

## CORRESPONDENCE.

## THE THREEFOLD DIVISION OF THE BOULDER-CLAY OF THE NORTH-WEST OF ENGLAND.

SIR,—Your correspondents Mr. Mackintosh and Mr. Morton raise a much wider question than the one immediately contained in their letters, and it is impossible for me to really discuss the nature of the North Dock Sections without inquiring into the foundations of the theory upon which their classification of these deposits rests. Having in a former letter expressed an opinion that there is not sufficient evidence to justify in this case the threefold division of the Boulder-clay, will you permit me to state more fully my views on the subject.

First then it will be necessary to inquire by what characters a geological subdivision is usually recognized,—there are three :

1st. By the distinctive character of the inclosed fossils.

2nd. By persistent lithological character and continuity over a considerable area.

3rd. By constant relation to well-defined and known deposits above and below.

It is evident that these involve the prevalence of physical conditions differing when each deposit was laid down. These conditions may have differed widely and extended over great areas, or may have been of a more restricted and local nature. Mr. Morton in his communication, it is true, does not commit himself directly to any theory on the subject, but his position involves it all the same.

Mr. Mackintosh, on the other hand, boldly states that the Lower Boulder-clay, Middle Sands and Gravels, and Upper Boulder-clay, are each representatives of considerable variations of climate, the upper and lower clays, of cold more or less intense, the middle gravels of a mild climate, or what are called interglacial conditions. This, I believe, is the theory generally accepted by those who uphold the threefold division of the Boulder-clay, though they differ as to the nature of the lower clay, some attributing to it a subaerial origin, and others considering it to be an older marine deposit.<sup>1</sup> Unfortunately the terms are often used so loosely, that it is not always possible to interpret what is really meant by them, though if the division is to be upheld, they must mean something.

Having examined the general principles, and attempted to extract the signification of the terms, Lower Boulder-clay, Middle Drift, and Upper Boulder-clay, let us see what support is lent to the theory by the Boulder-clay Sections at the Liverpool North Docks.

The distinctive differences existing between the deposits according to Mr. Morton, so far as I can gather from his letter, are that the Upper Clay contains fewer stones than the Lower, and is worked with the spade : while the Lower Clay is more closely packed with small stones, and has in consequence to be worked with the pick. The

<sup>1</sup> There are others who consider the whole to be the product of land-ice, while some deny altogether the glacial character of the beds, and consider them to be post-glacial clays reconstructed out of the pre-existing glacial deposits.

Upper contains large striated boulders; but the Lower, it is admitted, may possibly also contain large boulders, as it has not been excavated to any considerable depth. The most distinctive feature is that they are divided in places by a bed of sand and well-worn gravel. Mr. Mackintosh considers that these gravels were washed out of a pre-existing glacial clay, of which only hummocky patches remain<sup>1</sup> (Lower Boulder-clay), and their striæ effaced during an inter-glacial period, when the transportation of striated stones had ceased. Without discussing in detail the accuracy of Mr. Morton's description, which I submit does not produce a faithful impression of what actually exists, but rather records what exists in his own mind on the subject, I ask, is the foregoing evidence full enough, or of a nature to justify a careful geologist in accepting an interpretation of the Boulder-clay fraught with such tremendous consequences? For my part, candidly I think it is not, and until some upholder of the theory shows that the Lower Boulder-clay is either a subaerial deposit or contains fossils differing from those in the bed above, or offers any of the distinctive characteristics and continuity such as I have stated are necessary to constitute a geological subdivision, I cannot consider the evidence to be worth much. Looking at the question in a broad aspect, it also appears to me that any division founded as this primarily is on the separation of the Clay by sand and gravel involves, if applied over a wide area, a physical absurdity. Under what possible conditions could a period intervening between the deposition of two beds of clay be represented everywhere only by sands and gravels? If these were washed out of the pre-existing clay, as Mr. Mackintosh infers, what became of the much greater bulk of the clay in which they were imbedded? Where are the equivalent deposits of clay which would surely have representatives somewhere in the interglacial period?

So far as my experience goes, the marine Boulder-clay and sands of the lower plains—and none but marine beds have hitherto presented themselves to me—are from the base of red sand or rock on which they rest to the surface, but one great deposit containing local variations of such a puzzling character as to be interpreted differently by every observer, the supporters of the tripartite division being frequently quite at a loss as to which division the respective beds should be allocated.

BLUNDELLSANDS, LIVERPOOL.  
Nov. 9th, 1876.

T. MELLARD READE.

#### ON THE FORMATION OF GROUND ICE.<sup>2</sup>

SIR,—Relative to the formation of "Ground Ice," I have to offer the following theory. In order that this phenomenon may take place the water must be near the freezing-point. Then we have an analogous condition of things to that of the atmosphere when hoar frost is deposited upon the ground, trees and shrubs on account

<sup>1</sup> From Mr. Morton's description one would infer this deposit extended all over the dock.

<sup>2</sup> See Dr. Landor's paper on "Ground Ice," *GEOL. MAG.*, 1876, Decade II., Vol. III. p. 459.