

broad ear perforated. In front of the face were a long, narrow flint knife, carefully and minutely flaked, and a long and round scraper of flint. In this and the preceding barrow it will be observed that the primary interment had not, as is usual, been made in a grave, but placed on the original surface.

The last barrow opened was on Flotmanby Wold, and was seventy feet in diameter, 4 feet high, and made of earth with some flints. It was found to have been opened already at the centre, and from information gathered from the shepherd, a "pankin" had been found. At a distance of 4 feet from the centre, and  $2\frac{1}{2}$  feet above the surface level was an urn of the cinerary type, ornamented over the upper part with a diamond shaped pattern, made by the impression of a twisted thong. No bones, either burnt or unburnt, were found in association with it. In the material of this barrow there were a large number of flakes and chippings of flint, three cores, four scrapers, and two stones which had been used for pounding. With the opening of this barrow, Canon Greenwell brought his labours to a close, leaving several in the immediate neighbourhood to be opened on some future occasion. The total result of his "openings" this autumn has been exceedingly satisfactory, and it is the Canon's intention to forward the whole of the interesting articles herein described to the British Museum, thereby adding to the already large collection contributed by him to that institution during recent years.

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ON THE OCCURRENCE OF A BOULDER OF GRANITOID GNEISS OR  
GNEISSOID GRANITE IN THE HALIFAX HARD BED COAL.

BY JAMES SPENCER.

From time to time during the last thirty years, boulders of quartzite and other hard rocks, having quite a distinct structure from that of any native rock of the district in which they occur, have been found in the coal beds. Many years ago, before the great importance of these boulders from coal beds was recognized, a fine specimen was found in the Hard Bed Coal at Dam Head Pit, in Shibden-dale, near Halifax. At that time having no means of submitting it to

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microscopic analysis, the most notable feature about it was its spherical and highly polished form. It was a hard white rock streaked with patches of darker hue, and of about the size of an orange; it had evidently been subjected to a great deal of attrition.

About the same time, my friend, Mr. George Lister, had a fine quartzite boulder brought to him which was found in the Low Moor (near Bradford) Better Bed Coal. It was about the size of an ordinary football, and he informs me that the boulders in this locality were not very rare.

Since that time boulders of quartzite and other rocks have been found in coal beds in various places in the Midland Coal-fields, and also in Lancashire and Derbyshire, some of which were described by Professor Bonney in his presidential address to the Geological Section of the British Association at Birmingham in 1886. In the spring of last year two or three quartzite boulders were recorded by Mr. C. Brownridge, F.G.S., from the Black Bed Coal at Leeds. Two of these were subsequently sent to the writer to cut and mount sections for examination under the microscope, and a thin slice of each specimen was sent by Mr. Brownridge to Professor Bonney for examination, and have already been described.\*

In the spring of the present year, 1888, I was very fortunate in obtaining from Shibden Head Pit, near Halifax, a boulder of a most interesting character, which had recently been found in the Hard Bed Coal. The specimen is of a greyish colour, about four inches in length, by about two and a half square. The angles have been worn off, and the faces polished and striated transversely. The striæ are most probably due to slickensiding in the coal rather than to glaciation. After preparing thin slices for examination under the microscope, it was evident that the specimen presented a different structure from either of those recorded from the Black Bed Coal at Leeds. Upon receipt of a section of this boulder, Professor Bonney replied as follows :—"The boulder is one of unusual interest. It is not a quartzite but a granitoid gneiss or gneissoid granite, probably derived from some mass of pre-Cambrian age." "The specimen practically " consists of two minerals, quartz and felspar. The former occurs in

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\*Proc. of the Yorkshire Geological and Polytechnic Society, vol. IX., p. 405.

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“grains of irregular outline, sometimes associated, and often joined, as it were sewn together, by microcrystalline quartz, which also occasionally extends into small patches. Numerous small inclosures give it a dusty look; many are empty cavities; some contain fluid. The felspar also occurs in grains of roundish to rather irregular outline also often associated. It is much decomposed, but some is probably orthoclase, and microcline can be distinctly recognized. Parts occasionally are blackened by clustered granules. Without destroying the slide I cannot say whether these are iron oxide or some carbonaceous material which has infiltrated. As its presence has no important significance I have thought it needless to ascertain its precise nature, but believe it probably of secondary origin. Rather roundish grains of quartz are occasionally included in the felspar, as is common in old granitoid gneisses. I note a very little flaky viridite. It is possible that the gneissoid structure is due to mechanical deformation of a granite, but if so, reconsolidation has been complete. The structure, in short, recalls a type of rock which is exceedingly common among gneissoid rocks, which are universally admitted to be much older than any part of the Cambrian, and which is, so far as my experience goes, exceedingly rare, if not altogether wanting in any rock of Palæozoic or later date.”

Considering the great interest attached to the discovery and examination of these boulders from coal seams, it may be important to point out some of the conditions attending the deposition of the strata enclosing the coal seam in which they occur, and also the general character of the strata, and the direction from whence they appear to have come. Dr. Sorby has well shown, by data derived from microscopic examination of the sandstones and grits of the lower part of the Coal Measures, that these rocks are composed of materials which were most probably derived from Scandinavia; and this conclusion is supported by the general trend of these strata, which is from north-east to south-west. The Coal Measures were deposited in a slowly sinking area, with occasional pauses or even slight elevations of the land above the sea level. The strata enclosing the Hard Bed Coal furnishes one of the most striking examples of these mutations of land and sea. A short distance below this coal

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there are three separate layers, chiefly composed of Anthracosia, indicating marine or estuarine deposits, while the Hard Bed Coal has been fully demonstrated by microscopic examination of the admirably preserved plants which occur in it, to be a land deposit. Immediately overlying the coal a bed of marine shells, *Aviculopecten papyraceus*, occurs, followed by some yards of strata containing *Goniatites Listeri*, and other marine shells. Here then we have evidence of great changes of level indicated in these strata, during which the currents bringing deposits may have varied considerably. But there may have been other changes of level having important bearings upon the formation of coal and other matters in connection with the deposition of strata, which have either left no traces behind or they are so obscure as to have hitherto escaped observation.

The boulder of Gneissoid Granite for instance, now under notice, was found in the midst of coal which was not disturbed, or in any way differently disposed from the rest of the coal bed. This may indicate a slight depression of the area so as to bring it within the influence of the tides, or the area may have been near a large estuary which was subject to occasional floods, during which the boulder may have been brought down on floating masses of vegetable matter, or entangled in the roots of a tree and deposited in the submerged area. That the area now occupied by the Hard Bed Coal was occasionally subject to incursions of the sea, or at least overwhelmed by water containing Carbonate of Lime in solution, is proved by the abundance of calcareous balls, containing coal-plants, found in the midst of the coal. It has been suggested that these far-travelled boulders, found in coal, may have been brought by icebergs, but this idea does not seem to be supported by the facts. So far as I could gather, and I happened to be on the pit-bank when the one under notice was brought out of the pit, this boulder was not accompanied by any other detritus such as sand or clay or smaller pebbles, which might reasonably have been expected had ice been the carrying agent; and such is the case I am informed wherever the boulders are met with in coal beds. It seems to me, therefore, more reasonable to attribute their transportation to drifting and tangled masses of vegetable matter rather than to ice.

It may be of interest to note the exact locality in which the boulder was found. It came from under the north side of a hill called Barehead, in Shibden-dale, about two miles north of Halifax. The round whitish boulder above-mentioned came from under the south side of the same hill, at a distance of about half a mile from the place where the present one was found. The Hard Bed at Shibden Head Pit is found at a depth of 450 feet from the surface, the geological horizon of that coal being about 200 feet above the Rough Rock, the uppermost member of the Millstone Grit series. In conclusion it may be useful to note that about 600 feet of strata, including the Northowram and Elland Flag Rock, intervene between the Hard Bed and the Better Bed Coals, while the Black Bed Coal lies 120 feet above the Better Bed Coal. The materials forming these strata appear to have come from the north-west. A knowledge of this, along with that of the structure of the boulders, may help to form some idea of the locality of the parent rock from whence the boulders were derived.

Professor Bonney detected a resemblance between the rounded grains in the quartzite from the Black Bed Coal and those in a specimen of quartzite from the Lickey Hills and from the Charnwood series, he, however, very guardedly remarked, "Of course I do not mean to suggest that we must look in this direction for the parent rock." If we may judge from the direction in which the materials forming the Millstone Grits, and the Lower Coal Measure Grits and Sandstones have come, it is not improbable that the Gneissoid granite under notice may have come from some pre-Cambrian rocks connected with, or Scottish outlier of, the Scandinavian mountains.

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