XXI.—*A Description of some supposed Meteorites found in Seams of Coal.* *By* Mr. E. W. Binney.

Read May 13, 1851.

The component parts of sedimentary rocks afford the geologist most valuable data in assisting him to arrive at an estimate of the forces which have been in operation on the earth's surface in very remote ages. Accordingly, we find that the earliest cultivators of geology paid considerable attention to the conglomerates, sandstones, and slates of the older deposits, as well as to the gravels, sands, and clays of more recent formations. In a paper read by the author before this Society on the 1st day of December, 1846, and printed at p. 148 of vol. viii. (new series) of the Society's *Transactions*, the mechanical deposits of the coal-measures of Lancashire were investigated at some length, for the purpose of attempting to measure the intensity of the currents of water which brought them to the places where they are now found. At p. 166 is the following extract: "As before stated, rough gritstones, containing rounded pebbles of quartz, abound in the lower coal field; whilst the middle and upper measures, reaching to a thickness of 4,472 feet, as far as I know, have never yet afforded a piece of mineral matter, in their sedimentary deposits, of the size of a small pea. In two *seams* of coal, namely, the Four Feet Mine at Patricroft, and another seam under the same mine at Pendleton, I have obtained rounded stones of several pounds in weight; but as both these specimens came from the neighbourhood of great faults, probably

they may have been brought to the places where they were found by other causes than currents of water. They, however, are interesting, and difficult to account for, being well rounded. Their composition is the same, though found in different seams and at different places, being of a hard crystalline quartz, more resembling gannister than any other stone in the carboniferous series. The outsides of both stones are well coated with a covering of coal, shewing that they must have lain long in the places where they were found."

Ever since the reading of the above paper, I have devoted considerable time and trouble in attempting to obtain evidence of more stones having been found in coal seams—of course, by stones I don't mean any of those aggregations of iron pyrites and ironstone which are so frequently met with in coal seams, but foreign masses of stone, which must have been introduced into the coal when it was in a soft state, and not precipitations from water, or segregations from the substance of the coal itself, where they had previously existed either in solution or admixture. All my enquiries, however, resulted in obtaining no proof of more specimens having been found in coal seams except the one next alluded to.* In the *Mining Journal* of the 9th day of November, 1850, appeared the following paragraph: "A large pebble of crystalline or primary limestone,† was found imbedded in the solid coal at the Rhydgaled Colliery, near Mold, on Monday the 4th instant. It is supposed to be

* Since this paper was read, the author has had an opportunity of asking W. E. Logan, Esq., F.R.S., director of the geological survey of Canada, a gentleman of as great practical acquaintance with coal fields as any geologist of the day, and one who has investigated coal-measures in nearly all parts of the world, if he ever, in his great experience, had met with rounded pebbles of stone in the middle of coal seams, and that gentleman declared that he had not met with a single instance—E. W. B.

† This stone, as will be seen by the analysis hereinafter given, is not a limestone, but nearly pure silica.

the first instance known of such a pebble having been found in the coal strata." This convinced me more than ever that such stones were of rare occurrence, especially as none of the readers of that journal, which has an extensive circulation amongst the practical coal-miners of Great Britain, stated in its pages that any such pebbles had come under their observation.

In answer to a letter addressed to Mr. Edward Jones, a gentleman who has the management of the Rhydgaled colliery, in March, 1851, the stone was liberally sent to me for examination, with a consent to analyse it, accompanied by the following letter:—"The stone was found by a person of the name of Edward Price, on the 4th November, 1850, whilst hewing the coal. It was imbedded in the upper part of the coal, within ten inches of the top of the seam, in a part of it called bone coal from its extreme hardness. The layers of coal that surrounded it were perfectly regular; so that, had the stone been immersed in a vessel containing metal in a fused state, and allowed to remain there until it was cooled, it could not have been more accurately fitted in its place. The seam in which it was found is called the main coal, and is the lowest that has been discovered in this neighbourhood. It is superior in quality to any other seam in the formation, and is the one most extensively worked here. Perhaps I should state, that the place where the stone was found was within twenty-five yards of a fault of considerable size."

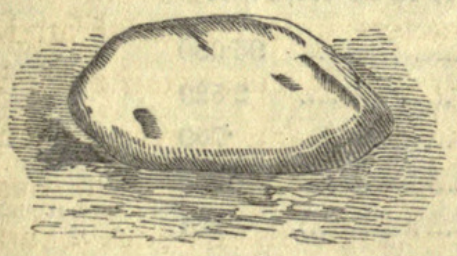
On comparing the Welsh stone with the two specimens of stones found in the Lancashire coal seams in my possession, their great resemblance in characters induced me to attribute them to a common origin, and to endeavour to find out what that origin was. My attention has therefore been directed to this enquiry; and, although considerable time has been spent in hunting after more specimens of stones found in coal seams, no further information has been obtained of

the occurrence of any. Descriptions will now be given of the stones in my possession.

THE PENDLETON SPECIMEN.

This was found by Mr. Andrew Ray, the intelligent manager of the colliery of the Pendleton Coal Company, in the year 1839, in sinking the new pit there. It was met with in the middle of the 6-feet seam of coal, at a depth of 245 yards from the surface. Mr. Ray, thinking it a great curiosity, brought it to me. At first I did not pay much attention to the specimen, thinking it was merely some boulder stone which had been squeezed into the coal from the great Irwell fault, which is not more than about 50 yards from the place where the specimen was found. On more careful examination, the external characters as well as the composition of the stone, however, soon led me to consider it unlike any stone that ever previously came under my notice. This specimen is composed of a crystalline quartzose stone of a light gray, with mottled marks of a black colour, and containing small crystals of sulphuret of iron dispersed through the body of the stone. Its outside is moderately smooth, with traces of slickenside, as if it had been subjected to considerable pressure. The colour is dark black, with a slight polish on the stone, and some portions of a substance like the pulverulent carbonaceous matter, so commonly found in coals adhering to it. The black coating is a remarkably thin one on the outside of the stone, without penetrating scarcely at all into it.

Fig. 1.



Its form (see fig. 1) is that of an irregularly compressed oval, having one of its ends a little pointed, 5 inches in length by $3\frac{1}{4}$ inches in breadth. It has a specific gravity of 2·58, and weighed about $2\frac{3}{4}$ lbs. avoirdu-

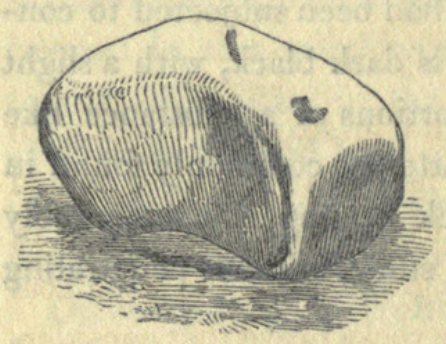
pois when whole. By the kindness of my friend, Dr. Robert Angus Smith, I am enabled to give an analysis of it, which is as follows:—

Silica	96·463
Alumina	2·578
Protoxide of Iron	·644
Lime	·161
	99·846

THE PATRICROFT STONE.

This was found by Mr. John Smith, in the colliery of Messrs. John Lancaster and Co., at Patricroft, near Manchester, in the 4-feet seam, at a depth of 440 yards from the surface, about the year 1845. It is composed of a crystalline quartzose stone of a darker gray than the specimen last described, and having very small black spots dispersed through its mass. The outside is partly smooth and partly irregular, of a shining black polish on the surface, but scarcely penetrating at all into the body of the stone. Marks of slickenside are seen on all parts of it, with several patches of sulphuret of iron.

Fig. 2.



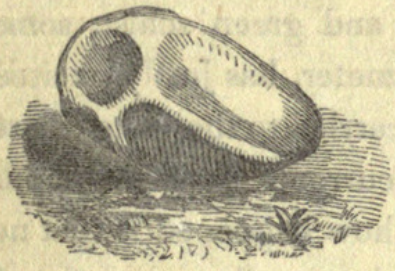
Its form (see fig. 2) is that of an irregular pyramid, having most of its angles rounded off. The greatest length is 7 inches, and the breadth 4 inches. It weighs 6½ lbs. avoirdupois, and has a specific gravity about 2·60. Dr. Smith's analysis of it is as follows:—

Silica	96·050
Alumina	2·529
Protoxide of Iron	·709
Lime	·525
Magnesia	·124
	99·937

THE RHYDGALED STONE.

This, as previously mentioned, was found in November, 1850, in the main seam of coal at Rhydgaled, near Mold. It is composed of a crystalline stone of a grayish-white, with some small streaks and spots of a black colour dispersed throughout the mass. The outside is generally smooth, but contains a few little holes on its surface. It is coated with a shining black polish, just like a thin varnish, without penetrating far into the body of the stone, as in the two last specimens. There are marks of slickenside on the outside, but not so strong as those on the specimen from Patricroft.

Fig. 3.



Its form (see fig. 3) is that of an irregular oval, with three of its sides and one end compressed. The greatest length is $5\frac{1}{4}$ inches by $2\frac{3}{4}$ inches in breadth. It weighs $1\frac{3}{4}$ lb. avoirdupois, and has a specific gravity of 2·60. Dr. Smith's analysis of it is as follows:—

Silica	99·182
Alumina	·649
Protoxide of Iron	·022
Lime	·016
	99·869

All the three stones were found in seams belonging to the middle division* of the coal field, the two first named in the higher, but the last named in the lower portion of it. Had they been found in the rough gritstones of the lower coal field, where most of the sandstone rocks prove that considerable currents of water had been in action; and that even some of the seams of coal, especially one known by the name of the Feather Edge Coal in Lancashire, are sometimes

* For the definition of this part of the coal field, see *Transactions of the British Association for the Advancement of Science*, vol. xii. p. 46; and Sturgeon's *Annals of Philosophical Discovery*, and *Monthly Reporter of the Progress of Practical Science*, vol. i. p. 126.

found to have been wholly or partially removed by the effects of running water, it would not have been very remarkable; but when these stones are found in the midst of the most tranquil deposits of the whole series, with no trace of a portion of rolled mineral matter of the size of a pea for thousands of feet in vertical height, their occurrence, in the places where they were found, is difficult to account for.

Sir Charles Lyell, at page 217 of the last edition of his *Elements of Geology*, in speaking of the pebbles in the chalk, states as follows:—"The general absence of sand and pebbles in the white chalk, has been already mentioned; but the occurrence here and there, in the east of England, of a few isolated pebbles of quartz and green schist, some of them two or three inches in diameter, has justly excited much wonder. If these had been carried to the spots where we now find them, by waves or currents from the lands once bordering the cretaceous sea, how happened it that no sand or mud was transported thither at the same time? We cannot conceive such rounded stones to have been drifted like erratic blocks by ice, for that would imply a cold climate in the cretaceous period,—a supposition inconsistent with the luxuriant growth of large-chambered univalves, numerous corals and many fish, and other fossils of tropical forms.

"Now, in Keeling's Island, one of those detached masses of coral which rise up in the wide Pacific, Captain Ross found a single fragment of greenstone, where every other particle of matter was calcareous; and Mr. Darwin concludes, that it must have come there entangled in the roots of a large tree. He reminds us that Chamisso, the distinguished naturalist who accompanied Kozebue, affirms that the inhabitants of the Radack archipelago, a group of lagoon islands in the midst of the Pacific, obtained stones for sharpening their instruments, by searching the roots of trees which are cast up on the beach.

"The only other mode of transport which suggests itself is seaweed. Dr. Beck informs me, that in Lym-Fiord in Jutland, the *Fucus vesiculosus*, often called Kelp, sometimes grows to the height of ten feet; and the branches rising from a single root form a cluster several feet in diameter. When the bladders are distended, the plant becomes so buoyant as to float up loose stones several inches in diameter, and these are thrown by the waves high up on the beach. The *Fucus giganteus* of Solander, so common in Terra del Fuego, is said by Captain Cook to attain the length of 360 feet, although the stem is not much thicker than a man's thumb. It is often met with floating at sea, with shells attached, several hundred miles from the spots where it grew. 'Some of these plants,' says Mr. Darwin, 'were found adhering to large loose stones in the inland channels of Terra del Fuego, during the voyage of the Beagle in 1834; and that so firmly, that the stones were drawn up from the bottom into the boat, although so heavy that they could scarcely be lifted in by one person.'"

No doubt there is a far greater abundance of fossil trees in the coal-measures than in the chalk; but still there is little evidence to show that it is at all probable that the stones found in coal seams had been carried to the places where they are now met with in the roots of trees, any more than that the trees themselves were drifted. Doubtless a Sigillaria, having immense stigmariæ roots, with radicles radiating from them in all directions to a great length, would be as likely a root as could be desired for the purpose of conveying a stone. But where and how is the Sigillaria to get loaded with its burden? This is a difficult question to answer. The plant, of which this remarkable fossil is the root, must have grown beyond all question in soft mud, and not on a rocky bottom; and, even if it had grown in the latter position, coal seams, in Lancashire at least, as I have shown in a paper printed in the last

volume of the *Transactions* of this Society, bear no evidence of the vegetables composing them having been drifted, but, on the contrary, show that they were grown where they are now found, the seam of coal being simply a mass of altered vegetable matter, lying upon a bed of tree roots, and having stems of similar trees resting upon it. A seam of coal like those in which the stones were found, bears no more evidence of a current of water than an ordinary peat bog does, and a rolled stone is just as likely to be found in the middle of the one as in the other, if we admit that the vegetable matter now constituting coal, grew on the spot where it is found. In the bog, over which the Liverpool and Manchester Railway now passes, known by the name of Chat Moss, are some pits containing water called ringing holes. The people residing near the moss have a tradition, that if any one can find a stone on the bog which has not been brought from a distance, and throws it into the holes, it will ring like a church bell. But this interesting experiment has not yet been tried, from the simple reason that no one, up to this time, has yet been able to discover such a stone!

If, therefore, it is difficult to account for the occurrence of the stones, previously described in this paper as found in seams of coal, being conveyed to the places where they were met with by the action of running water, we must look to some other cause for their origin.

The shape of the stones is not such as we should expect to have been precipitated from solution in the water in which the vegetable matter was immersed, like the flints in chalk. Nor does their size allow of any probability of their being secreted from the sap of plants, like the crystals of silica, which are sometimes met with in the sugar-cane and some other plants. The trees of the carboniferous series have, without doubt, been of a most extraordinary character when compared with those at present existing; but still we cannot

for a moment imagine even that they were capable of producing in their insides stones similar to those described in this paper.

Now, in my humble opinion, there is another cause to which we can attribute the position of the stones in the seams of coal in which they were, without doubt, found, by supposing that they are meteorites which fell from the atmosphere, and became imbedded in the coal when it was in a soft state, and before it was covered by the overlying roof.

Up to this time, few meteorites have been found in the strata composing the crust of the earth. In note 83 of Lieutenant-Colonel Sabine's translation of Baron Humboldt's *Cosmos*, is the following passage:—"Olbers acutely observes, that it is a remarkable circumstance, not hitherto noticed, that no fossil meteoric stones have as yet been found, like fossil shells, in secondary and tertiary formations. Are we to infer that, previous to the last and present arrangement of the surface of our planet, no meteoric stones had fallen upon it; although, according to Schreibers, it is probable that 600 falls of aerolites now take place in each year?—(Olbers in *Schum. Jahrb.*, 1838, S. 329.) Problematical nickeliferous masses of native iron have been found in Northern Asia, at a depth of 31 French feet, and recently among the Carpathian mountains; both these masses are very like meteoric stones."

Sir Charles Lyell, in the third edition of his *Manual of Elementary Geology*, at page 145, alludes to the first-named mass of native iron above mentioned, and as having been found in the alluvium at Petropawlowsker in the Mrassker circle with more confidence. He, however, states that no sufficient data are supplied to enable us to determine whether it be of post-pliocene or newer pliocene date. He further adds—"We ought not, I think, to feel surprise that we have not hitherto succeeded in detecting signs of

such aerolites in older rocks; for, besides their rarity in our own days, those which fell into the sea (and it is with marine strata that geologists have usually to deal), being chiefly composed of native iron, would rapidly enter into new chemical combinations, the water and mud being charged with chloride of sodium and other acids. We find that anchors, cannon, and other cast-iron implements, which have been buried for a few hundred years off our English coast, have decomposed in part or entirely, turning the sand and gravel which enclosed them into a conglomerate, cemented together by oxide of iron. In like manner meteoric iron, although its rusting would be somewhat checked by the alloy of nickel, could scarcely ever fail to decompose in the course of thousands of years, becoming oxide, sulphuret, or carbonate of iron, and its origin being then no longer distinguishable. The greater the antiquity of the rocks—the oftener they have been heated and cooled, permeated by gases or by the waters of the sea, the atmosphere or mineral springs—the smaller must be the chance of meeting with a mass of native iron unaltered; but the preservation of the ancient meteorite of the Altai, and the presence of nickel in these curious bodies, renders the recognition of them in deposits of remote periods less hopeless than we might have anticipated."

In the translation of Humboldt's *Cosmos*, before cited, at page 118 of Vol. I. is the following passage, which, as it contains valuable information on the subject before us, will be given at length :—"The solid masses which reach the earth—whether they have been seen to fall at night from balls of fire, or in the daytime from a small dark cloud, usually in a clear sky, and with a loud noise—though considerably heated, are not incandescent. They exhibit, on the whole, a general unmistakeable resemblance to one another in their external form, in the nature of their crust, and in the chemical composition of their principal constitu-

ents; and this resemblance is traceable, when and wherever they have been collected, at all periods of time, and in all parts of the earth. But this remarkable and early recognised similarity of general character in solid meteoric masses, suffers many exceptions in detail. How different are the very malleable masses of iron from Hradschina, in the district of Agram; or those from the banks of Sisim, in the Jeniseisk government, mentioned by Pallas; or those which I brought from Mexico—all of which contain 96 per cent. of iron—from the aerolite of Sienna, which hardly contains 2 per cent. of iron; from the earthy meteoric stone of Alais, in the Department du Gard, which falls to pieces when immersed in water; and from those of Jonzac and Juvenas, which are without any metallic iron, and are composed of various crystalline ingredients? These diversities have led to the division of the cosmical masses under consideration into two classes—nickeliferous meteoric iron, and fine or close-grained meteoric stones. The crust of these masses, which is only a few tenths of a line in thickness, is very characteristic; it has often a pitchy lustre,* and is sometimes veined. The only instance which I know of the absence of this crust, is in the meteoric stone of Chantonnay in La Vendee, which is marked by another circumstance equally rare, viz., the presence of pores and vesicular cavities, like the meteoric stone of Juvenas. The separation of the black crust from the light grey mass beneath, is always as sharply defined as in that of the dark leaden-coloured crust of the white granite blocks which I brought from the cataracts of Orinoco, and which are also found by the side of many cataracts in other parts of the world, as those of the Nile and the Congo. The greatest heat of our porcelain furnaces can produce nothing similar to the crust of the aero-

* Pliny has remarked the peculiar colour of the crust of aerolites "colore adusto" (11, 56 and 58). The expression "lateribus pluisse" also refers to the burnt appearance of the exterior.

lites, so distinctly and sharply separated from the unaltered mass beneath. Appearances which might seem to indicate a softening of the fragments, have been occasionally recognised; but, in general, the condition of the greater part of the mass—the absence of any flattening from the effects of the fall—and the moderate degree of heat perceived on touching the newly-fallen aerolite—are far from indicating a state of internal fusion during its rapid passage from the limits of the atmosphere of the earth."

The chemical composition of the three stones previously described in this communication, undoubtedly shows less iron than exists in the majority of meteoric stones hitherto examined. The composition of the Waterloo stone, found in Seneca county, New York, and described by Professor Shepard in his Report on Meteorites, at page 40, No. 31, Vol. XI. of *Silliman's Journal*, has some analogy in its composition and specific gravity to the stones now under consideration. The analysis of this stone gave,

Silica	78·80
Peroxide of iron	8·72
Alumina	6·28
Moisture	4·75
Lime and magnesia, and loss	1·45
	100·00

Specific gravity 2·30.—The Waterville and Concord stones, also described by Professor Shepard at pp. 414 and 416 of No. 18 of Vol. VI. of *Silliman's Journal*, contain no iron, but a large quantity of magnesia. According to Dr. Shepard, the first five chemical elements thus far known to exist in meteoric masses, in the supposed order of their prevalence, are as follows:—Iron, nickel, magnesium, oxygen, and silicon, p. 386, Vol. II. No. 6 (second series), of *Silliman's Journal*. For a long time scarcely any meteorites were recognised as such, which did not contain a large amount of metallic iron; but, now attention has been directed to

these bodies, many without iron will doubtless be met with. So there is nothing in the composition of the stones described in this paper to prevent them from being considered as meteoric, even supposing that such bodies which fell to the earth in so remote an age as the carboniferous strata, were exactly similar in their nature to those which visit the earth at the present time—a supposition not very probable.

Scarcely any of the strata of the earth, in England at least, have been so thoroughly explored as the valuable seams of coal, which have contributed so largely to our national resources; and therefore it is in those strata that we should certainly look with the greatest probability for finding ancient meteoric stones. Also, as Sir Charles Lyell has observed in the preceding quotation, in his remarks on fossil meteorites, it is not the masses of iron which fell in the waters of the ancient globe that we should expect to find preserved in the strata, but rather such stones as we have previously described, consisting nearly altogether of silica, and, therefore, capable of resisting the decomposing agents, which metallic iron, and many other bodies, would be nearly incapable of enduring. The rare occurrence of such bodies as the stones before described in seams of coal, may, with propriety, be adduced in attributing them to some extraordinary cause rather than the effects of currents of water, and their transport by the roots and branches of trees.

The shape of the three specimens, the specific gravities and chemical composition, do not prove much either for or against their being considered as meteorites; for if the seams of coal in which they were found had been formed of drifted trees, as was formerly the favourite hypothesis for accounting for the origin of coal, the stones might be taken for travelled pieces of quartzose stone, equally with the drifted vegetables; but each of the seams in which they occurred (and they were found in the middle of the beds), is placed on

a floor full of stigmariæ roots, thus affording conclusive proof that the plants of which the seams were formed grew upon the spots where they are now found.

The crust of the specimens, consisting of only a few tenths of a line in thickness, of a shining black lustre, and so sharply defined from the light gray mass of the stone beneath, is the strongest evidence of their being meteorites. This is the peculiar character of meteorites, so forcibly alluded to by Humboldt in the quotation previously given. The black colour of the stones might certainly have been derived from the decomposing vegetable matter in which they have been so long enveloped; but it is very remarkable that the colouring matter should have penetrated so slightly into the body of the stone. An ordinary pebble of quartz, after only a few years' immersion in black mud, composed of decaying vegetable matter, would be much more discoloured in depth than the specimens in question, which have lain for countless ages; and the present slight coating of the latter can only be attributed to their outsides having been subjected to the action of great heat, and thus so vitrified as to prevent the colouring matter from entering into the body of the stones before they came amongst the vegetable matter now forming coal.

Nothing is more difficult than to establish, without question, the meteoric character of a stone. For ages doubts were thrown even on those specimens which were seen to fall from the heavens, and were actually found in a hot state. With fossil meteorites still greater difficulties occur; and the specimens described in this paper can only be considered as such bodies, by their resemblance in their characters to recent meteorites, and by their being found in a position where it is more probable to suppose they came through the atmosphere, than by currents of water, or any other ordinary cause.