The Chairman then called upon Mr. W. S. Ward to read a Paper

ON THE GEOLOGY OF THE ESK VALLEY. BY JOHN WATSON, ESQ., OF WHITBY.

This paper is illustrated by a section laid down from actual measurement, of 554 feet in thickness, taken in the Esk valley, near Whitby, Yorkshire, (see page 100.) The section, geologically speaking, comprises part of the lower Oolite, the upper and part of the lower Lias. I will remark on such as are of most value.

2.—The freestone is very valuable, generally speaking, on account of its texture, colour, and large sized blocks; and has been extensively worked for upwards of 50 years, and sent from Whitby, by shipping, for the construction of piers, breakwaters, &c., in nearly all parts of the United Kingdom.

9. Oolitic Ironstone.—This seam of ironstone is very valuable for smelting purposes, but varies very much both in quantity and quality; in some places showing a thickness of 20 and even 30 feet, containing only from 15 to 20 per cent. of iron, and a large proportion of silica; and in other places, from 5 to 12 feet in thickness, containing from 30 to 40 per cent. of pure iron, with only a moderate percentage of silica. This seam of ironstone has only been known and worked for about eight years. It is, however, now worked very extensively, and sold to the iron smelters, principally in Newcastle, for the purpose of mixture with...
the argillaceous ores of the lias. Its principal advantage is
on account of its being more easily fluxed in the furnace.

10. Upper Lias.—Consisting of aluminous shale, cement
stone, ironstone, nodules, &c. From this shale the Whitby
alum has been made for centuries. The upper part is used
for this purpose on account of its containing a greater per­
centage of sulphate of alumina and magnesia, and being
more free from iron, which is injurious to the process. The
Mulgrave Alum Works, which have been so long carried on,
are the largest on the coast, and are situated at Sandsend and
Kettleness, three and six miles north of Whitby. They
manufacture, when in full operation, at these two works
about 150 tons of alum, and 120 tons of rough sulphate
of magnesia (Epsom salts), monthly. I will endeavour to
give a short description of the process, which runs as follows,
viz. :—First, the shale is worked and broken up into pieces,
say fourteen pounds weight, run into heaps containing many
thousand tons, always having refuse wood, faggots, &c.,
placed at the bottom of the heap, and in a proper position for
burning the same. When the fuel is fired, there is sufficient
bituminous and sulphurous matter in the rock to calcine it.
The calcined mine is then lixiviated with water in large pits.
The liquors are then taken and evaporated down to a certain
specific gravity, and an alkali added, generally sulphate of
ammonia,—then run into large vats or coolers, and allowed
to stand six days to crystallize the alum. The crystals are
then taken out, washed, then dissolved again in water, and
run into large casks to re-crystallize; after that broken into
large lumps, or ground according to the requirements of the
markets. It must be remembered that the sulphate of mag­
nesia is held in solution during the crystallization of the alum,
and evaporated again to a higher specific gravity, then run
into vats and crystallized in the same way as the alum.
In working the alum shale, large quantities of cement and
ironstone nodules are found, from which is made the far-
famed Mulgrave cement. There are also a quantity of
fossils found in working this shale, chiefly ammonites, but
some excellent specimens of the higher vertebrated forms of
life have been met with. In the Kettleness Alum Works
some years ago, almost in the same place, two large specimens
were taken out in a very perfect state: an Ichthyosaurus
and a Plesiosaurus, measuring from 20 to 30 feet each in
length. Many other of those immense saurians in an
imperfect state have been extracted; they are found at a
depth of about 65 feet below the surface of the alum rock.

11. Hard Jet Rock.—This bed of shale is much stronger
and of a more bituminous and sulphurous nature than the
aluminous shale; it is always indicated by a nodulous band
of inferior limestone, locally known as the top jet dogger.
The usual mode of getting the jet is by taking the front of
the cliff away where the line projects, until a seam is found,
then followed by mining until it runs out. The seams vary
very much both in length and thickness, in some places only
a few inches broad, and not more than a quarter of an inch
in thickness, extending only a few feet; in other cases, from
eight to fourteen inches broad, and from one to two inches
and a half in thickness, extending as far as thirty yards.
I have frequently observed when the workmen are taking
the jet out, the centre of the seam was the thickest, thinning
towards each edge. The jet from this line is superior to any
other, in consequence of its being easier to work, much
lighter, and susceptible of a higher polish. Its present
price in the market is from 5s. to 15s. per lb. The manu-
facture of jet ornaments appears to have been known in
Whitby since about 1589; however, after that time it had
gradually declined, for in 1810 there was no consumption of jet
in the town. I know individuals who have told me when they
were employed on the beach collecting and burning sea-weed
to make into kelp (formerly used as an alkali in the manufacture of alum) that they frequently collected and brought a bag of jet home to burn, there were such quantities at that time on the beach, undoubtedly produced by the washing away of the cliffs for centuries. Those individuals affirm that no coals are equal to it for making a good fire. The origin of jet is held as a matter of doubt, but the prevailing opinion is that it is of vegetable origin—fossil wood in a high state of bituminization, and I have no doubt but this is correct. I have observed in Kettleness Alum Works pieces of lignite, weighing two to three hundred weight, completely encrusted with jet, about half an inch in thickness; but, on becoming exposed to the air a few months, the jet falls off, leaving the lignite perfectly clean, and in a high state of preservation. Although I have never observed the real hard jet of the lias having a ligneous structure in the strata where it is found, nor have I observed any lignite encrusted near so low down as the jet lines; but the fact of having found lignite encrusted with jet (and even jet in a soft state, as if forming) in working the alum shale 90 to 100 feet above the jet lines, has led me to the conclusion that those jet seams lower down are nothing more than the lignite found above, dissolved and reformed by the agency of the more powerful sulphurous and bituminous gases of the jet shale. The chemical composition of the lias shale varies considerably, the top part containing a large percentage of alumina and magnesia; but as you go deeper in the lias those ingredients decrease, and the shale becomes so highly impregnated with sulphur and bitumen, that by the time you arrive at the jet shale, such is the percentage of those ingredients, it is not at all uncommon after wet weather that this shale will ignite spontaneously and burn for months. The manufacture of jet ornaments must, in some measure, be regarded as the staple trade of Whitby at
present; although it will not probably long remain so, as
the immense formation of iron ores is now being fast
developed, and smelting works in the course of erection.
The amount of money turned over in jet at Whitby is
over £20,000 annually. The population is about 14,000,—
800 to 1,000 of whom are employed in the manufacture
of jet ornaments.

13 and 17. *Pecten* and *Avicula Ironstone.*—Those two
important measures of argillaceous or clay band ironstone,
together nine to ten feet in thickness, are of excellent quality,
and have been extensively worked for upwards of 20 years, and
sent to the Tyne for smelting. Now that we have got direct
Railway communication to the Durham Coke Fields, and an
immense limestone formation close at hand, preparations are
making on a large scale to convert the ores into iron on
the place where risen; and the day is not far distant when
this locality will rival, if not excel, the Cleveland district
—this district having the advantage of a variety of ores for
mixing, so essential to the production of good iron.

From calculations made by practical men, (iron masters),
good pig iron can be produced for from 45s. to 47s. per ton
in the Esk valley. Those measures of ironstone, geologically,
are the same as the Cleveland ores, although the latter is in
one seam, and partaking more of our Oolitic seams. However,
they can be traced along the Cliff from one place to the
other, shewing distinctly where the seams begin to separate at
Kettneness Beach. The difference in appearance is probably
from our stone laying at a greater depth, and subject to a
greater pressure. I observe that S. H. Blackwell, Esq., in
his little work on the Iron Making Resources of the United
Kingdom, represents the Cleveland seam as the Oolitic or
Northampton ore, and refers to Eston mines, and the
Whitby, under the class of argillaceous ironstone of the
lias. But in this Mr. Blackwell is not correct, for they are
one and the same seams, geologically speaking, with the
hard jet lines, running with the same regularity above the Cleveland seam as those, and worked to a considerable extent.

Professor R. Hunt, F.R.S., of London, next rose to read a Paper, entitled "A short notice of the Recent Discovery of a Deposit of Iron Ore in Lincolnshire." He said that before he commenced to read his paper, he would make a few remarks on the view set forth in the preceding paper respecting the origin of jet. He did not think the direct conversion of lignite into jet was made out. He was disposed to believe that the vegetable matter from which jet may have been derived, was first converted into a sort of fluid bitumen, which was eventually consolidated into jet. In fact there was evidence of this in the museum at Whitby, in examples of ammonites having bituminous matter still fluid in their cells. Something analogous to the process he had indicated was now taking place in the bituminous lake in the island of Trinidad.

The Chairman asked if amber might be regarded in the same light?

Mr. Hunt replied that it was a matter for inquiry, but he believed not.

Mr. O'Callaghan said that he had resided in Trinidad, and with regard to the bituminous lake, he might say that it was a volcano, in a state of constant ebullition, and not a vegetable asphalt lake.

Mr. Hunt replied that the immense quantities of vegetable matter which were brought down to the sea by the great rivers of South America, might possibly re-appear in the shape of bitumen in this lake.

Mr. O'Callaghan said that the Orinoco, which was the river alluded to, brought down great quantities of mud, though not of timber, and even if it did bring timber it would be intercepted before it reached Trinidad.