

P H I L O S O P H I C A L
T R A N S A C T I O N S :

**LIII. Remarks on the bovey coal: In a letter
to the right honourable George Earl of
Macclesfield, president of the royal society**

Jeremiah Milles, D. D. F. R. S.

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Excepting a few old houses, none of the buildings in Aleppo were actually thrown down; but the walls of a considerable number of houses have been rent.

We have had the wettest winter I ever saw in this country. The Coic has every-where overflowed its banks, and is just now much higher than it has been known to rise for many years.

LIII. *Remarks on the Bovey Coal: In a Letter to the Right Honourable George Earl of Macclesfield, President of the Royal Society.* By Jeremiah Milles, D. D. F. R. S.

My Lord,

Read Feb. 28,
1760.

THE description, which the learned professor Hollman has given the Society *, of two remarkable strata of fossil wood in Germany, one in the neighbourhood of Munden, in the duchy of Grubenhagen, and the other near Alendorf in Hesse, corresponds, in so many particulars, with some strata, discovered about fifteen years ago, in Devonshire, that it suggested to me a doubt, whether those German strata were really (what the learned professor supposes them) fossil wood, and formerly a vegetable substance, or (what he says the miners call them) fossil coal. The reasons, on which this doubt is founded, are submitted to the judgment of your Lordship, and the Society, in the following

* See the above, N^o xlix. p. 526.

account of the Devonshire fossil, which is commonly known by the name of the Bovey coal. It is found on a common surrounded with hills, called Bovey Heathfield, in the parish of South-Bovey, 13 miles south-west of Exeter, and 3 miles west of Chudleigh. The uppermost of these strata rises within a foot of the surface, under a sharp white sand, intermixed with an ash coloured clay, and underlies to the south about 20 inches in a fathom.

The perpendicular thickness of these strata, including the beds of clay, with which they are intermixed, is about 70 feet. There are about six of each, and they are found to continue eastward, in an uninterrupted course, to the village of Little-Bovey, a mile distant, and probably extend much further. The strata of coal near the surface are from 18 inches to 4 feet thick, and are separated by beds of a brownish clay, nearly of the same dimensions, but diminishing in thickness downwards, in proportion as the strata of coal grew larger; and both are observed to be of a more compact and solid substance in the lower beds. The lowermost stratum of coal is 16 feet thick; it lies on a bed of clay, under which is a sharp green sand, not unlike sea sand, 17 feet thick, and under that, a bed of hard close clay, into which they bored, but found no coal. From the sand arises a spring of clear blue water, which the miners call mundic water, and a moisture of the same kind trickling through the crevices of the coal tinges the outside of it with a blue cast.

Some small and narrow veins of coal are found intermixed with, and shooting through, the beds of clay, forming impressions like reeds and grass, and

very

very similar to those, which are generally found on the top of coal mines. The clay also (at least that part of it, which lies nearest to the coal) seems to partake of its nature, having somewhat of a laminous texture, and being in a small degree inflammable; and amongst this clay, but adhering to the veins of coal, are found lumps of a bright yellow loam, extremely light, and so saturated with petroleum, that they burn like sealing wax, emitting a very agreeable and aromatic scent.

Though the substance and quality of this coal, in its several strata, are much alike, and it is all indiscriminately used for the same purposes; yet there is some difference in the colour, form, and texture, of the several veins. The exterior parts, which lie nearest to the clay, have a greater mixture of earth, and are generally of a dark brown, or chocolate colour; some of them appear like a mass of coal and earth mixed; others have a laminous texture, but the laminæ run in such oblique, waving, and undulating forms, that they bear a strong resemblance to the roots of trees, of which kind I have seen some specimens from Lough Neagh in Ireland, which seem to be the same sort of fossil.

There are other veins of this coal, which lie more in the center of the strata, and abound most in the lowest and thickest bed, the substance of which is more compact and solid: these are as black, and almost as heavy, as pit coal; they do not so easily divide into laminæ, and seem to be more strongly impregnated with bitumen: these are distinguished by the name of stone coals, and the fire of them is more strong and lasting than that of other veins.

But

But the most remarkable and curious vein in these strata is that, which they call the wood coal, or board coal, from the resemblance which the pieces have to the grain of deal boards. It is sometimes of a chocolate colour, and sometimes of a shining black. The former sort seems to be less impregnated with bitumen, is not so solid and heavy as the latter, and has more the appearance of wood. It lies in strait and even veins, and is frequently dug in pieces of three or four feet long, and, with proper care, might be taken out of a much greater length. Other pieces of the same kind are found lying upon them, in all directions, but without the least intermixture of earth, or any other interstices, except some small crevices, by which the pieces are divided from each other, in all directions. When it is first dug, and moist, the thin pieces of it will bend like horn, but when dry, it loses its elasticity, and becomes short and crisp. At all times, it is easily to be separated into very thin laminæ, or splinters, especially if it lie any time exposed to the heat of the sun, which, like the fire, makes it crackle, separate, and fall to pieces. The texture of this fossil consists of a number of laminæ, or very thin plates, lying upon each other horizontally, in which small protuberancies sometimes appear, like the knots of trees; but, upon examination, they are only mineral nuclei, which occasion this interruption in the course of the laminæ; and pieces of spar have been sometimes found in the middle of this wood coal.

Though the texture of this coal is laminated, yet it does not appear to have any of those fibrous intersections, which are observed in the grain of all wood.

This

This coal easily breaks transversely, and the separated parts, instead of being rugged and uneven, are generally smooth and shining, in which even the course of the laminæ is hardly discernable.

They dig this coal in an open pit, together with the clay that is mixed with it; and though it lies very close and compact in its original bed, yet it is so easily separated, that they can afford to sell it for half a crown a ton at the pit. The smaller coal is separated from the clay by a skreen, or grated shovel; the larger, which rises sometimes in pieces of above an hundred weight, is piled up by hand. There is hardly any other use made of it at present, but to bake the earthen ware of a manufacture erected at South-Bovey, and for burning of limestone, which rising in great quantities at the neighbouring town of Chudleigh, the coal is carried thither, and they return with limestone to the pit; which they burn there, for the use of the northern parishes, to whom it lies more convenient than the kilns of Chudleigh.

The fire made by this coal is more or less strong and lasting, according to its different veins: those which lie nearest to the clay, having a greater mixture of earth, burn heavily, leaving a large quantity of brownish ashes; that, which they call the wood coal, is said to make as strong a fire as oaken billets, especially if it be set on edge, so that the fire, as it ascends, may insinuate itself between, and separate the laminæ. But that of the stone coal is accounted most strong and durable, being apparently more solid and heavy, and probably also more strongly impregnated with bitumen. One of the proprietors of this coal made an experiment of burning it in the fire-engines of Cornwall,

wall, to which it might have been transported, without much trouble or expence, being only four miles distant from the navigable river Teign; but the heat of the coal was not sufficiently intense, and the consumption of it too great, to answer the purpose. When this coal is put into the fire, it crackles, and separates into laminæ, as the cannel coal does into irregular pieces, burns for some time with a heavy flame, becomes red-hot, and gradually consumes to light white ashes. Though the transverse crevices made in it by the fire give it the external appearance of a wooden brand, yet, if quenched when red-hot, the unconsumed part does not look like charcoal, but seems to be almost as smooth and solid, as when first put into the fire.

The thick heavy smoak, which arises from this coal when burnt, is very foetid and disagreeable; entirely different from that aromatic scent of the bituminous loam, which is found adhering to it, but much resembling that of the asphaltum, or bitumen of the Dead Sea. The whole neighbourhood is infected with the stench, which is wafted by the wind to the distance of three or four miles. When burnt in a chimney (as it is sometimes in the neighbourhood), the offensiveness is lessened by the draught: however, it is found, by those, who live continually in the smoak of it, not to be unwholesome; nor is it in the least prejudicial to the eyes, like the smoak of wood. The most shining and solid pieces of this coal have not the least degree of electrical attraction.

Notwithstanding the resemblance, which this fossil bears to wood, especially when viewed in detached pieces, yet the following observations on its situation,

its form and properties, will prove it to be not of a vegetable, but of a mineral origin.

In the first place, there does not seem to be any imaginable cause in nature, which could bring together such a mass of fossil wood, as is found in this, and other strata of the like kind in different parts of Europe. It extends here to the depth of 70 feet: in that near Munden they have sunk 50 feet, without coming to the bottom. Fossil trees, though frequently found single, or in small numbers, are generally discovered in morasses and soft ground, where they have either buried themselves by their own weight, or been overwhelmed by some accidental cause: but the Bovey strata are found in a dry soil, intermixed with clay and sand, and, by their regular course and continuance, carry the most undoubted marks of never having been disturbed since their original formation. Fossil trees likewise preserve their form and size, their length and roundness, their branches and roots, their fibrous texture and strength, and are either found entire, or in such large pieces, that there is no room to doubt of their nature, since the very species of wood is frequently distinguishable in them; whereas the Bovey coal comes out only in flat pieces, of a few feet long, like the splinters of large masts; and on them we discover no signs of roots, branches, or bark, no round pieces, or concentric circles, which distinguish the annual growth of trees; the laminæ, which have the appearance of wood, being always horizontal, according to the situation of the pieces in the strata: or could we suppose a number of fossil trees to be brought together, and ranged in this regular manner in the several strata,

strata, yet, by the form and roundness of their trunks, they must be, in a great measure, encompassed by the soil, in which they are buried; whereas there is not the least mixture of earth, or any other aperture, in the Bovey strata of coal, except a few crevices, common to this sort of fossil, which divide the pieces from each other in all directions, and seem to be inconsistent with the nature and fibrous texture of wood.

If the basis or matrix of this fossil were wood, it would acquire, by being impregnated with bitumen, a greater degree of inflammability; whereas it neither kindles nor consumes so fast as wood.

The inflammability and laminated texture of this fossil, which have been the only reasons for supposing it of vegetable origin, may be accounted for from the nature of its principles, and their disposition, when united, to assume certain forms. The bituminous matter uniting with various kinds of earth, in certain proportions, will form an inflammable substance; and a similar mixture of these will generally assume a similar texture and form, as will appear from the accounts given us of this fossil both by the ancients and moderns, most of whom speak of it as a mineral substance.

Theophrastus * mentions “ a stone on the promontory of Erineas in Peloponesus, and another
“ in the mines of Binæ in Thrace, which being
“ burnt, emitted a bituminous odour; and another
“ stone in the mines of Scaptisulæ, not unlike to rotten

* De Lapidibus, p. 4.

“ wood, which would burn, if oil was poured on it,
 “ but would cease burning as soon as the oil was
 “ consumed.”

Dioscorides * observes of the lapis gagates, which is certainly a species of this fossil, “ that the sort, “ which kindles quickly, and gives a bituminous “ odour, is the best.” He describes it as generally of a black colour, and uneven substance, broad and flat, and very light. He mentions † also a black earth, found at Seleucia in Syria, called terra Ampe-litis, which resembled long pieces of fossil coal, splitting easily, of an uniform glossy superficies, which being pounded, and immersed in oil, immediately liquified.

Pliny ‡ describes the gagates as black, porous, and flat, not much unlike wood, brittle, of a disagreeable smell when rubbed, and emitting a sulphureous odour when burnt.

Galen || calls it “ a black stone, which, when put “ in the fire, sends forth a bituminous odour.” And he speaks of some other black stones, brought by him out of Cœlosyria, “ which were broad like a “ board, and, being put into the fire, burnt with a “ slender flame: they were generated in the hills on “ the east side of the Dead Sea, where the bitumen “ is produced, and the smell of the stone was like “ bitumen.” I cannot but observe on this passage, that the smell of the Bovey coal, when burnt, is the

* Lib. v. cap. 103.

† Lib. v. cap. 138.

‡ Hist. Nat. lib. xxxvi. cap. 19.

|| De Simplicium Medicamentorum Facultat. lib. ix. de Gagates.

fame with that of the asphaltum, and of a stone impregnated with it, which is found at a small distance from the Dead Sea.

Agricola * mentions these, and several other kinds of bituminous fossils, taken notice of by the antients, and points out several places in Europe where they are now found. Later writers describe it under the name of metallophyton, or lignum fossile; and most of them suppose it to be a mineral substance. Francisco Stelluti, in a treatise printed at Rome 1637, has accurately described some very curious strata of this kind, near Todi and Aqua Sparta in Umbria: he says, “ they consist of large oval and compressed pieces, “ lying horizontally, resembling the trunks of trees, “ but larger: he mentions one above 3 feet broad: “ they have neither roots, branches, nor fibres, but “ something like bark; and the heart of the tree, “ which in some is as hard as a bone, in others as “ black as a coal. The extremity of these pieces is “ as smooth, as if they had been divided by a saw. It “ is full of veins of a dark brown colour, which, in- “ stead of running strait like the fibres of wood, are “ undulated and irregular, taking a variety of forms, “ and are only superficial; for, upon taking off one “ of the thin laminæ, of which this fossil is com- “ posed, the veins underneath appear in a different “ direction. This fossil, when first taken out of the “ earth, bends like a bow; and when put into the “ fire consumes slowly, with a great smoak, and dis- “ agreeable smell; but, if burnt when dry, the smell “ is more pleasing. The heat is more intense than

* De Natura Fossilium, lib. iv. p. 596.

“ wood,

“ wood, and it does not consume so fast. Many of
 “ these pieces are sprinkled with marcasite, and there
 “ exudes from it a white bituminous substance, like
 “ rosin. It is full of crevices, in all directions, and the
 “ pieces appear in a variety of forms,” which the au-
 thor has exhibited, together with a representation of the
 veins of the fossil, in several copper-plates accompany-
 ing his work. He is clearly of opinion, “ that this
 “ substance is not generated from the seed or roots of
 “ any plant, but from a cretaceous earth transform-
 “ ing itself into wood, by the assistance of sulphu-
 “ reous water minerals, and subterraneous heat,
 “ which appears there in a thick smoky, and some-
 “ times in flames, particularly in rainy weather.”
 He forms his supposition on the different appear-
 ances of this fossil, “ some pieces of it being like
 “ chalk, others like wood, and again others like
 “ coal; some are either totally or partially petrified,
 “ being stone without and wood within, or *vice*
 “ *versa*.” But these various appearances may be
 easily accounted for, from the different kinds and
 proportions of earthy matter, with which the bitu-
 men is mixed.

Of the same kind are the fossil strata in Iceland,
 mentioned in the Musæum Wormianum, and by
 Horrebow, in his natural history of that island. The
 former of these authors * describes it as “ a laminated
 “ substance, generally of a black, but sometimes only
 “ of a dark colour, heavy, and, when dry, brittle;
 “ though the merchant, who gave the specimen,
 “ assured him, that when it was first dug out of the

* Lib. ii. cap. 16. p. 169.

“ earth

“ earth it would bend like a twig. It consists of
 “ oblique fibres, and here and there some knots
 “ like the roots of a great tree. A carpenter, who
 “ was a judge of wood, thought it to be the root
 “ of a walnut-tree grown black with age. It was
 “ not easily to be polished, too brittle to be used
 “ in cabinet work, and was full of crevices. This
 “ stratum is found some yards under the earth, in a
 “ mountain so high and perpendicular, that those
 “ only who have been accustomed to climb such
 “ precipices can venture to dig for it. There is not
 “ the least appearance, that trees ever grew where this
 “ fossil is found, notwithstanding this author sup-
 “ poses them to be roots of trees turned black, by a
 “ subterraneous vitriolic juice. The dust of this stra-
 “ tum is accounted, by the Icelanders, an excellent
 “ preservative of cloaths from moths and worms.”

Horrebow * says, “ it is an extraordinary sort of
 “ wood, which they call fortebrand, or black brand,
 “ very hard, heavy, and black like ebony. It is
 “ found deep in the ground, in broad, thin, and
 “ pretty large pannels, or leaves, fit for a moderate
 “ sized table. It is generally wavy, undulated; and
 “ is always found between the rocks, or great stones,
 “ wedged, as it were, close in.” He was doubtful,
 whether it were wood, or a petrification; but in-
 clined to the former opinion, because it could be
 planed and managed like wood.

The same sort of fossil, according to Wormius †,
 “ is found in the islands of Faro. It does not easily

* Page 33.

† Musæum Wormianum, p. 31. cap. 13. de Bitumine.

“ take

“ take fire, but has a splendor like gagates. It is
 “ found in the joints of the rock, and is taken out
 “ in laminæ, or splinters, of 3 or 4 inches thick.”

Of the like kind is the stratum of fossil wood near Thun in Swisserland, mentioned by Schentzer, in his *Itinera Alpina* *; which he describes as lying under several strata of flints, clay, and ash coloured marle. Being exposed to the air, parts of it grew hard, and others broke to pieces. “ It is (he says) “ observable of this fossil wood, that the trunks and “ branches are not round, but compressed; yet, in “ some places, cloathed with their bark, and here “ and there adorned with their leaves. The wood “ is inflammable, making a strong fire, and serves “ instead of fossil coals.” The author supposes the compression of this stratum to be owing to the great superincumbent weight; but others, he says, imagine it to be so formed by nature, from clay, in the bowels of the earth. I would observe here, that the crustaceous appearance, so common to these bituminous fossils, might easily be mistaken by this author for the bark of the tree, the same appearance being observed by Stelluti, in that of Umbria; but it is not so easy to account for the leaves, which certainly have no connection with a mineral substance.

John George Liebnecht, in his *Hassia subterranea*, quotes Pillingius's treatise on *bitumen* and *lignum fossile*, for the following description of a stratum of this latter kind. He says, that at Meisslibitz, in the duchy of Altenburg in Saxony, there is a mountain, with a gradual ascent and fertile summit, the

* Quarto, 1724. p. 604.

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outward stratum of which is vegetable earth, three feet deep; and under it a stratum of clay, two fathom thick; then a stratum of sand, made blackish by bituminous fumes: *subtus lignum putridum, flammam concipiens, pectines annuos referens, ita à naturâ natum, ut nec aqua aquæ, nec lac lacti similis, quam ligno huic minerali lignum vegetabile putridum.*

Our English naturalists have likewise described this fossil, as found in several parts of the kingdom, and always in or near strata of clay.

Dr. Plott, in his natural history of Oxfordshire *, observes, “ that the scarcity of firing in some parts
“ of that county has induced people to burn a sort
“ of black substance, of a grain somewhat like rotten
“ wood half burnt, partaking also of a mineral nature,
“ and therefore by authors called metallophyton, or lignum fossil. Put into water, it will not
“ swim; and into fire, it consumes but slowly, and
“ sends forth very unpleasant fumes. A vein of it
“ at Duchlington looked like wood; yet broken,
“ shewed a smooth and shining superficies, not unlike to stone pitch; and put into the fire, has not
“ near so ill a smell. As to the substance of lignum
“ fossil, it is thought to be a cretaceous earth, turned
“ to what it is by subterraneous heats; for that it was
“ never formerly wood, notwithstanding its specious
“ and outward likeness, is plain from its never being
“ found with roots or boughs, or any other signs of
“ wood.” And, in his history of Staffordshire, he quotes Scoochius’s opinion, “ that many of the
“ stumps and trunks of trees found in Holland, Zea-

* Page 65.

“ land, and Friezland, are of this mineral wood,
 “ chiefly because most of them are found without
 “ knots or roots.”

Dr. Morton, in his natural history of Northamp-
 tonshire *, mentions two or three varieties of this
 metallophyton; one of which he describes, as “ of
 “ a dark colour, and having a grain; for in one di-
 “ rection (which is usually according to the length
 “ of the pieces), it cleaves or parts pretty readily
 “ into plates and splinters, the other way it snaps
 “ into shorter pieces, and will not cleave at all.
 “ There is another sort, which does not so readily
 “ part into flakes. None of these are found in any
 “ large masses. They are all, more or less, of a
 “ glossy black, and have a density or smoothness within
 “ like that of bitumen, or jet. In that also, they
 “ resemble the true bitumen, or pissaphalton. They
 “ are not so firm and hard as the common coal, and
 “ are much brittler than canal or jet. They like-
 “ wise all of them agree pretty nearly in the same
 “ properties. In water they sink. They are all in-
 “ flammable, but consume slowly in the fire, and
 “ emit a somewhat unpleasant fume, not unlike that
 “ of bitumen, only fainter.”

Of the same kind is the inflammable slate, or coal,
 of Dorsetshire, found in the cliffs at the north-west
 corner of the isle of Portland, near the castle, of
 which I have received the following account from a
 gentleman of that county. The upper stratum is the
 natural black earth 14 feet deep; the next is a greyish,
 soft, paving stone, 6 inches thick; then follows the vein

of coal, of 10 inches; under which is a black earth, and at the bottom of the clift, clay. It rises in laminae, and is discovered in the outermost part of the clift, whence it is taken, by digging horizontally: some is black, and some of a redish colour; which latter is reputed the worst, and does not burn so well. The ashes of both are reckoned very good manure for clay ground. It is made use of to heat ovens; and when piled up as turff, gives a clear light, and yields a strong bituminous smell. It is found more to the west, at Chickerel and Fleet, in the sands, the shore being open.

The Kimendge coal, which, in all respects, resembles that before-mentioned, and is so called from the place where it is dug, appears in most of the cliffs of the isle of Purbeck, from St. Aldhelm's chapel to East-Lulworth, and at Osmington, opposite to that part of Portland where the coal is dug. It is found 16 feet below the top of the rock, in great lumps; but the stratum does not exceed 2 feet in thickness, nor extend far from the shore. It emits, when burnt, a strong sulphureous smell, and has a great many yellow strokes and spots on it, which seem to be marcasite. It is almost wholly used by the poor, in their ovens and chimneys, and is sold for nine pence *per* hogshead, or six shillings *per* ton. Under water, and in the cliffs, it is very hard; but when exposed to the air it shivers into pieces like slate.

At Kimendge are found small round pieces of this coal, from one to three inches in diameter, one side of which is flat, the other tapering, like the lower part of a cone. In some there is a square hole in

the center on the flat side; in most of them two, or sometimes four holes, near the edge, but they do not penetrate quite through the piece. They are sometimes found at the top of the cliffs, between two stones set on edge, and covered with a third, mingled with human bones. Sometimes they are found by themselves, but always in made ground. The common people call them coal money. I think it can scarce be doubted, that they are British antiquities.

To these, I shall add Dr. Hoffman's * account of a stratum of the same kind in Prussia, in the neighbourhood of Fischhausen, &c. where they dig for amber. "The upper stratum is sand, under it a
" bed of clay, and then a woody stratum, consisting
" of a substance like old wood, but inflammable;
" under this was a vitriolic mineral; and, lastly, a
" bed of sand, in which a great quantity of amber was
" found." There is a remarkable resemblance between the order of these strata, and those at Bovey; and though no amber has been discovered at the latter place, yet it would seem, as if there were some connection between that and these bituminous strata; for it is remarkable, that Theophrastus †, speaking of an earthy inflammable substance in Liguria of this kind, adds, that amber is found there.

The resemblance likewise, which the strata of Munden and Allendorf bear to those of Bovey, is remarkable, the soil in which they lie consisting of clays, boles, and sand. This is so much the case at Bovey, that they have large beds of a very fine pipe

* Observationes Physico-chemicales, lib. ii. obs. 23. p. 199.

† De Lapidibus, p. 4.

clay in the neighbourhood, which has for many years been exported to Liverpool, and manufactured there into earthen ware; but there is one now erected at Bovey. The depth of the strata is likewise much the same; for at Munden they have sunk 50 feet, without coming to the bottom. The pieces, that form these strata, seem to lie much in the same manner; they are compressed, without any intermixture of earth, full of cracks and fissures, and lying so close upon each other, that the professor says, "it could not be discovered, whether they were entire trees, or only parts of them," and when taken out, they easily fell to pieces. The German strata resemble those of Bovey in colour. That of Allendorf, which Dr. Hollman calls bitumen, and which he distinguishes from the fossil wood lying under it, is said to be little inferior in blackness, splendor, and hardness, to jet; and he adds, that the fossil wood approaches very nearly to the same colour. He observes, indeed, that the stratum of Allendorf is not so strongly impregnated with bitumen, and therefore left by the workmen for future ages; and, no doubt, some species of this fossil have so much earth, and so little bitumen, that they are not at all, or only in a small degree, inflammable. I shall only observe further, that the layer of stone, which divides the two strata in the quarry of Munden, is a strong objection to the notion of their being fossil wood, properly so called; and that the vein of the stratum at Allendorf, being taken in the adit of a mine, could not give an opportunity of examining the nature and disposition of its parts, with the same advantage, that we can view the strata at Bovey.

I shall

I shall conclude this paper with observing the several particulars, in which all the species of the bituminous fossils before-mentioned resemble each other. They seem to be generally found between beds of clay, or stone; are of a dark brown, or black colour, of a laminated texture: pliable when moist, and fresh dug, but crisp and brittle when dry; full of cracks, and easily breaking transversely; they all sink in water, and emit the same nauseous and bituminous smell; they differ in being more or less solid, heavy, and inflammable, according to the proportions and principles of which they consist; and if any doubt could remain of their being a mineral substance, it must be removed by the following analysis.

One pound of Bovey coal, of the woody kind, powdered, put into a glass retort, and distilled in sand, yielded four ounces and a half of phlegm, which had the appearance of common water, but somewhat of a bituminous smell and taste; near four ounces of a turbid whitish bituminous liquor, of an intolerable foetid smell, and extremely pungent to the tongue; about two drachms of a heavy bituminous matter, which would not mix with the liquor above-mentioned, but sunk entirely to the bottom, and (which is very remarkable) there was not the least appearance of any light oil floating on the bituminous liquor. There remained in the retort about seven ounces of a very black powder, which had the same bituminous smell, not very heavy; some of which being put on a red-hot iron, emitted a little smoak, but no flame.

The

The ashes of this fossil, when burnt, being boiled in water, and the water evaporated, there remained no salt behind.

I am, my Lord, &c.

Grosvenor-Street, Feb. 28, 1760.

LIV. *A new Method of computing the Sums of certain Series; by Mr. John Landen: Communicated by Mr. Thomas Simpson, F. R. S.*

Read Feb. 28,
1760.

AS the improving the analytic art, especially any branch of it that relates to the summation of series, may, by facilitating computations, conduce to the improvement of several branches of science; it is presumed, that this paper, which exhibits a new and easy method of computing the sums of a great number of infinite series, may be acceptable to the mathematical world, and deemed worthy to be inserted in the British Philosophical Transactions.

I.

Supposing x to be the sine of the circular arc z , whose radius is 1, $\frac{\dot{x}}{\sqrt{1-x^2}}$ will be $= \dot{z}$; and, consequently, $\frac{\dot{x}}{\sqrt{x^2-1}} = \frac{\dot{z}}{\sqrt{-1}}$. From whence, by taking the correct fluents, we have hyp. log.

$$\frac{x + \sqrt{x^2 - 1}}{\sqrt{-1}} = \frac{z}{\sqrt{-1}}.$$

Hence,