

His diagrams, which are intended to illustrate this statement, show that he believes his Upper Boulder-clay to be *POSTERIOR* to the "Middle Drift" or Kame series. What are the reasons assigned by the author for slumping these Boulder-clays as part and parcel of his upper series? Because "this clay is found almost always at a higher level than the Middle Drift Sands, and from its containing scarcely any but local rocks, and those always angular or in a very slightly rolled condition, I conclude that it is the wash of the mountains towards the later part of their rise and in the beginning of their second submergence in the sea, and due partly to the action of the sea itself by tides and waves, partly to rainfall and an accumulation of snow and ice upon the land, combined with the most effective cause of all—the grinding of coast-ice swept along by violent currents." In the absence of any direct evidence of superposition, I fear that these arguments can have but little weight. In Scotland, for instance, true *LOWER* Boulder-clay occurs very frequently at higher levels than the Kame series; and in the Till there always is a preponderance of local over foreign rocks, the number of the latter diminishing in proportion to the distance from the parent source. As to the last of these reasons, my observations enable me to state that such is *NOT* the case with reference to all the Boulder-clays included in his upper series.¹ In the case of those Boulder-clays described in my paper as representing true Till, the stones are neither angular nor slightly rolled; on the contrary, they have the smoothed character of ordinary Till stones with well-marked scratches. Mr. Birds indicates localities unvisited by me, and, of course, I have nothing to say with reference to these sections.

The author further says: "As to which is the true order of the formations, the question must be determined, of course, by reference to sections, such as that of which Mr. Horne has given a lithograph, near the mouth of the Ballure Glen, and by all sections thence along the northern base of the hills to Kirkmichael." Glancing for a moment at this section exposed on the coast cliff, we have here two Boulder-clays, regarded by Mr. Birds as belonging to his upper series, which are separated by sands and gravels and capped by stratified sands and gravels, which appear to stretch northwards to Ramsay, where the "Middle Drift" series begins. This section seems to indicate that these Boulder-clays pass *UNDERNEATH* the stratified sands and gravels of the "Middle Drift" series. Other sections might be adduced which seem to point to the same conclusion.

NOTICES OF MEMOIRS.

RED CHALK AND RED CLAY. By PROFESSOR A. H. CHURCH.
From the "Chemical News," May 7, 1875.

SOME years ago I published an analysis² of the Red Chalk of Hunstanton, Norfolk. The specimens which I examined more minutely were those in which the red colour, so characteristic of this variety of chalk, was exceptionally developed. In these speci-

¹ See *Trans. Geol. Soc. Edin.* vol. ii. part iii.

² 1863. *Journ. Chem. Soc.* (2), vol. i. p. 99.

mens I found a high per-centage of ferric oxide, with very little silica and alumina. Mr. R. C. Clapham had shown,¹ however, that some samples, at all events, of red chalk contained as much as 9·28 per cent. of silica, with 9·6 per cent. of ferric oxide and 1·42 per cent. of alumina, and that these three ingredients were also present in white chalk, though in much smaller proportions.

In view of the recent discoveries as to the materials constituting the floor of the deep sea, and acting upon a suggestion made by Professor J. Morris as to the probability of some near connexion between red chalk and the "red clay" of certain deep tracts of the ocean bottom, I have again studied the chemical nature of the former material; but this time I employed a different method of analysis, and I operated upon the paler and more ordinary variety of red chalk. The samples used were numerous, but the results of the treatment to which they were submitted were nearly uniform.

The following is a brief outline of the plan which was pursued in order to see if it were possible to separate from red chalk a red clay, slime, or ooze, similar to that which is reported by the officers of the *Challenger* Expedition to cover the Atlantic bed at average depths of some 2700 fathoms. Treatment with very dilute hydrochloric acid in the cold seemed the best way of removing the calcium carbonate present. This acid was allowed to act upon small crushed pieces of selected red chalk until fresh acid failed to remove any further traces of calcium. By appropriate washing in an apparatus similar to that figured in my "Laboratory Guide,"² the finer portion of the undissolved residue from the chalk was readily separated from the siliceous fragments which accompanied it. This finer portion remains suspended for some time when stirred up in pure water, and was found to be almost, if not quite, homogeneous; it contained no lime. It amounted, on the average, when air-dried, to 9·3 per cent. of the weight of the chalk taken, but some dark samples furnished higher per-centages. Its physical characters correspond, so far as I can learn, to those of the red residue obtained by Mr. Buchanan from the Globigerina ooze, and to those of the smooth red clay before referred to as brought up from the deeper parts of the sea-bottom.

The following analysis abundantly proves how closely the chemical composition of the red argillaceous residue from red chalk resembles the red clay in question:—

Analysis of Red Clay from Red Chalk.

	In 100 Parts.		
	Air-Dried.	Dried at 100° C.	Ignited.
Water	14·73	7·54	—
Silica	52·87	57·33	62·01
Ferric oxide (Fe ₂ O ₃)	12·81	13·89	15·02
Alumina	15·65	16·97	18·36
Magnesia (MgO)	2·65	2·87	3·11
Potash (K ₂ O)	1·33	1·45	1·56
	100·04	100·05	100·06

¹ 1862. Chemical News, vol. vi. p. 313.

² "Laboratory Guide," 3rd edition, 1874, p. 163.

Although the above numbers clearly indicate a substance which may be fairly designated "a silicate of red oxide of iron and alumina," like the "red clay" of Professor Wyville Thomson,¹ it would be idle now to speculate as to the probable correspondence, in the minuter details of their composition, of the red chalk residue with the red clay of the deep Atlantic and Southern Sea. Still it may be profitable to allude to two or three points which are likely to throw light upon the relationship of the white, grey, and red chalk with the globigerina, the grey and the red ooze, respectively. First, analysis seems to show that the removal, in different degrees, of calcareous matter, however effected, has been the main cause of the differences of such formations. Secondly, it would appear that, although manganese dioxide is present in granules and nodules in the red oceanic clay and in the coarser particles of the red chalk, it is absent alike from the finely-divided substance of the former and the similar red residual slime of the latter. And, thirdly, the suggested relation between both these red matters and the mineral known as *glauconite* receives an unexpected light through the detection of sensible quantities of magnesia and potash in the red chalk residue; for the latter base is an invariable constituent, and the former an usual one of this species.

The complex and rather variable silicate which, from its grey-green hue, has received the name of *glauconite*, is known both in ancient and recent formations of greensand. The casts of animal forms which constitute the *glauconitic* grains of Cretaceous Greensand strata are paralleled by similar remains in the recent greensands of the Australian seas, and of those of the Agulhas current investigated by the scientific staff of H.M.S. *Challenger*. But the problem of the formation of recent greensand, or rather of *glauconitic* matter, at moderate depths, and of the related red clay at very great depths, is not yet solved. It is by no means necessary to suppose that *glauconite* was always first formed, and that it yielded the red clay in question by oxidation and partial solution, just in the same way that kaolin or white clay has been produced from felspar. This has probably happened in some instances; but it may be assumed, on the other hand, that the same constituents have yielded one or other of these two products, in accordance with differences in the dissolved gases and salts of the ocean and in the nature of its prevalent animal and vegetable forms.

One step towards the discovery of an answer to the problem now under discussion might be furnished by a careful study of the action, under pressure, of water holding oxygen and carbon dioxide in solution, upon powdered *glauconite*. But we really stand in need of more information as to this species itself, for the composition of the numerous minerals included under this name is somewhat ill-defined. Still we may conclude that it contains, as essential constituents, silica to the extent of 50 per cent.; a variable amount of alumina; much iron in the ferrous, as well as in the ferric condition; several per cents of potash; a little magnesia; and, finally, about

¹ Proc. Roy. Soc., vol. xxiii. pp. 39 and 45.

7 or 8 per cent. of water. It would not require a very profound alteration of such a mineral to give it the composition indicated by the analysis of our red chalk residue when dried at 100° C. Such alteration would involve peroxidation of the iron, removal of most of the potash, and relative increase of the alumina, results commonly seen in many altered mineral residues.

Great interest attaches to all questions concerning the red oceanic clay. Its minute analysis will, doubtless, solve some of the problems referred to in the present imperfect note. In the mean time, I am anxious that it should not be supposed that I ignore the differences which must subsist between recent oceanic deposits and the rocks which we may consider to have originated in former ages from similar materials. It is not that the mere process of consolidation must have altered them, but that the influences to which they have been subsequently exposed may have caused unsuspected, though not inconsiderable, changes in their chemical constitution. Materials for the discussion of this question are still deficient, and we must await complete quantitative analyses of recent glauconite, and of the red oceanic clay, before a decision can be reached. On account of this insufficiency of data, I have refrained from suggesting any formula for the red chalk residue, though it may have, like kaolinite, a claim to be regarded as a mineral species.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.—May 12th, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Occurrence of *Eozoon canadense* at Côte St. Pierre." By Principal Dawson, LL.D., F.R.S., F.G.S.

The author commenced by describing the arrangement and nature of the deposits containing *Eozoon* at the original locality of Côte St. Pierre on the Ottawa River. The Eozool limestone is a thick band between the two great belts of gneiss which here form the upper beds of the Lower Laurentian. *Eozoon* is abundant only in one bed about 4 feet thick; but occasional specimens and fragments occur throughout the band. The limestone contains bands and concretions of serpentine, and is traversed by veins of chrysotile; the former an original part of the deposit, the latter evidently of subsequent formation. A thin section, $5\frac{1}{2}$ inches in depth, showed:—1. Limestone with crystals of dolomite and fragments of *Eozoon*; 2. Fine-grained limestone, with granules of serpentine, casts of chamberlets of *Eozoon* and of small Foraminifera; 3. Limestone with dolomite, and containing a thin layer of serpentine; 4. Limestone and dolomite with grains of serpentine and fragments of supplemental skeleton of *Eozoon*; 5. Crystallized dolomite, with a few fragments of *Eozoon* in the state of calcite; 6. Limestone containing serpentine, as No. 2. The author criticized some of the figures and statements put forward by Messrs. King and Rowney, and noticed two forms of *Eozoon*, which he proposed to regard as varieties, under the names of *minor*