surfaces scratched and polished. As the movement is greater than the possible velocity of glaciers, it is only natural to expect great erosive effects from stones held as graving tools, or wrenched out owing to the brittleness of the ice, under such great stress, or from loose materials roughly thrust forward by the pack.

12. These observations and those of Prof. Milne¹ in Newfoundland, and others upon the action of coast-ice, all confirm the correctness of the verdict given by many geologists, especially in Europe, who have had the opportunity of studying living glaciers, viz. that the potency of land-glaciers as great *eroding* geological agents is not proven, if indeed they operate at all in such a manner.

IX.—TERTIARY OUTLIERS ON THE NORTH DOWNS.

By the Rev. A. IRVING, B.Sc. (Lond.), B.A., F.G.S.

IN "Nature," August 26, 1886, vol. xxxiv. p. 387, I ventured to draw a distinction between the outliers of unfossiliferous Tertiary sands found at high altitudes on the North Downs and the deposits containing casts of fossils of Pliocene age which are found in hollows in the Chalk at Lenham. Last summer I visited and examined, I believe, all the more important outliers of the former series, Mr. J. Hutchins French, F.G.S., having kindly conducted me to those at Headley and Chipstead; those at Netley were visited with other members of the Geologists' Association under the direction of the same gentleman. The conclusion at which I have arrived from the lithological evidence (and there seems to be no other available) is, that these sands are more probably of Bagshot age than of any other.²

There is a vast amount of reconstructed clay material capping these hills over many square miles, which, in colour and other characters, points to its original deposition as part of the Reading Beds, and in these unrolled Chalk flints are generally sparsely distributed. There are also a good many outliers of those beds mapped by the Survey on the higher parts of the North Downs.³ But there appear to be no traces of London Clay or of the Middle Bagshot clays.

Of the unfossiliferous sands referred to, those exposed in the sand-pit in Chipstead Wood, and those seen in the pit on Netley Heath (where only one section occurs of undoubted Tertiary sands *in situ*, clearly differentiated from the overlying "run-of-the-hill" of later

¹ See GEOLOGICAL MAGAZINE, Dec. II. Vol. III. No. 7, p. 303, 1876.

² "Nature," Oct. 16, 1887, vol. xxxvi. p. 531.

³ Surely these are the patches of "clay-with-flints" (*Argile à silex*) of W. Whitaker and the French and Belgian geologists.—H. W.—The clays referred to are quite distinguishable from the "clay-with-flints" of Mr. Whitaker and the Survey, if by that term is understood the insoluble residue frequently found on the surface of the Chalk, the calcareous constituents of the original rock having been dissolved away by carbonated atmospheric waters; a kind of deposit known to the French geologists as "*argile à silex*" or "*terrain superficiel de la craie*" (*Memoir Les Causes Actuelles en Géologie*, p. 306).—A. I.

date) are the *exact counterpart in every way of the Upper Bagshot Sands*, as these are seen in the interior of the district; e.g. about Sandhurst, in the Fox Hills, and at Aldershot. Of those at Headley I should speak with more reserve as to their being *Upper Bagshot*, although I saw no good grounds for denying that they might represent the more marginal facies of the beds of that group. There is rather more distinctness of bedding than usual, and the sands are rather less loamy, and more marked by colour-bands, as the result of subsequent infiltration. But this can be observed even in the highest beds of the Fox Hills in places, and elsewhere in the district.

Associated with these sands on the Chalk hills at Headley, and in the *débris* of the hill-slope, well-rounded flint pebbles are met with in great numbers; at Headley they constitute a large proportion of the drift-gravel, which overlies the sands. These pebbles are so different from those which occur *in the clays* on the Downs, and so closely resemble the bluish Bagshot pebbles of Bearwood, East-hampstead, St. Anne's Hill, Chertsey, Aldershot, etc., that it seems impossible to deny that they may belong to the same formation. Sarsens also are not infrequently met with.

So far as the evidence goes, we seem (though it is not very strong) to have better grounds for assigning these outlying sands to the Bagshot (and perhaps to the Upper Bagshot), than any which has yet been brought forward for assigning them on the one hand to the Reading Beds, and on the other to the Pliocene.¹

Assuming that they are of Bagshot age, and taking their present altitudes (550 to 600 feet above O.D.) into account, we arrive at the interesting and important result, that this represents approximately the extent of the post-Eocene elevation of the North Downs above the sea; and the differences between these and the present altitudes of the same horizons in the interior of the Bagshot area (if they could be precisely identified) would represent the extent of accentuation which the Wealden axis has undergone since the Eocene period.

The extensive prevalence of the Reading Beds to the south points to a later date for the elevation of the Wealden axis than that marked by those beds; while the presence of the pebbles in great force seems to indicate that the Chalk over the Wealden area was subjected to the abrading action of the sea to a large extent before the Eocene period² came to an end (as is well known); and to such an extent was this carried on, that even the Lower Greensand was exposed to the action of denuding agencies, and furnished a great part of the materials of the Upper Bagshot, in which scattered glauconitic grains occur locally.

¹ See Mem. Geol. Survey, vol. iv.

² Exclusive of the Oligocene.