IV.—ON THE OCCURRENCE OF EXTENSIVE DEPOSITS OF TUFa IN FLINTSHIRE.

By GEORGE MAW, F.S.A., F.L.S., F.G.S.

OF the various geological evidences inferring a vast duration of the existing contour and conditions of surface since the latest marine submergence, there is, perhaps, none more striking than the accumulation of great masses of Tufa charged with recent organic remains.

Whether the extreme slowness with which limestone is capable of undergoing watery dissolution, or the smallness of the volume of the water, which has generally been the medium of its transfer to a tufacious condition is considered, any great mass of Tufa must of necessity imply an immense lapse of time for its formation.

The Mountain Limestone district of North Wales contains several examples of Tufa deposits, and one, to which my attention has been drawn by my friend the Rev. D. Williams, of Nannerch, seems, from its position and great extent, to be worth a special notice in the *Geological Magazine*.

At the south side of the great Mountain Limestone range of Flintshire, connecting the plain of Chester, near Mold, with the vale of Clwyd, opposite Denbigh, runs a long, narrow, tortuous valley, from which branch numerous ravines, intersecting the limestone range, forming its northern boundary.

One of these ravines, immediately to the east of Caerwys, and a second, about a mile further to the east, are occupied for a considerable distance with extensive deposits of soft Tufa, commencing against the Mountain Limestone, and expanding downwards through a range of altitude of about 150 feet in broad delta-shaped masses towards the main valley, where the Tufa flow appears to have been arrested on the north bank of the river Wheeler.

The more westerly of the two ravines is occupied from north to south for a distance of three-quarters of a mile, and the total area occupied by both masses cannot be less than 200 acres. I believe that deposits of Tufa at all approaching these in extent are unknown in any other part of the kingdom.

At the embouchure of the eastern ravine, close to the Smell turnpike-gate, a cutting in the new Mold and Denbigh railway has exposed the deposit for a distance of more than a furlong, and in one place to a depth of 12 feet. At the point in digging the foundations for a bridge a further depth of six feet was penetrated, and a bed of peat, one or two feet thick, containing fragments of semi-decayed wood, found to intervene between it and the subjacent drift-gravel. The thickness of the Tufa would therefore be 18 feet. Higher up the lateral valleys it ascends in terrace-like ranges, and appears to be much thicker as the streams have cut channels into it 15 or 20 feet deep without exposing the fundamental drift.

For the most part the Tufa is of a soft marly texture, occasionally containing harder masses, which appear to have accumulated round plant remains; the harder parts are full of tubular perforations,

bearing the impressions of Equisetums, Carices, and other marsh plants; also, occasionally, willow leaves. The remains of recent shells are most abundant — *Helix memoralis* occurring in great quantities throughout the deposit.

Mr. Gwyn Jeffreys has also determined the following species :—

<i>Limnæa peregra</i> (Müll.)	* <i>Helix concinna</i> (Jeffreys.)
<i>Succinea putris</i> (Linn.)	„ <i>caperata</i> var. <i>Gigatii</i> (Charp.)
* <i>Zonites nitidulus</i> (Drap.)	„ <i>rotundata</i> (Müll.)
„ <i>crystallinus</i> (Müll.)	„ <i>pygmæa</i> (Drap.)
„ <i>fulvus</i> (Müll.)	„ <i>pulchella</i> (Müll.)
„ <i>radiatulus</i> (Ald.)	<i>Vertigo antiwertigo</i> (Drap.)
<i>Helix aculeata</i> (Müll.)	<i>Zua</i> (<i>Conchlicopa</i>) <i>lubrica</i> (Müll. sp.)
* „ <i>aspera</i> (Müll.)	<i>Carychium minimum</i> (Müll.)
* „ <i>memoralis</i> var. <i>hortensis</i> (Penn.)	* <i>Cyclostoma elegans</i> (Müll.)
* „ <i>arbusorum</i> var. <i>alpestris</i> (Zugler.)	

The species marked thus * were obtained between Pwll Gwyn and Caerwys; all the others and some of those marked * from the railway-cutting, near the Smell turnpike-gate.

Mr. Jeffreys observes that all the species at present inhabit Wales, and, probably the locality where found; and considers the deposit an extremely modern one. Some of the species indicate a moist situation, others a dry soil.

In a former communication to the Magazine (Vol. II., p. 200), I described the occurrence of curious cavities or pockets in the Mountain Limestone of the same district, which I suggested had been formed through the gradual dissolution of the limestone, by a process similar to that which has been supposed to explain the method of formation of sand-pipes in the chalk. The occurrence of the redeposited lime as Tufa in the immediate neighbourhood affords another point of analogy between the limestone-pockets and the chalk sand-pipes, and further supports the theory suggested to account for their excavation.

The subterranean derivation of the Tufa is here also indicated by the existence of a cavernous opening in the limestone, lined with a stalactitic coating immediately over the upper end of one of the Tufa beds (see Section); and it seems probable that from this cavity the water that deposited the Tufa once flowed. The cavern is now dry, and the deposition of the Tufa appears to have entirely ceased; the only water that flows over it occurs as a stream that has its origin higher up the valley, and instead of adding to the accumulation of the deposit it has cut a channel through it, in some places to a considerable depth. These facts seem to imply a change of circumstances from those which obtained when the Tufa was originally deposited, and the present stream, if it existed at the time, must have occupied a different position.

Assuming that the various cavernous openings in the Mountain Limestone have been similarly formed, it appears probable that these subterranean excavations proceeded during a long geological period; the caves of Cefn, on the opposite side of the vale of Clwyd, appear to have been excavated before the Boulder-clay-drift

CONDENSED SECTION ACROSS THE VALLEY OF THE WHEELER, BETWEEN SMELL TURNPIKE GATE AND YSCEIFIOT,
NEAR CAERWYS, FLINTSHIRE.

a. Denbighshire Flags. b. Mountain Limestone. c. Drift. d. Peat, from 1 to 2 feet in thickness, intervening between Drift-Gravel (c) and Tufa, e.
(Not drawn to scale.)

period, with the gravels of which (?) they are partly occupied. On the other hand, the great deposits of soft Tufa near Caerwys could not have resisted the marine submergence, and their deposition subsequently to the drift is also evident from their resting on its eroded surface.

The subterranean dissolution of the limestone commenced, therefore, some time before the submergence of several hundred feet that filled the Cefn caves with gravel, and continued afterwards sufficiently long to provide materials for the great masses of Tufa, near Caerwys.

It is worthy of observation that no evidence is to be found that the calcareous deposition is still proceeding, and that with an apparently similar condition of surface, the causes tending to the formation of a Tufa have entirely ceased.

NOTICES OF MEMOIRS.

I.—ON THE *RHINOCEROS LEPTORHINUS* OF OWEN.

By W. BOYD DAWKINS, M.A., F.G.S.

[Abstract of a Paper read before the Royal Society, April 26th, 1866.]

THE fossil remains of the genus *Rhinoceros*, found in Pleistocene deposits in Great Britain, indicate four well-defined species. Of these the *R. tichorhinus*, or the common fossil species, ranged throughout France, Germany, and Northern Russia, and like its congener, the Mammoth, was defended from the intense winter cold by a thick clothing of hair and wool. Its southern limit in the Euræo-Asiatic Continent was a line passing through the Pyrenees, the Alps, the northern shore of the Caspian, and the Altai mountains. It has not yet been proved to have existed in Europe anterior to the deposit of the Boulder-clay. The second species, the *R. megarhinus*¹ of M. de Christol, characterized by its slender limbs, and the absence of the "cloison," has been determined by the author among remains from the brick-earths occupying the lower part of the Thames Valley, and from the Pre-glacial Forest-bed of Cromer. The species ranged from the Norfolk shore, southwards, through Central France, into Italy. In France and Italy it characterizes the Pliocene deposits, being found in the former country in association with *Mastodon brevirostris*, and *Halitherium Serresii*, in the latter with *M. Arvernensis*. From its southern range we may infer that the megarhine species was fitted to inhabit the warm and temperate zones of Europe, just as the tichorhine was peculiarly fitted for the endurance of an Arctic winter.

The third species is the *R. etruscus* of Dr. Falconer, confined to

¹ For Paper on the *Rhinoceros megarhinus* see Dawkins, Nat. Hist. Review, 1865. p. 399.