huron. By ignition in a closed vessel it lost 12.4 per cent., the residue being black, and not calcareous.

A portion in fine powder was digested for several hours with heated benzole, which took up .8 per cent. of brown combustible matter. The residue carefully dried at 200° F. and subjected to dry, destructive distillation resulted in 11.3 per cent., and, by following calcination, 11.6 per cent. additional. By destructive distillation, 4.2 per cent. of oily hydrocarbon, and a large percentage of gas, and some ammoniacal water were obtained.

PREVIOUS EXPERIMENTS IN UTILIZING THE BLACK SLATE.

Referring to the Geological Report of Indiana for 1873, we find the statement that the black slate has been tried for manufacturing a roofing material by Dr. Samuel Reid & Co., but it could not withstand exposure to the weather. I also have seen it used for making fences on farms with the same unsatisfactory result. Small huts built from it exhibited a pile of crumbled pieces after a few years.

The reasons are already explained. Experiments have also been made in utilizing this slate as fuel. Fishermen on the Ohio River banks often use it in their camping fires together with driftwood. They know very well that freshly broken slates burn with a bright flame as long as the bitumen lasts. Slates exposed for some time to the atmosphere lose a great percentage of the bitumen. Experiments made with freshly pulverized slate blown with a blast into a furnace have rendered good results, but at the low prices of Indiana coal it would hardly pay to crush and pulverize slates for fuel.

Mr. Very, of New Albany, told me that fishermen near Blackiston's mill, on Silver Creek, set the slates on fire several years ago and that the fire burned for several weeks and could not be extinguished until high water overflowed it.

I also mention the fact that the natural gas used near Brandenburg, Ky., is all derived from the same slates. The bore hole made at Salem gave, at the depth of 1,775 feet, gas and petroleum for some months. When the writer visited Salem in 1894 it furnished gas for a few cooking stoves only.

One can not expect to find gas or petroleum in large quantities near New Albany in this stratum, as the slates are exposed and the inclination is so considerable that it would escape, there being no impervious roofing over it. When going along the roof of the slates, which at the foot of the knobs consist of three feet of hard, non-porous limestone, one can smell, especially on a still day, the penetrating odor of sulphurized carburetted hydrogen. The volatile components of the bitumens are escaping into the air and can not be utilized.

NEW WAYS OF UTILIZING THE SLATE.

During the fall of 1894 I made experiments in utilizing slate by dry, destructive distillation. It was my aim to produce directly from the slate an illuminating gas, but after long experimenting I finally came to the conclusion that it would be much better to distill at a very low temperature to get all the oil undecomposed. The resulting oil can be put to different uses, as gas-making, lubricating, burning, etc.

A retort made from four-inch pipe, six inches long, capped on both sides, was connected by three-quarter-inch pipe with a washing and refining apparatus. The retort filled with slate was subjected to red heat and the resulting gas collected in a tin reservoir. With this arrangement I obtained from—

5 lbs. of Pittsburgh coal	105 gallons of gas.
8.5 lbs. of black slate	45 gallons of gas.
8.5 lbs. of black slate, Ohio banks	50 gallons of gas.
8.5 lbs. of black slate, Falling Run banks	65 gallons of gas.
15 lbs. of freshly broken slate	105 gallons of gas.
15 lbs. of the same after exposure to air for 14 days	100 gallons of gas.

The gas was left standing for several days in the reservoir during cold weather without undergoing any condensation. It burned with a light flame which resembled petroleum gas light.

The Gas Light and Coke Company of New Albany made a trial last year to carbonize the slate, which is exposed a few hundred feet from their gas plant. Superintendent T. W. Dunbar, in a letter, says as follows: "I carbonized three tons of the New Albany black slate and obtained a yield of 2.20 cubic feet per pound of twenty-two candle power gas. Ordinary unenriched coal gas is about eighteen candle power. The quality of gas, therefore, is better and the yield 45 per cent. of that obtained from Pittsburgh coal. Of the amount of oil or tar obtained I know nothing, as I did not make any measurements. The slate does not materially change its color or form by being carbonized. The residue contains much sulphur, and, so far as I know, is useless for fuel. I made no scientific test. With the arrangement we have for making gas, it would not pay us to use the slate even though we could obtain it for nothing. The slate was obtained from near the exposed surface of a creek bottom, and I am sure that if a sample was gotten at a greater depth that a much better yield of gas would be obtained."

These are the results with a new raw material, "the Black Slate," worked in a gas plant having the apparatus suitable for Pittsburgh coal. As I have already mentioned, I discarded this process. It requires too much fuel to bring all the bulk of slates to the temperature necessary to convert all the bitumen into gas.

By selecting retorts which insure a quick movement of vapors into the condenser, it is possible to get at a very low temperature a great percentage of oil without much fuel expense. Crude oil obtained by atmospheric pressure from the slate exhibits a black coloration, has a very bad smell and is very difficult to refine. In oil obtained with stills provided with a vacuum pump the vapors are removed from the hot still walls as quickly as formed. At the same time the temperature necessary to form the vapors is materially lowered (about 100° C.). A vacuum of fifteen inches gave very good results. The oil is nearly colorless and without much smell. By leading into the still a small amount of steam and the vacuum apparatus left as in the last case, then in the watery part of the distillate ammonia was increased materially and can be used for manufacturing sulphate of ammonia.

It is well known that in a still of large dimensions the vapors are more easily overheated than in a laboratory still. Nevertheless the results of the experiments will be also true in working on a manufacturing scale. Taking into consideration its thickness of more than 100 feet, the State of Indiana possesses in this Devonian slate a storehouse of power greater than the coal seams, which can furnish an almost inexhaustible supply of oils for illuminating, heating and other purposes, provided the proper methods of utilization are devised. It is, therefore, of the greatest interest to learn as much as possible of the methods and apparatus used by other nations for working with profit a similar raw material.

It is surprising that in spite of the low prices of American and Russian petroleum it was possible in two different districts of Europe to carry on the manufacture of distilling with profit bituminous schists on an enormous scale. I mean the Scottish mineral oil industry with a yearly output of 60,500,000 gallons crude oil in seventy factories,* and the Actiengesellschaft A. Riebecksche Montanwerke, centering in the province of Saxony, with a yearly production of 17,348,650 gallons of crude oil. To-day the Scottish industry has adopted the Young and Beilby's retorts, and also the Henderson retort. At the close of the year 1890 there were 1,520 Henderson retorts and 3,528 Young and Beilby's stills in active operation, while 64,560,000 gallons of crude oil and 25,000 tons of sulphate of ammonia were produced. The crude oil yielded, after refining, the following products:

Naphtha	2,030,128 gallons.
Burning oil	19,086,650 gallons.
Gas oil—sp. gr. .840—.850	973,768 gallons.
Medium oil—sp. gr. .865	2,729,928 gallons.
Heavy lub. oil—sp. gr. .875—.95	6,440,632 gallons.
Soft scale paraffine	3,605 tons.
Hard scale paraffine	17,482 tons.

Young and Beilby's latest patented retort insures a greater gain of ammonia, and is, therefore, superior. After complete distillation of the volatile matters the shale is submitted to the action of steam under high pressure. The oxygen of the steam combines with the fixed carbon. The nascent hydrogen combines with the remaining nitrogen, forming ammonia. The good results obtained from this device have aided, to a great extent, to better the profit of distilling the schists. Mr. Fletcher's twenty-third Report on the Alkali Acts (26) states that in Ireland 18,080 tons of sulphate of ammonia were produced during the

*Journal of Gas Lighting, 1894, I, p. 973; 1894, II, p. 605.

year 1886 from the shale works alone. The superiority as a fertilizer of sulphate of ammonia when free from thiocyanate is well known to the agriculturists.

The refining of crude oil consists in repeated distillations and treatment with sulphuric acid and caustic soda. Before bringing the crude oil into the retort it is treated with a small percentage of concentrated sulphuric acid (66° Beaume) at 50° C. for some time. Air is blown into the mixing tanks. Sulphurous acid is evolved and resinous bodies are partly dissolved and partly precipitated as tarry matters; a continuous washing with water follows; finally the last traces of sulphuric acid are removed by baryta water. The crude oil is now ready for distillation. This is separated into fluid crude oil and the paraffine mass by subjecting the whole to a low temperature. Hard paraffine is pressed off in hydraulic presses, refined by bleaching with bone-char, and filtering through a filter press. The residue in the still is worked down to coke.

The Scots proceed in a somewhat different way. A first distillation separates the naphtha only. The rest of the distillate forms the "once-run oil." After the sulphuric acid treatment and precipitation of tarry matters, consisting of pyridin and pyroll bases, the oil is allowed to settle over night and the clarified portion is run into the soda washer and treated with caustic soda of 1.3 sp. gr. Cryselic and phenilic bodies are absorbed by the lye. The oil is now ready for the still, and is separated by fractional distillation into light and heavy oil. The sulphuric acid used for refining is generally utilized by boiling it with water and separating the precipitated tar. The resultant weak acid solution is sufficient to convert all ammoniacal compounds into the sulphate of ammonia. The soda tar is treated with carbonic acid, and the soda combines with it, forming carbonate of sodium, and the liberated creosote oil is obtained, which is well known for preserving timber. Of course the process is subject to changes, depending on the nature of the oils and their market price.

The Saxon Thuringia mineral oil industry is using the retorts invented by Rolle, 1858, with improvements made by Schliephake, Grotowsky and others. Their aim has been to produce an illuminating oil (Solar oil), but when American petroleum entered the European market a high percentage of hard paraffine became the desideratum. The "cracking" in the still was overcome by the use of "Körting's Dampfstrahlgebläse," an ingenious steam injector which furnished steam and at the same time created the partial vacuum.

The Scottish mineral oil trade has in the past had its hard times, but has so far always succeeded in finding new channels of utilization for its products. During the year 1890 the Scots put on the German market their overstock of crude oil. Wagner's Jahresberichte über die Leistungen der Chemischen Industrie, 1890, gives, on pages 83–89, a very interesting résumé by Oberkontz. On September 17, 1896, another very valuable addition to the uses to which the oil can be put was demonstrated to the Incorporated Institution of Gas Engineers.* The patented oil gas plant constructed by Mr. William Foulis at the Dawsholm gas works has already been found so satisfactory that a second apparatus is to be erected. The plant consists of three vessels—a generator for making producer's gas from coke, a retort for vaporizing the oil, and a retort for fixing the oil vapors in the form of gas. As spray, the oil is sent into the top of the retort against a plate or dispenser in such a way that it is broken up into a fine mist, which enables most of it to be gasified without coming into contact with the hot still walls of the retort.

The largest shale distilling works of the Scottish combination is the factory of Young, of Glasgow. It produced, in 1885, from 500,000 tons of shale, 72,000 tons of crude oil and 4,000 tons of ammonium sulphate. The crude oil yielded 6,000 tons of paraffine, 30,000 tons of burning oil, 4,000 tons of naphtha and 9,000 tons of lubricating oil.

†At Broxburn, shales have been worked since 1861. They contain about 20 per cent. of carbon, 3 per cent. of hydrogen, .7 per cent. of nitrogen and 1.5 per cent. of sulphur. In treating the shales with naphtha no other oil is obtained. The following are the products of distillation:

Crude oil	12 per cent.
Gas	7 per cent.
Ashes	67 per cent.
Ammonia water	8 per cent.
Carbon residue	9 per cent.

To get the best results by distilling, the temperature ought to be at a dark red heat. An addition of lime or soda during the distilling process has no effect. One ton of shale results, on an average, in 135 liters of dark green crude oil, 295 liters of ammonia water and fifty-seven cubic meters of gas, the latter being used for fuel and illuminating purposes at the works.

SOURCE OF BITUMEN.

In attempting to explain the remains of organisms preserved in rocks, we must constantly refer to animals and plants of the present age. By carefully comparing, and at the same time observing, all the surroundings of the place where fossils are found we are able to make conclusions which will give us a picture of the past ages.

Taking it for granted that the Genesee slates are a marine deposit, then we can certainly expect to find the remains of organisms of the Devonian sea preserved in the mud. It is remarkable that not a single shell

*Oil Trade Review, 1896, October.

†Stuart Town Soc. Chem. Industry, 1889, page 100.

has been found around New Albany in the slate formation. Let us now consider the possibilities under which marine plants are, perhaps, preserved.

Seaweeds are thrown on the sea shore by flood and storm and exposed to the oxidizing influence of air. The harder, more leathery kinds, as fuci, laminarias, etc., are able to withstand the weather for some time. The seaweeds are bleached by the exposure to light and begin to swell up by the absorption of moisture. By diffusion of this moisture through the membranes, the plants change slowly into a jelly-like substance; "the algin" and the salts are soon leached out. The more tender kinds are not able to resist any length of time and become disintegrated. They are completely changed into a sticky fluid which is absorbed by the sand. Very different are the conditions under which seaplants may be preserved on the bottom of the sea. Plants loosened by the waves of a storm sink by their higher specific gravity to the sea bottom and into the deposited mud, which forms a complete casing for the buried plant, excluding the decomposing influence of air, or at least reducing it to a minimum. Under such conditions it is very likely that a plant is preserved by carbonization. The products of the slow decomposition have saturated the surrounding mud and are represented by the bitumen (solid, fluid and gaseous) and the fixed carbon.

The Fifteenth Indiana Report on Geology, page 17, gives the following statement: "Vegetable remains consisting of huge tree trunks are found imbedded in the New Albany black slate, usually near the upper surface of the formation. These furnish, to my mind, a suggestion of the source whence has been drawn all the combustible matter dispersed throughout the slate."

Mr. Maurice Thompson thought that the small layer of three to four feet of driftwood imbedded in the blue clay on top of the New Albany black slate was sufficient to explain the source of an amount of at least 23 per cent. of carbonaceous matters in a formation of 104 feet thickness. Specimens of well preserved cones of conifers and nuts of walnut trees, found by myself, are a sure proof that it is really driftwood of a recent age, and not vegetation of the old Devonian formation.

I am also well aware of the paper written by T. F. James, custodian of the Cincinnati Society of Natural History on the "Fucoids of the Cincinnati Group." (Vol. 7, 1884–'85, Journ. Cincinnati Soc. Nat. History.) He comes to the following conclusion: Reviewing all the supposed algæ, there is not a single one which seems entitled to remain in the class. They are referred to three different sources: (1) To inorganic causes; (2) to trails and burrows of marine mollusks; (3) to hydrozoas.

The fossil plants which I describe below all show a carbonaceous film, and No. 1 is so completely preserved that every cellwall can still be seen. They all have been found in a very small district along the Ohio River, beginning near Force's handle factory and extending to the mouth of Falling Run. The banks are terrassic and accessible only at very low water.

DESCRIPTION OF DISCOVERED PLANTS.

Before my discovery of plants in the New Albany black slate no fossils had been found therein. I had only heard of some micro-organisms, but had never seen specimens of them. Writers in several of the past Indiana Geological Reports had expressed the wish that more information was available concerning the fossils of the black slate.*

Prof. David White of the United States Geological Survey has aided me much by giving me a list of American literature on Devonian plants. His own opinion about Nos. 1 and 4 is that they are "unique. I do not recollect anything like them." The plates, as well as the descriptions, will give a fair idea of the plants. I would also like to call attention to the fact that the plants are perhaps compressed and their original size is therefore somewhat changed. The plants are always found lying between the laminæ. I never found specimens perpendicular to the cleavage.

PARENCHYMOPHYCUS gen. nov.

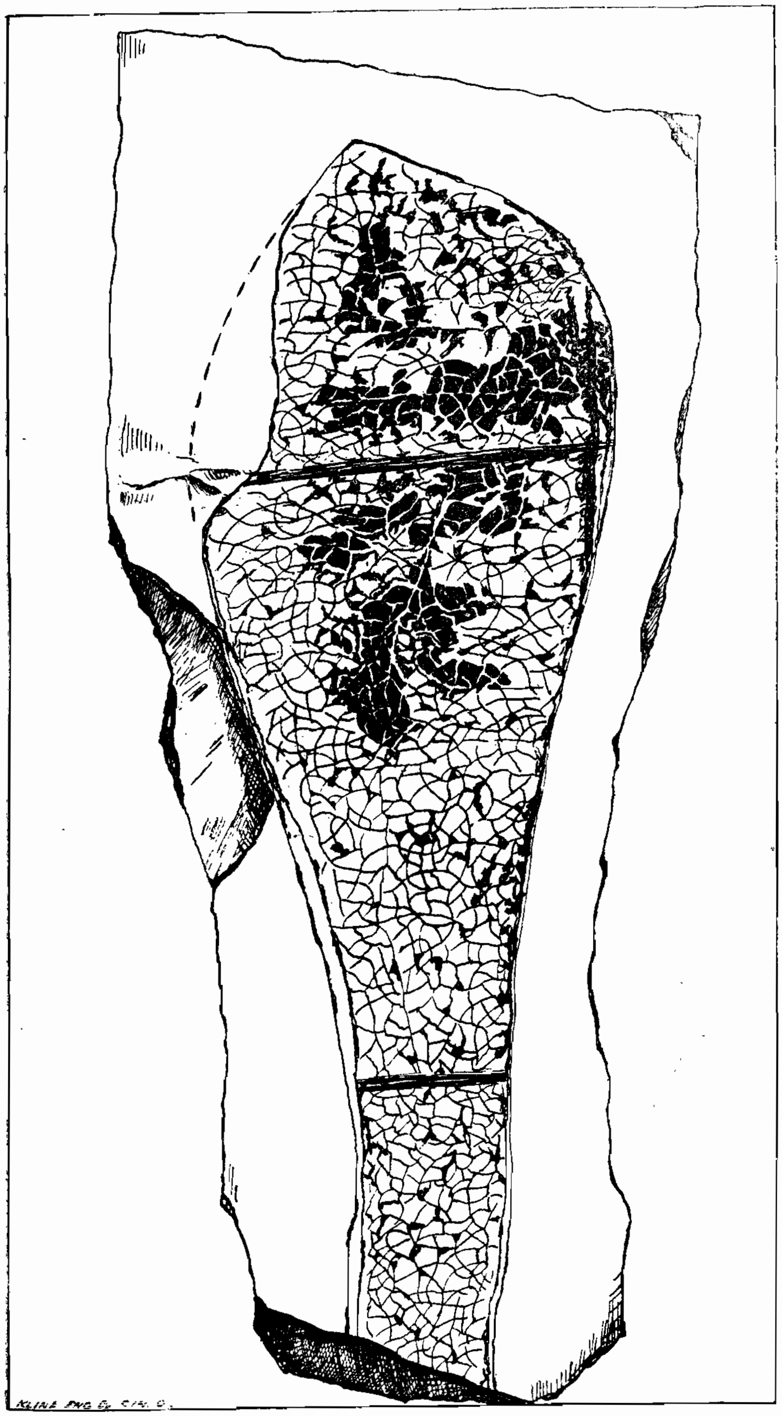
(*Parenchymus*, cell. *Phycos*, seaweed.)

Fucoidal plants with parenchymatic cells and a flat, linear nodose thallus. The genus is based on *P. asphalticum.*

1. *Parenchymophycus asphalticum*, sp. nov. Plant with a band-like thallus from 10 to 150 mm. wide, the well preserved spongy parenchymatic cells always filled with asphaltum. The cell walls are rich in silica. Cross divisions (nodes) at regular distances divide the band into rectangular oblong pieces (internodes). The termination of the plant consists of an oval shaped bud similar to that of *Fucus vesiculosus* L. of the present age. The length of specimens found varied from a few centimeters to 183 centimeters. The cell walls of this most interesting sea plant have resisted so well the influence of decomposition that they served as a means of diffusion for fluid bitumen, which, after a long time, gave off the volatile components and left only the hard asphaltum. All specimens found show no ramification. (Pl. II., fig. 1.)

Locality: Ohio River banks at extreme low water between the handle factory of Mr. Force and the mouth of Falling-run Creek. I also found one specimen in the Silver Creek bed near Blackiston's mill. Specimens deposited at New Albany Society of Natural History in the fall of 1894, and at the State Museum, December, 1895.

*1873, page 158; 1885–86, pages 16-17; 1888, pages 60-61, 198.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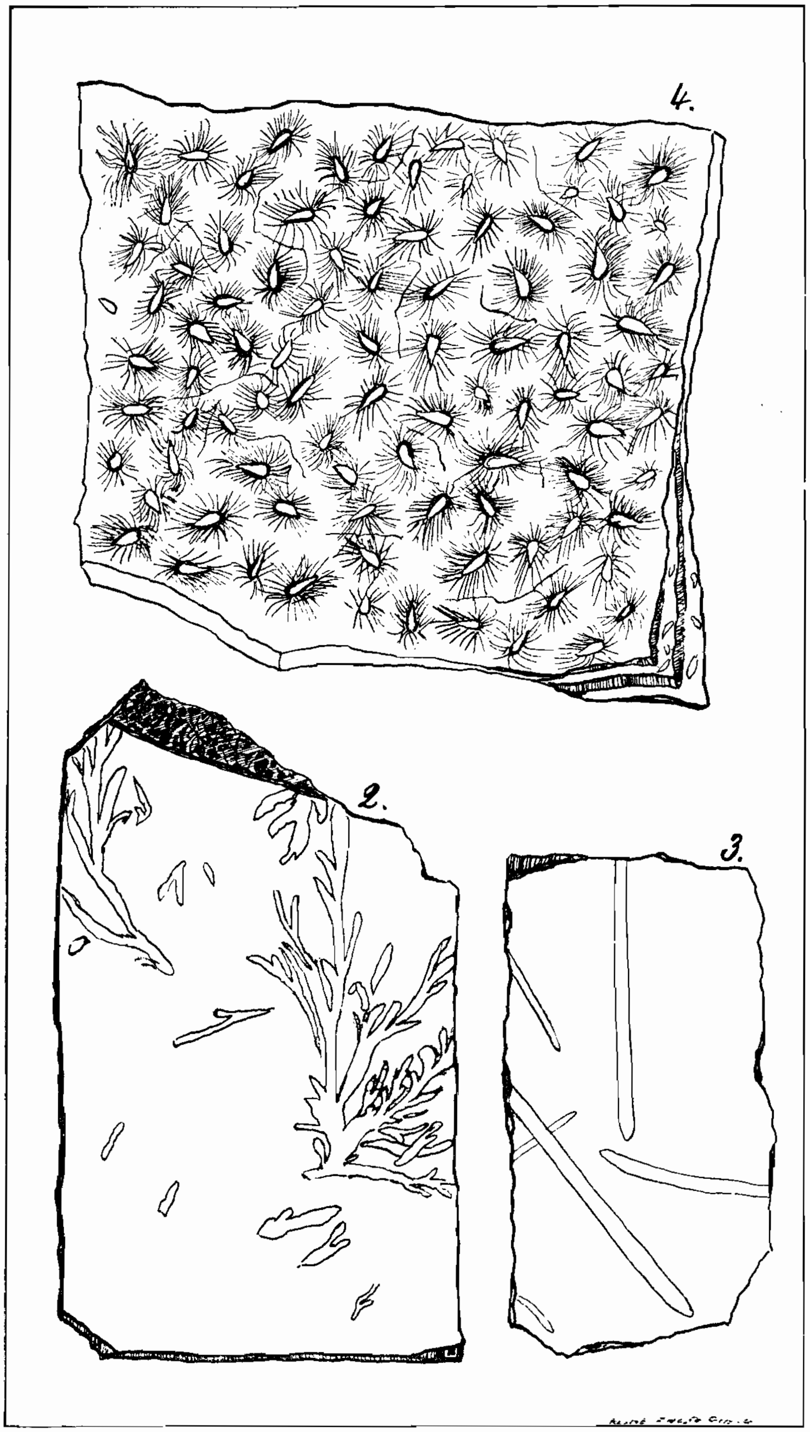
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3.

PALAEOPHYCUS Hall.

(*Palaios*, ancient. *Phycos*, seaweed.)

Stems simple or dichotomous, branches cylindrical or slightly flattened with the obtuse surface smooth or dotted. Type *Palaeophycus tubulare*, Hall, 1847, Pal. N. Y., Vol. I, p. 7.

2. *Palaeophycus new-albanense* sp. nov. Thallus flat, linear, entire, often branched; ramification, dichotom branches erect alternate, branchlets leaflike, tapering gradually into a narrow, more or less prolonged termination. Thallus 1 to 2½ millimeters wide. Length of plant from 6 to 10 centimeters. (Pl. III., fig. 2.)

Locality: Ohio River banks at New Albany.

3. *Palaeophycus lineare* sp. nov. Thallus flat, linear, entire, very rarely branched, 2 to 4 millimeters wide and sometimes of considerable length. Similar to *Corda fillum* of our seas. (Pl. III., fig. 3.)

Locality: Ohio River banks at New Albany.

SPORANGITES Dawson.

(Seed Vessel.)

Dawson, 1863, Can. Nat. and Geol. Vol. 8. Type *S. papillatus*, Dawson.

4. *Sporangites radiatus* sp. nov. Ovoid shaped bodies with radial hairs around them. Completely filling the slates at some places. I have only found specimens of this organism near specimens of *Parenchymophycus asphalticum*, and this fact caused me to believe that they are perhaps spores of this gigantic fucoid. (Pl. III., fig. 4.)

Locality: Ohio River banks.