IV.—ON SOME POINTS CONNECTED WITH THE DRIFT OF DERBYSHIRE AND YORKSHIRE.

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IN a paper of mine on "The Glacial Phenomena of the Yorkshire Uplands," read before the Geological Society of London in the spring of 1872,¹ I compared the valley of the Wye in Derbyshire to those of the Aire and Calder in Yorkshire. This was a mistake: the Wye rises on the west side of the geological axis and crosses the anticlinal; but its valley does not cross the physical axis, which is nowhere broken through, as in the cases of the Aire and Calder. The lowest part of the watershed at the head of the Wye basin is at Doveholes, near Chapel-en-le-Frith. I made some observations by aneroid to ascertain the height of this point. The watershed south of Doveholes was by aneroid 1300 feet above the sea, and that north of Doveholes 1250 feet; but as the glass was falling on the day of my visit, these heights are too great by somewhat less than 75 feet, the total amount of the fall. This will make them between 1225 and 1300, and between 1175 and 1250 feet respectively. On another occasion I estimated the height of the watershed north of Doveholes at 1200 feet, and that on the Peak Forest Railway at 1175 feet. A couple of miles to the N.N.E. I found Sparrow Pit to be 1350 feet above the sea, and Perrydale 1200; the plateau above Perrydale 1350; the watershed under Mam Tor 1500; and the lowest point of Rushup Edge 1525 feet above the sea.

We may say then that the lowest part of the watershed north of Buxton is about 1200 feet above the sea.

The general mass of the Drift on the western side of the Pennine table-land reaches to the height of about 800 feet above the sea, though erratics are found at higher levels. In the Memoir of the Geological Survey on Sheets 81 N.E. and S.E., Mr. Green states that the depression of the land in glacial times exceeded 1200 feet. It cannot, however, have been much more than this, as no Drift has found its way over from the Etherow into the basin of the Don by way of Saltersbrook, where the height of the watershed is 1366 feet. Notwithstanding this, and the total absence of Drift from the plateau of the Wye basin, where not even a solitary erratic is to be seen, I see no better explanation of the occurrence of Drift with foreign stones in the Wye valley than that given by Mr. Green in the Memoir alluded to above.

In the same paper I stated that, with the exception of some Silurian erratics near Threshfield, no foreign ones are found in Wharfedale. At that time I supposed these Silurians to be surface erratics, distinct from and subsequent in date to the general mass of Drift; but I afterwards found them imbedded in the regular Drift. The most northerly point at which they occur is near the Wharfe, a mile and a half above Threshfield: this is where the valley opens out on the west and merges into the Drift-covered plain

¹ See Quart. Journ Geol. Soc., 1872, vol. xxviii., p. 382.

that stretches from the Wharfe to beyond the Ribble; from this point the Silurian erratics can be traced nearly as far as Burnsall, where the valley of the Wharfe again contracts into a narrow dale, closely hemmed in by steep hills; and they are found, singularly enough, on the west side of the river only. They are not to be found on ascending the hills west by north of Threshfield above say 800 feet, though this is the direct way to the nearest outcrop of Silurian rock in place. Thus they occur solely in the Drift of the plain, and would seem to have come on floating ice; for it is pretty clear that they were not pushed by an ice-sheet over the fells, as they are not to be found anywhere on the high ground: and it is, in my opinion, quite impossible that the Ribblesdale glacier should, after debouching on the low ground at Settle, have spread out at right angles to its course for the distance of twelve miles.

The fact of these erratics being found only on the west side of the river shows that something barred their passage; this may have been a current issuing from the higher part of Wharfedale, which would then have been a fjord; or possibly an ice-sheet descended from the Grassington moors on the east; or an ice-foot clung to the coast; and thus the floating ice, laden with Silurian blocks from Ribblesdale, would be unable to reach the present left bank of the stream.

In the narrow part of the dale below Burnsall I have not found any foreigners; for this fact I can only account by supposing that that narrow channel was so blocked with ice descending from the neighbouring fells that there was no passage.

It is worthy of remark, with reference to these erratics being found up to 700 or 800 feet, that the mass of the marine drift in South Lancashire reaches an average height of 800 feet above the sea, and that the Eskers of the dales are found generally up to 700 or 800 feet, and further that 700 feet is the amount of the last submergence recognized in Norway. Thus we have evidence of a submergence to about the same amount in several localities.

Before concluding, I may say that I have just seen Mr. Wilson's interesting paper on the Formation of Rock Basins in Norway.¹ I think his suggestion well worth attending to; but I fear it will not help us much here, for we have piles of Drift where the beds could have presented no edges to the moving ice; and yet, from the position and extent of the Drift, we know that the boulders could not have been derived in all cases from the waste of cliffs falling on to the ice, for such did not exist, but must have been torn out by the ice from its rocky bed. It has often occurred to me that the bottom of a glacier being at the temperature of 32° F., as is shown by the existence of sub-glacial rivers, ordinary disintegration of the rocks by means of frost may go on beneath a glacier as in the open air; and thus we may account for the stones in Drift where there could have been no cliffs to afford ordinary moraine matter. The close jointing and numerous alternations of hard and soft beds in the case of the Carboniferous rocks would greatly facilitate such sub-glacial

¹ See *Geol. Mag.* 1872, Vol. IX., p. 481.

denudation, and such too would be the case, as Mr. Wilson suggests, where the beds presented their upturned edges to the moving ice.

The vast numbers of well-rounded and scratched stones that occur in the Drift, and of which it is in fact in many cases mainly composed, have always been a great difficulty. Much has been written of late years about the moraine profonde, as such masses of Drift are now called: but no attempt has been made, that I am aware of, to explain in a definite manner the origin of such heaps of scratched gravel; it seems to have been thought sufficient to call them moraine profonde. This term, when originally used in Switzerland, was employed, as I am informed by one who is an authority on the subject, to describe the case of an advancing glacier overriding its own terminal moraine. In such a case no doubt the glacier might so grow as to shove its terminal moraine along in front of and partially beneath it: and the matter of the moraine would be greatly altered in nature and arrangement.

Doubtless also at the commencement of the Glacial epoch the ice as it advanced would sweep before it all the loose detritus from the hill-sides and beds of river-gravel or old sea-beaches; and in this progress the stones would get scratched and further rounded. But all such heaps of detritus must have been long since swept away from the hills and deposited mostly at the outskirts of the ice-sheet; and must now be sought perhaps in the vale of York. We must seek another way to account for the masses of scratched gravel and Boulder-clay found in the very heart of the fells. When these were formed and deposited, the country must have been entirely buried in ice, as Greenland now is. There could, therefore, have been no cliffs sticking through the ice to afford boulders for the Drift; we are thus driven to suppose that such boulders were derived from beneath the ice: and I see no means by which this could have been effected save by the disintegrating power of frost, aided in cases by a happy disposition of the chief divisional planes. But however difficult to account for, and however hard to conceive, I repeat the fact is certain that there has been an enormous amount of rock disintegrated sub-glacially, so as to form gravel and coarse stony detritus over and above the grinding of the rocks superficially into fine powder or mud.

V.—ON THE OCCURRENCE OF LEAD, ZINC, AND IRON ORES, IN SOME ROCKS OF CARBONIFEROUS AGE IN THE NORTH-WEST OF ENGLAND.

By CHARLES E. DE RANCE, F.G.S.

PART I.

IN former papers I have described central Lancashire as capable of division into three plains of different elevations. The lowest being often beneath high-water mark, and always below the 25-foot Ordnance contour; the second ranging from 25 and 50 feet to 500 feet above the sea, terminating at the foot of the steep escarpment at the western edge of the Lancashire and Yorkshire moorlands forming the Pendle portion of the Pennine chain, with an average eleva-