ARE THE BOWLDER CLAYS OF THE GREAT PLAINS MARINE?

SEVERAL trains of evidence show that the western plains, as well as the Cordilleran region, have been affected by great changes in elevation relatively to the sea level and to that of the eastern parts of the continent in later Tertiary and Pleistocene times. Facts bearing upon these changes have been detailed by the writer in previous papers and more particularly in those entitled respectively "Later physiographical geology of the Rocky Mountain region," and "Glacial deposits of southwestern Alberta in the vicinity of the Rocky Mountains."[1]

The observations made are in effect such as to lead the writer to believe that the bowlder clays and other deposits of the glacial period covering a large part, at least, of the Great Plains in Canada, are glacio-natant deposits, not directly due to an ice-sheet and not calling for an extension of glacier ice as such to this part of the continent. He has further ventured to suggest that the water covering the western plains at this time may have been at the level of that of the sea and in more or less direct communication with it. The present note relates, however, to the discovery in the bowlder clays of the Great Plains of marine organisms which appear to be contemporaneous with their deposition, and the general observations above alluded to need only be mentioned in introducing the subject.

Some time ago Mr. T. Mellard Reade, writing in comment on the paper last referred to above, and in the light of his own investigations and those of Mr. Joseph Wright on the bowlder clays of Great Britian,[2] suggested that a search should be made for

[1] Trans. Royal Soc. Can., Vol. VIII, Sec. 4 (1890). Bull. Geol. Soc. Am., Vol. VII, (1895).

[2] Cf. Present Aspects of Glacial Geology, T. M. READE, Geol. Mag. (IV,) Vol. III, p. 542. Bowlder Clay a Marine Deposit, J. WRIGHT, Trans. Geol. Soc. Glasgow, Dec. 1894 and May 1895.

micro-organisms in the bowlder clays of the plains. In conjunction with Mr. B. W. Thomas, I had some years ago examined several of these clays microscopically, but, as pointed out by Mr. Reade, the material examined in this case, was, in consequence of the mode of preparation adopted, that resulting from the elimination of all lighter particles by successive decantations, and not likely to include any foraminiferal forms still unfilled with mineral matter, which as a rule contain sufficient air to float to the surface of the water employed. In respect to the existence of forms contemporaneous with the deposit of the bowlder clays, the results arrived at by me were scarcely more than negative, but foraminifera evidently derived from the Cretaceous strata of the region were found in some of the clays from the Northwest.[1] Mr. Wright having very kindly offered to examine some of the western bowlder clays by the methods found applicable by him to those of Great Britian, several specimens were collected for the purpose and submitted to him. The results arrived at form the subject of this note, which is, however, essentially of a preliminary character, and is intended to be followed by further investigation as soon as it may be possible to obtain additional material.

The specimens sent to Mr. Wright were from the following places:

Nos. 1 and 2. Saskatchewan River, twelve miles below Victoria, collected by Mr. R. G. McConnell. These represent a bed of bowlder clay about fifty feet thick, the first being from its upper, the second from its lower part. Present height above the sea level about 1850 feet.

No. 3. Bowlder clay from near Victoria, Saskatchewan River, one and one-half miles up Egg Creek, also collected by Mr. McConnell. Height about 1900 feet.

No. 4. Bowlder clay from Selkirk, Red River, Manitoba. Collected by Mr. J. B. Tyrrell. Height above sea, 720 feet.

To these specimens from the West was added one collected by Dr. H. M. Ami, at Ottawa (No. 5).

It is not certainly known whether the bowlder clay represented by the first three specimens is the "lower" or "upper"

[1] Bull. Chicago Acad. Sci., Vol. I, No. 6 (1885).

bowlder clay elsewhere recognized in the western part of the plains,[1] but it is probably the latter. Microzoa were found only in the three samples from the Saskatchewan Valley. In giving the results of his examinations Mr. Wright writes as follows:

"In the clays from Victoria (1, 2 and 3) I find foraminifera (and Radiolaria) and I am of opinion that they are contemporaneous with the clay and not derived from Cretaceous strata—I judge by the general resemblance of the foraminifera to those we find in British bowlder clay. The foraminifers in the Cretaceous rocks of Canada may possibly be different to those which occur in the rocks of this age with us—I have never seen Cretaceous microzoa from Canada and so can give no opinion on this subject.

"Our chalk foraminifera are invariably of a dull white chalky appearance, the tests alone being calcareous, the interior being usually siliceous. On the other hand, our bowlder clay foraminifera differ in no respect from recent specimens, except in being usually smaller in size, the species being such as are now met with in shallow water around our coasts.

"All the species which I have been able to identify in the clays you sent me, are referable to recent species, and with the exception of *Cristellaria Italica* and *Rotalia orbicularis*, have been found in British bowlder clay. *Nonionina depressula* is the most abundant form in our bowlder clay, and it is instructive to find the species, so common with us, also occurring in your clay.

"*Bolivina lævigata*, *Cristellaria Italica*, as also some of the other specimens, have the clear hyaline luster of recent specimens. If Cretaceous, we would expect to find *Globigerina Cretacea* and *Textularia globulosa* plentiful."

The above references to Cretaceous foraminifera, are explained by the fact that Mr. Wright's attention had been called, when the specimens were sent, to the probable existence of such forms in the bowlder clays.

In replying to the letter from which I have just quoted, half a dozen specimens of Cretaceous foraminiferal material from the

[1] Cf. Bull. G. S. A., Vol. VII, p. 60.

Canadian Northwest, collected by Mr. J. B. Tyrrell, were sent to Mr. Wright, and allusion was also made to the report by Messrs. A. Woodward and B. W. Thomas on the "Microscopic Fauna of the Cretaceous in Minnesota, Nebraska and Illinois."[1] In this report, all the foraminifera found in bowlder clays, as well as those actually obtained from Cretaceous rocks, are classed together as Cretaceous.

After carefully examining the Cretaceous material sent, and preparing lists of the forms represented, Mr. Wright notes the occurrence in it of a great preponderance of the two species already mentioned by him as likely to be characteristic. He further points out that these Cretaceous foraminifera are filled with calcite, differing in that respect from most of those of the same age in Great Britain, but none the less stony and unlikely to float during the treatment of the clays. In Yorkshire he has met with clays containing about equal proportions of Cretaceous (derived) and Pleistocene (contemporaneous) foraminifera, but found no great difficulty in separating the two lots by the criteria already alluded to. Referring to Messrs. Woodward and Thomas' report, he expresses the belief that it really comprises a mixed fauna of the same kind, stating that of twenty-nine species recognized by these gentlemen, ten had not before been recorded from rocks of Cretaceous Age, according to Brady's monograph in the Challenger report.

One of the localities mentioned by Messrs. Woodward and Thomas for foraminiferal bowlder clay, that of South Chicago, lies so far from known Cretaceous outcrops and away from the line of any recognized drift from such outcrops, that I ventured to address a question on the subject of the probable origin of the microzoa to Professor T. C. Chamberlin. The foraminifera found in this bowlder clay, appear to be in part, at least, undoubtedly Cretaceous in age. In reply, Professor Chamberlin quotes observations made in northern Wisconsin which tend to show the existence of Cretaceous outliers there, as well as perhaps beneath the northern part of Lake Michigan, or even further east. He

[1] Geology of Minnesota, Vol. III, Part I (1895).

writes: "Taking the evidence all in all, I do not think there is any serious difficulty in accounting for Cretaceous forms in the drift of this region" (Chicago). After referring to the interest attaching to Mr. Wright's observations, he adds the following interesting suggestion concerning them: "It has occurred to me to raise the question whether a certain number of marine microscopic forms are not to be expected in any slow-accumulating deposit like a clay, in the interior of the continent, having been borne there by the wind with other dust picked up from marine flats on the windward side of the continent."

The purpose of this communication is accomplished in stating as above, briefly, the new facts which appear to bear upon the question asked in its title. It seems to be at least very probable that, in addition to derived Cretaceous foraminifera often found in the drift deposits of the Great Plains, we have contemporaneous forms of the sea of the glacial period, still unfilled with mineral matter, unaltered, hyaline in aspect, and representing the same species elsewhere commonly found in deposits of this period. Should further investigation confirm the contemporaneous and autochthonous character of this fauna, it will greatly assist in enabling the formation of definite hypotheses respecting events of the glacial period in the western part of the continent.

Mr. Wright's notes on the specimens of bowlder clay from the Saskatchewan, are as follows :—

No. 1. Bowlder clay, twelve miles below Victoria. Weight 4 lbs. 4.5 oz. Troy. After washing — Fine 1 lb. 3.7 oz. Course 0.7 oz. Stones mostly rounded, some angular.

Gaudryina Sp., very rare.
Bulimina pupoides D'Orb., frequent.
Pulvinulina Karsteni (Rss.), very rare.
Nonionina depressula (W. & J.), very rare.
Rotalia orbicularis, D'Orb., very rare.
Radiolria, frequent.
Sponge spicules, rare.

No. 2. Bowlder clay, twelve miles below Victoria. Weight 2 lbs. 6.2 oz. Troy. After washing — Fine 8.9 oz. Coarse 0.5 oz. Stones mostly rounded, some angular.

Bulimina pupoides D'Orb., rare.
Bolivina lævigata (Will.), very rare.
Cristellaria Italica, Defr. (young), very rare.
Truncatulina Sp., very rare.
Rotalia orbicularis, D'Orb., very rare.
Radiolaria frequent.
Sponge spicules, rare.

No. 3. Bowlder clay near Victoria. Weight 3 lbs. 1.6 oz. Troy. After washing — Fine 1 lb. 0.1 oz. Coarse 0.6 oz. Stones mostly rounded, some angular.

Gaudryina Sp., frequent.
Bulimina pupoides, D'Orb., rare.
Rotalia orbicularis, D'Orb., frequent.
Nonionina depressula (W. & J.), very rare.
" *scapha* (F. & M.)? very rare.
Radiolaria, frequent.
Sponge spicules, rare.
Ostracod, very rare.

It may be of interest to add for comparison, the species actually recognized by Mr. Wright in the several small samples of Cretaceous material supplied to him. These are, nearly in order of relative abundance, as follows :—

Textularia globulosa Ehr., very common.
Globigerina Cretacea, D'Orb., very common.
" *digitata*, Brady, rare.
Anomolina ammonoides, (Rss.), rare.
Nodosaria Zippei, Rss., very rare.

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