XVIII. *On the Evidences of a Submergence of Western Europe, and of the Mediterranean Coasts, at the Close of the Glacial or so-called Post-glacial Period, and immediately preceding the Neolithic or Recent Period.**

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Received December 15, 1892,—Read March 9, 1893.

[Plate 33.]

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*I briefly broached this subject at the meeting of the British Association at Swansea in 1880: an abstract is given in *Reports*, p. 581.

28.11.93

Introductory Remarks.

In a paper read before the Geological Society* early this year, I gave the evidence—the result of personal observation—which led me to conclude that the South of England had been submerged to the depth of not less than about 1000 feet between the Glacial (or Post-glacial) and the recent or Neolithic periods. That evidence was based upon the characters, physical and palæontological, of a peculiar superficial drift, for which I proposed the term of "Rubble-drift," to distinguish it from the valley, marine, and glacial drifts of the same districts.† Under this term I include various detrital deposits to which different designations have been attached. Amongst the more important of these are the drift called "head" over the Raised Beaches of the Channel and the Ossiferous Fissures of South Devon.

Various explanations have been suggested to account for the "head," such as, 1st, an excessive rainfall, accompanied by great cold; 2nd, the sliding of masses of snow and ice over slopes; 3rd, waves of translation; 4th, torrential fluviatile action during a period of great cold. I have stated in the paper referred to the objections to these several explanations.‡ Some of them, no doubt, would suffice to produce a portion of the observed effects, but they fail to embrace the whole, and they all involve consequences which are incompatible with the general facts. They all, also, with one exception, depend on subaërial agencies, to which there is the general objection that these agencies involve a certain amount of friction and weathering which are conspicuously wanting—or, if present, it is in a very slight degree—in the deposits under review. There is the further objection that some of the phenomena indicate the exercise of a propelling force for which the suggested causes are manifestly inadequate. There are other points, apparently inconsistent with such agencies, connected more especially with the Ossiferous fissures and the Loess of the continental area, which will be considered more fully in the following pages.

In the present paper my object will be to show that the phenomena on which I relied as proofs of submergence in England, extend likewise over large continental areas. Owing to the extent of the subject, it will be necessary to confine the inquiry to the more prominent and typical cases. Nor will it be necessary to give full geological details, as they are to be found in the works of the several geologists referred to. I

* 'Quart. Journ. Geol. Soc.,' vol. 48, p. 263, 1892. I have there entered into more details, and specified the objections to previous explanations, which it is therefore unnecessary to repeat here.

† Both Sir R. Murchison ('Quart. Journ. Geol. Soc.,' vol. 7, p. 349), and Professor J. Geikie ('Prehistoric Europe,' p. 140), have contended that certain detrital deposits, spread widely over the South of England, could not be referred to ordinary marine or fluviatile agencies. The former attribute them to a wave of translation: the latter (which I unknowingly overlooked in the above-named paper) to the agency of frozen snow-drifts during the Glacial period.

‡ *Ibid.*, pp. 326–328.

shall, therefore, give only such particulars as are needed for the discussion of their views, and for the purpose of generalizing the phenomena they describe.*

Though this rubble-drift in some of its phases sometimes simulates the characters of the other drift deposits, I found it impossible to reduce it to the terms of any of those others. Whereas these latter are spread out in beds more or less horizontal, and keep to definite lines, this drift drapes the hills, follows divergent directions, and ends only when it reaches the floor of the valleys. The faunal débris of this drift also differs essentially in its main characteristics from that of the other drift deposits. There is an entire absence both of marine and fluviatile shells; the remains found in it are those of *land animals* and *land shells* alone, with traces of land plants, such remains in fact as could have been derived from a *land surface*, and from a land surface only. Owing to their extreme friability, the shells are of rare occurrence, and the most common one, the *Pupa marginata*, is so minute, that it often escapes observation. Another feature to be noted, is that the bones of the Mammalia (which belong to the ordinary Quaternary group), are distinguished by their very *fragmentary state* and by the *absence of wear*, whether of the broken fragments or of the

* [The notices of the several detrital beds I have included under the term of "Rubble-drift" have, with the exception of the Loess, generally been incidental and limited to some one phase. With respect to that form of it represented by the Ossiferous fissures, an impression would appear to have prevailed that the subject was exhausted by the early researches of Cuvier and Marcel de Serres, for though so much has been done of late years in explanation of the contents of the remarkable Prehistoric Caves in France and elsewhere on the continent, there have been no detailed descriptions of those Ossiferous fissures, with the exception of those of Gibraltar (1878), and slight notices of those of Nice (1887), since that of De la Beche in 1828; nor, with the exception of the short notice by M. Lanza in 1855, has anything been added to our knowledge of the numerous Dalmatian fissures since the Abbé Fortis wrote in 1778. In Italy, the latest contribution I can find is the one by Professor Capellini in 1879. The recent papers of Stefani in the 'Annales de la Soc. Géol. de Belgique' (1891), on the Upper Tertiary and Post-Pliocene beds of the Mediterranean Basin barely touch on any of those which form the subject of this inquiry.

It is the same with the rubble-drift on slopes. Besides the instances I have given in France (1860–71), and at Gibraltar (1878), and of the *Argile à blocaux* in Belgium (1872), I am not aware of any more recent memoirs on this particular subject. The later more general works on the geology of the South of Europe and the North of Africa, have added nothing to the facts described by the earlier writers I have referred to.

The contemporaneous deposit of Loess forms an exception to this neglect. The recent literature on this subject is copious and varied, but it is mainly confined to that section of the Loess which has a fluviatile origin, and is not applicable to that other section which extends beyond the reach of river-floods and to the greater heights of Central Europe. It is to the latter alone that my observations are at present confined, and they only relate to a few points.[1]

I should add that I have been obliged, for various reasons, to confine myself in each section to a limited number of the more typical instances. I have not, however, I believe, omitted any cases but such as would confirm the evidence of those which I have adduced.—J. P., *June*, 1893.]

[1] I have discussed the subject of the fluviatile Loess in a paper which appeared in the 'Phil. Trans.' for 1864, p. 247.

entire bones, as well as by *their freedom from all traces of gnawing;* conditions in marked contrast with those presented by the bones of the caves, which have commonly been gnawed by predaceous animals, and with those of the fluviatile deposits which are usually more or less worn.

The physical characters of this drift are equally well marked. The detritus of which it is composed, is always of *local origin* and *angular.* The component fragments retain their *sharp angles* uninjured. It is without stratification, and yet not without a certain order such as might result from successive masses of débris sliding down slopes and shot into hollows. In many respects, such as its wide distribution, and its want of stratification, it resembles a subaërial glacial detritus, but its entire want of wear, the presence of and condition of the bones, and especially the presence of delicate land shells, are incompatible with such an origin. The absence of foreign transported materials or boulders, and of marine shells, is equally incompatible with a submarine glacial origin.

Taking all these facts into consideration, the only agent which appears to me capable to have produced such results, is that of an upheaval of a submerged land following upon a wide-spread submergence. This upheaval by displacing the superincumbent body of water, would give rise, as shown in a paper by the late Mr. W. HOPKINS, of Cambridge,* to divergent effluent currents, which would sweep down from the higher to the lower levels the débris of the submerged surface. Such would have happened, if after a temporary submergence the land had again been upheaved, and the former levels approximately restored. All the phenomena presented by this Rubble-drift are explicable upon this hypothesis, and upon none other that I can see. Of the submergence we can only infer that it was slow and gradual, but of the upheaval we have evidence to show that it was by stages alternately slow and more or less rapid. That evidence is best exhibited, not in districts where the rocks are of an uniform character, as then, in the absence of any difference in the débris, the rubble has the appearance of a talus without divisional planes, but where the rocks are composed of beds of different textures and degrees of hardness then the débris shows sorting and a kind of rough bedding, and this gives a clue to the manner in which the accumulation took place. These conditions obtain best in chalk districts,

* 'Quart. Journ. Geol. Soc.,' vol. 4, p. 90, Mr. HOPKINS, shows that if a considerable area at the bottom of the sea were *suddenly* elevated, currents, the velocity of which would depend principally upon the depth of the sea, would diverge in all directions from the central disturbance. "Calculations," he says, "prove beyond all doubt that paroxysmal elevations, beneath the sea, varying from 50 to 100 feet in height, may produce currents of which the velocities shall vary from at least 5 or 6 to 15 or 20 miles an hour, provided the depth of the sea do not exceed 800 or 1000 feet." In considering the magnitude of the blocks which might be moved, he found that the force exerted on a surface of given magnitude *increases as the square of the velocity*, and that it "varies as *the sixth power of the velocity of the current.*" But the movements must be repeated for large blocks to travel beyond short distances. In this inquiry, however, we have to deal with smaller quantities and less paroxysmal movements.

where layers of light earthy chalk débris alternate with others of heavy splintery flints, as in the case of the mass of Rubble-drift (or *head*) overlying the Raised beaches of Brighton and Sangatte.

The Brighton beach abuts, like the recent one, against a cliff, over which the drift was shot from the uplands above, not in one sweep, but in a succession of throws, some of which were of sufficient force to move large masses of flints and great blocks of Tertiary sandstone from a distance of two to three miles inland, whilst others had only force enough to carry down the lighter chalk rubble, and impalpable marly sediment often finely laminated, showing that it was deposited in water, and in water, at the time, comparatively still. We thus have, as it were, a measure of the forces in operation during the upheaval, for as the divergent currents, caused by the upheaval of the land through the superincumbent body of water, would vary in velocity and power according to the rapidity of the upheaval, it is evident that the weight and quantity of material moved will be in accordance with the strength and length of those currents. The variations in the structure of the "head" show the movements to have been alternately slow and more rapid, or by fits and starts, though, as there is no break in the continuity of the deposit, it is probable that they were continuous or nearly so. It is also obvious that a body of water 1000 feet or more deep, moving even slowly off the land, would have formed an engine of enormous power, and as I have before remarked, capable, like NASMYTH'S hammer, of exerting that power with the gentlest touches or with almost irresistible force. For the fuller discussion of these points, I must, however, refer to the paper before mentioned, in which these points are described more fully.*

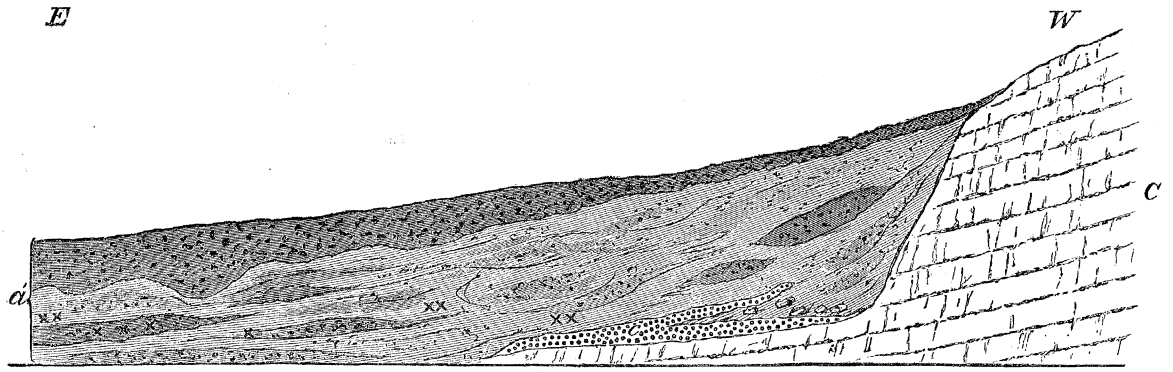
In that paper I have shown that the Rubble-drift is very widely, though generally very sparsely, spread over the South of England. I now propose to show that it may be traced over much of Western Europe and the Mediterranean coasts (see Plate). My own personal observations are limited to parts of France and Italy. I have, however, the less cause to regret this circumstance, as some of the principal exhibitions of it have been explored by other geologists in a way which would have been difficult for a single individual to have accomplished, and their evidence is free from the bias which might be supposed to attach to the advocate of a theory. At the same time there is the disadvantage, that without attention being specially directed to this particular drift, some of its phases may easily be overlooked and passed by, so that further research may prove it to be far more general than here described. It is also to be observed that in continental areas we meet with fresh phases of the rubble-drift, which, while differing from what we find in England, equally bear testimony in the same direction.

* 'Quart. Journ. Geol. Soc.,' vol. 48, p. 331.

The Coast Sections of France.

The phenomena on the north coast of France are very similar to those on the south coast of England. The section of the Raised Beach and overlying Rubble-drift (or *head*) at Sangatte on the northern slope of Cape Blanc Nez is identical with that at

Fig. 1.—*Section of the west end of Sangatte Cliff, near Calais.*



a'. Alternating irregular masses, often contorted, of coarse and fine flint-and-chalk rubble and marl, with layers of light coloured loam (or Loess). The top bed has lost much of its chalky matter, and passes at Sangatte into mere flint gravel. Mammalian remains have been found at xxx, land shells at xx, and a *palæolithic* flint implement at x (others have been picked up on the shore.)

c. Raised beach. A portion of the beach has been caught and turned up in the rubble. At the foot of the old cliff lie large blocks of chalk. *C*. Chalk.

Brighton, but the former is more accessible and better exposed. The raised beach (*c*), which rises about 10 feet above the level of the present beach, abuts, as at Brighton, against an old cliff. It contains very few shells, and those mostly in fragments. The species are the same as those commonly met with in the English raised beaches, and consist of*—

Purpura lapillus.	*Tellina balthica.*
Littorina littorea.	*Mytilus edulis.*
,, *obusata.*	*Cardium edule.*
Modiola modiolus.	

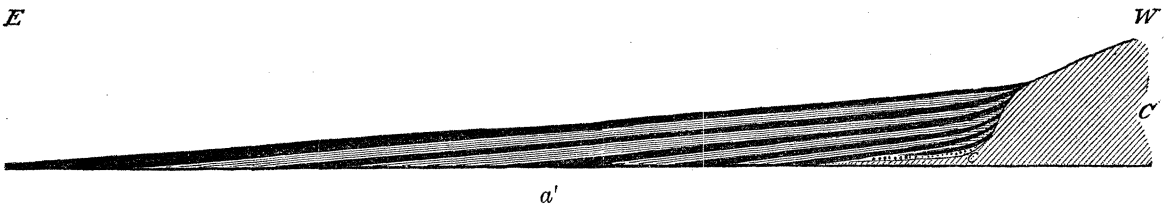
This beach is buried under a *head* consisting of chalk and flint rubble not regularly stratified, but spread out in irregular lenticular masses. In some of these the detritus is coarse and the bedding tumultuous; in others the débris is fine, and even laminated in places. These alternations are repeated several times, but it is not possible to say how often, as the beds overshoot one another, and the lines of demarcation are obscure. The last or upper bed is, however, as at Brighton, the most massive and important,

* M. C. Barrois, in 'Ann. Soc. Géol. du Nord,' vol. 7, p. 182, 1880.

and is the one which has been propelled to the greatest distance. A view of part of this fine section* is given in fig. 1. The section, however, varies with every fall of the cliff. The partial uprooting of a portion of the beach (*c*) is a noticeable feature.

The following diagram will show the successive increments of growth,† supposing them to have been regular and defined.

Fig. 2.—*Diagram to illustrate the mode of formation of the 'Head.'*



The dark bands represent coarse débris, and the light, fine rubble and loam, or derived Loess. The uppermost bed has lost much of its calcareous matter through filtration of the surface waters.

Except at Folkestone and Portland, land Mollusca are very scarce in the English coast sections. At Sangatte they are numerous in places, though limited to the few following species, and to the finer portions of the rubble :—

Helix concinna.	*Pupa marginata.*
„ *pulchella.*	*Arion ater.*
Succinea oblonga.	*Limax agrestis.*

On the other hand, Mammalian remains are scarcer than with us. I have found a few indeterminable fragments of bone, and M. Robbe had in his collection part of the lower jaw of *Elephas primigenius*. Of palæolithic flint implements, several specimens have been found on the shore, and one *in situ* in the rubble.

Another point calling for notice is the distance to which the flint rubble spreads out into the plain, which extends from the foot of the chalk hills to near Calais and Guines. Here, as in the coast-plain between Brighton and Selsea, the calcareous portion of the rubble decreases in amount as the drift ranges from its base on the slope of the hills to the more distant points to which it has been carried. The chalky portion is lost either through solution or broken up by friction and incorporated with the loess or brick-earth. In a pit near Hames I found in the thin beds of ochreous flint, gravel, and brick-earth, to which the rubble-drift is there reduced, fragments of a tooth of the *Mammoth*, and a few specimens of *Pupa marginata*, as in the analogous beds at Upchurch, in Kent.

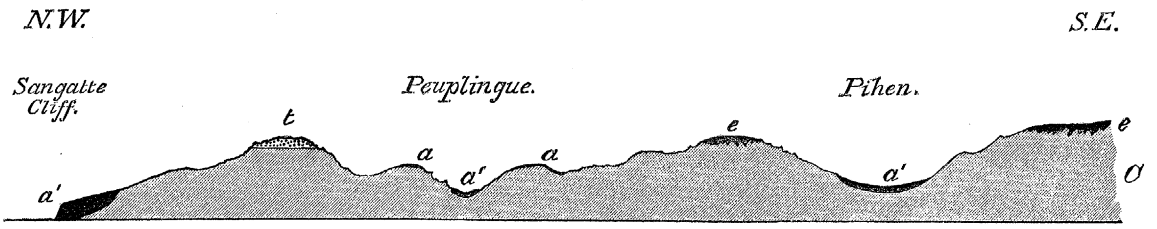
The dry chalk valleys at the back of Blanc Nez exhibit that phase of this drift, so

* I have described this section with its land shells in detail in 'Quart. Journ. Geol. Soc.,' vol. 7, p. 274, 1851, and vol. 21, p. 440, 1865.

† It is the same in the Brighton Cliff (see 'Quart. Journ. Geol. Soc.,' vol. 48, p. 263).

common in the chalk hills of Kent, consisting of trails of ochreous gravel. These are usually attributed to the action of former streams, but they seem to me to be more intimately connected with the rubble-drift, into the main body of which these gravel-streams debouche in the plains below.* Such, for instance, as in the case of the narrow stream of unstratified ochreous gravel from 3 to 10 feet in thickness, which descends the dry chalk valley from near Pihen to Hames, where it enters the broad alluvial plain near Guines. Midway in this stream of gravel M. SAUVAGE found a jaw of *Rhinoceros tichorhinus*.†

Fig. 3.—*Section from Sangatte Cliff to above La Queenvacherie.*



a. Loess. *a'*. Angular rubble. *t*. Lower Tertiary strata.
e. Red clay with flints. *C*. Chalk.

The relation of these streams of gravel to the *head* at Sangatte is similar to that which exists between the *head* (Elephant Bed) at Brighton and the drift in the bed of the valleys on the coast of Rottingdean and other places thence to Eastbourne.‡ They all consist of débris from the surrounding hills, except that in the one case only a trail has been left, whilst in the *head* it has accumulated *en masse*.

There is a small counterpart of the chalk-rubble on the Wissant side of Blanc Nez; and at a short distance out of Wissant on the road to Tardinghen is a hillock of gravel, containing a remarkably large proportion of chert fragments of the Lower Greensand, referable probably to the Rubble-drift.

Thence to Boulogne there is little to notice, the encroachment of the sea having removed all the later coast deposits, only leaving here and there slight traces of angular rubble. To this also belongs a pocket of drift with remains of the Mammoth exposed in carrying the railway through the Kimmeridge clay on the high slopes between the old town of Boulogne and the coast.

Abbeville.—The sections here are of much interest, as they show the relation of the Rubble-drift to the fluviatile deposits of the old river, and likewise to the Raised Beaches. The marine or estuarine bed at Menchecourt is 24 feet above the sea-level, which, allowing for its distance inland, corresponds with that of the Raised Beaches of the Channel. It is here, however, overlaid by the old river beds with fluviatile shells

* In some instances streams may have preceded these later gravel trails.

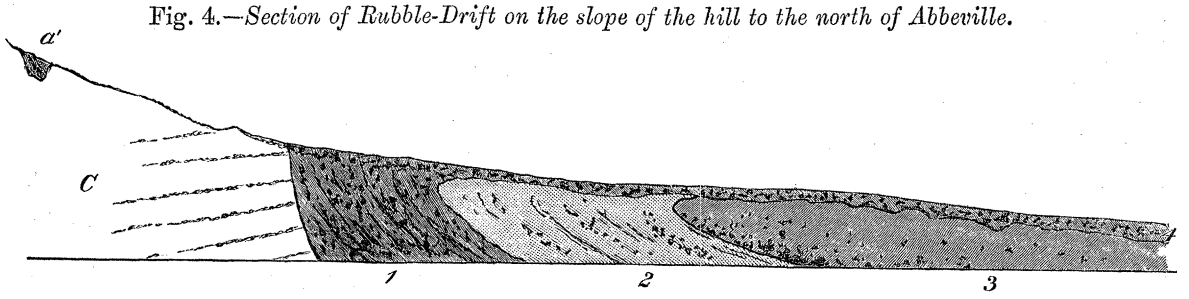
† The specimen is in the Boulogne Museum.

‡ See section in 'Quart. Journ. Geol. Soc., vol. 48, Plate 7, fig. 1.

and Mammalian remains together with palæolithic flint implements, while the bed marked *b* in my original section,* and which, after descending the hill slope, passes beneath the alluvium in the valley, represents the rubble-drift such as is met with on slopes.

Since that section was taken another (fig. 4) very illustrative section, corresponding in its main features with the *head* on the Channel coast, was for a short time to be seen in a road-cutting in the suburb of Mercadé, north of Abbeville. This section showed the same remarkable reversal of the out-cropping edges of the beds, so conspicuous at Brighton and Portland, with additional features of some importance.

Fig. 4.—*Section of Rubble-Drift on the slope of the hill to the north of Abbeville.*



a' {
1. Coarse angular flint- and chalk-rubble.
2. Chalk-rubble with seams of Loess and flint gravel. Land shells (*Helix*—several species, *Pupa marginata*, &c.) abounded in this bed.†
3. Coarse brown loam or brick-earth, with dispersed flint gravel and a seam of it at base.
4. Mixed rubble derived from the underlying beds.

The dip of the base line should correspond more closely with that of the surface.

I saw no Mammalian remains nor any shells other than land shells. The slope above is bare with the exception that about half-way up there is a cavity, *a'*, 10 to 15 feet deep and filled with chalk débris and brick-earth. The summit of the hill is capped by plateau Loess. The total thickness of the beds Nos. 1 to 4 (fig. 4) may be estimated at about 40 feet. This rubble possibly forms, at Porte Mercadé, the bed of ochreous flint gravel in which M. BOUCHER DE PERTHES found a considerable number of palæolithic flint implements.

Besides the unusual abundance of land shells, this section is of interest from the circumstance that whereas at Brighton and Sangatte the rubble is piled up without distinct divisional lines, here, on the contrary, there are well-marked main divisions. To whatsoever cause this may be due—whether to the lesser force of the effluent currents than on the coast where the successive layers are more intermingled and the divisional lines rendered more obscure, or to the position being more sheltered, I cannot say. In any case, we have here three major divisions corresponding with three main

* 'Phil. Trans.' for 1860, figs. 1, 2, p. 284, and Plate 10, section 1.

† On my first visit I had not time to make a complete collection of these shells, and when I returned the section was covered over.

upheavals, besides some minor ones in bed No. 2. This agrees, as a whole, perfectly well with the Brighton and Sangatte sections, where fine marly beds predominate in the central division, with coarse beds below and above, the last one evidently resulting from a stronger propulsion and exercising greater erosive action.

This section strengthens the conclusion forced upon us by the coast sections that the upheaval was not one continuous and uniform movement, but a succession of movements of greater or lesser rapidity, irregular in their action and not long prolonged. By prolonged, I mean continuous movements but of variable rapidity. If there were rests, they did not last long enough to leave marks of shore-wear at these successive stages on the upraised land. That there were pauses is shown by the division of the beds in fig. 4, but they could not have been of long duration.

The Normandy Coast.—Between the Somme valley and Hâvre the coast presents a line of chalk cliffs, closely resembling in all their features those between Brighton and Eastbourne. Like as on those parts of our coast, where the encroachment of the sea has removed the raised beach and left only detached trails of the rubble-drift in the valleys, so on the French coast the erosion of the cliffs, which may be estimated at 1 to 2 feet annually,* has removed all traces of the beach; but of the rubble-drift which overlaid the beaches and ascended higher inland, considerable portions remain in the bed and at the mouth of the valleys of Tréport, Fécamp, and Etretat. This drift also contains at places remains of the extinct Mammalia. At Mers it consists of a mass of loam with chalk-and-flint rubble, as at Freshwater. It is probable also that the great bank of flint shingle or gravel from 12 to 18 feet thick which lies off the Pointe du Houdel, near St. Valéry, and extends along the coast for a distance of about 10 miles, at a height of 16 feet above high tide, originated with the rubble-drift of the Somme valley. At St. Adresse, near Hâvre, the rubble-drift appears to be represented by a bed of slightly subangular flint gravel forming a low cliff extending to the foot of the chalk hills, and connected by a thin trail with the chalk of the hills and with the red clay with flints which caps them.

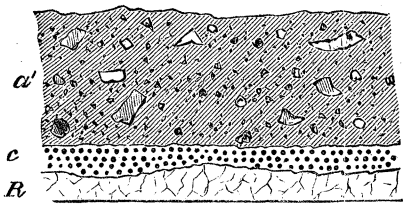
Six miles to the westward of Cherbourg a "head," 25 feet thick, of large angular fragments of the local granitic rocks in a matrix of clay, sand, and Loess, fronts the cliffs. Under it are traces of a raised beach in the form of rolled and water-worn pebbles, but there is no clear section, nor could I find any fossils. Between Granville and St. Paire, is a section showing a small quantity of Rubble-drift on a slope, and under it the broken edges of the rock are bent back in a manner similar to the case I have recorded in Devonshire.

The Channel Islands afford evidence of submergence and upheaval of a character different from that we have hitherto noticed, but no less striking. Both Guernsey

* Lambardie estimated the loss on the Normandy coast at 1 "pied de roi" annually. M. Baude mentions later observations continued from 1800 to 1847, which show that at the Cape d'Ailly, near Dieppe, the loss was 0·80 mètre yearly, but at the Cape La Hêve, near Hâvre, it was only 0·30 mètre.

and Jersey have been surrounded by a Raised beach* overlaid by a "head" of Rubble-drift, though it is only at intervals that remnants of the beach are now to be seen. In Guernsey, sections more or less perfect are shown on the cliff south of St. Peter's, at St. Martin's Point, in Saints Bay, La Pezerie,† Creux des Fées,† Hâvre, Bordeaux,† at Fort Gray, Lihou Fort, and Cobo.‡ Also at a few places on the north side of the island. Amongst the best preserved are those at Lihou passage and Firman Bay, of which latter the following (fig. 5) is a section.

Fig. 5.—*Raised Beach, Firman Bay.*



a'. Head of angular fragments of the local rocks—some of the fragments of large size—in a matrix of loam or brick-earth, 20 feet thick.

c. Raised beach of well-rolled pebbles and subangular blocks of granite, &c., 6 feet thick.

R. Granite (decomposed), 5 feet.

The height of the beach is less than on the English coast, being generally only 5 to 8 feet above the high tide level. No shells are recorded.

The greater part of the Island (as also Jersey) forms a plateau 300 to 350 feet high, of granitic and metamorphic rocks, and is without any commanding heights. This plateau is covered very generally by a deposit of Loess or brick-earth from 5 to 10 feet thick, extending over the highest points of the surface. The Loess is identical with that on the mainland, and that it is not to be confounded with the decomposed granite or other rocks which it overlies, is shown in the following section (fig. 6).

To whichever of the generally assigned causes the origin of "Loess" has been attributed—whether to river floods, or to glacial inundations, or to rainwash—it is impossible to admit that the Loess of Guernsey and Jersey can be attributed to any of them. There are no rivers in either island, and the watercourses are mere small brooks that could scarcely flood the lowest ground, and certainly could never, in present nor past times, have reached the plateau on which the Loess occurs. Nor are there any hills, rising above the general level of the plateaux, the wash from which could have been spread over those plateaux. Nor can it be admitted that it was formed when the island was connected with the mainland, and that the Loess is due

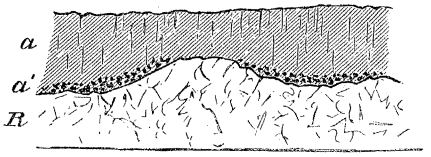
* For notices of the raised beaches and drift beds of these islands, see the papers by Sir W. C. Trevelyan, 'Proc. Geol. Soc.,' vol. 2, p. 577, 1837; by R. A. C. Godwin-Austen, 'Quart. Journ. Geol. Soc.' vol. 7, p. 118, 1851; Ansted's 'Channel Islands,' p. 280–296, 1862.

† These places I give from sketches in my possession made by Mr. De La Condamine.

‡ At Cobo there is a second beach about 30 to 40 feet above the lower one, which latter is the one I have taken for my base line.

to the extension of the land flood-waters, over what was then part of the continental area; for, unless the Loess were older than the raised beaches, it is obvious, as those beaches extended all round the islands, that at the time of the deposition of the Loess, the islands were then, as now, detached from the mainland. The Loess in fact is closely connected with the "head" and not infrequently associated with it. A thin layer of an angular rubble similar to that which forms the "head," is also often to be found at the base of the Loess, and as the rubble is newer than the beaches, so must the Loess likewise be newer, and subsequent therefore to the severance of the islands from the mainland. Further, if the formation of this brick-earth cannot be attributed to floods or to a rain-wash from higher ground, it must have an origin independent of those to which the Loess is ordinarily assigned.

Fig. 6.—*Section on the hill near St. Andrews.*



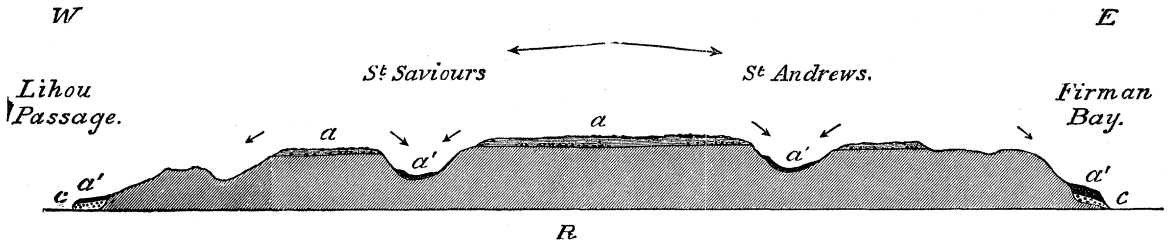
a. Light brown Loess with a few angular rock fragments (*a'*) at base, 4 to 6 feet.
R. Decomposed granite, 4 to 8 feet. The solid rock does not show here.

On the other hand—that a uniform sediment of that character should be formed during such a submergence as we have described, is, owing to the waste of the softer surface beds and decomposed rocks by the advancing waters, what we might expect. This waste was general over all the area submerged, and the waters must have been rendered turbid to a considerable distance from the coast,* so that not only the mainland but the adjacent islands also were covered with a mantle of sedimentary matter deposited during those periods of comparative quiet or lulls, which are shown to have occurred in the formation of the *Head*. The absence of marine remains is readily accounted for by the temporary nature of the occupation of the land by the sea waters, as well as by the circumstance that the waters would be rendered for a time unfit for the habitation of marine life. We shall revert to this subject again when we have to speak of the continental Loess.

If we suppose that the Loess in these islands was deposited during and after submergence, it follows that as the land rose, it would be removed where it was in the way of the effluent currents, and carried with the angular rubble down to lower levels, or to a distance. That this was the case is shown by the fact that the "head," which covers the beaches, consists of angular local rubble, with Loess or brick-earth (derived from the plateaux) as a matrix and forming occasional seams and overlying beds. The following diagram (fig. 7) will illustrate my meaning.

* On the coast of China the sea is coloured yellow to a distance of 100 miles from land by the fine Loess-mud carried down by the rivers.

Fig. 7.—*Diagram Section across the Island of Guernsey.*

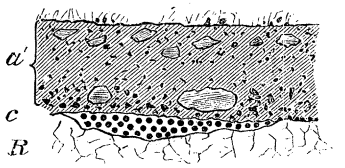


a. Brick-earth or loess.
a'. Rubble-drift or "head."
c. Raised beaches.
R. Slates and granite rocks.

The arrows represent the direction of the effluent currents as the land emerged from beneath the waters, leaving portions of the fine sediment on the plateaux, but sweeping it off the slopes and down the valleys.

Jersey.—In this island there are the remains of a low-level Raised beach at Fort Regent, St. Clements, La Motte, Mont Orgueil, Ann's Port, St. Catherine's Bay, Rozel Bay, and Boulay Bay.* They are covered as in Guernsey by a rubble-drift or "Head," and are about 5 to 15 feet above the sea-level.† They are well seen at Ann's Port and St. Catherine's Bay; the section at the former place is as under.

Fig. 8.—*Section of the Raised Beach and Head on the north side of Port Ann Bay.*



a'. "Head," largely composed of loam roughly bedded, with fragments, and a few angular blocks, of the rocks from the hills above, 12 feet.
c. Raised beach, chiefly of diorite pebbles, 2 feet.
R. Diorite rock.

In none of these beaches have there been found any pebbles of foreign origin, with the exception of fragments of chalk flints, as in the beaches on the Devon and Cornish coasts; nor did I see any shells, nor have any been recorded, except by Mr. T. W. Danby, who discovered in a Raised Beach on the Hermitage Rock, St. Aubyn's Bay, "an abundance of shells of species now flourishing on the adjacent shore." The Beach, which was about 6 feet above high water mark, has since been concealed by the harbour works.‡ In Jersey, as in Guernsey, brick-earth or Loess is widely spread

* Professor Noury mentions besides, Portelet Bay, Crabbé, Petit Port (Vicard): he assigns a different origin to the beaches, 'Géologie de Jersey,' p. 162, 1886.

† Dr. Dunlop informs me that there are some beaches considerably higher, but these I have not seen.

‡ 'Geol. Mag.,' for 1876, p. 143.

and covers the highest parts of the island. It likewise has been referred to disintegration of the rock *in situ*, or to rain-wash. But as I have explained in describing Guernsey, the height at which it occurs, precludes the possibility of its being rain-wash, while though superposed on the disintegrated rock surfaces, the absence of the quartz grit of decomposed granite or syenite, and the presence of angular rock fragments or rubble at its base,* equally show its special and independent origin. This was the opinion of Professor ANSTED,† who says "In addition to the soil derived from the decomposition and disintegration of the rocks in all the island, there are occasional deposits of some extent of brick-earth and potter's clay." It is also the opinion of Dr. A. DUNLOP,‡ who found that in one place the brick-earth had a thickness of 50 feet. No Mammalian remains have been found in these drifts, which tends to confirm the early separation of the islands from the mainland.

Similar phenomena are exhibited on the French coast. M. TRIBOLET§ says that, on the small island of Bréhat on the north coast of Brittany, there are deposits of loam about 2 feet thick, overlying the granite, "completely identical with those which are known in Switzerland and Germany, under the name of *Loess*." It there contained a few land shells (*Pupa, Helix, Succinea*, &c.), with the small concretions termed *race*, so common in Loess. M. TRIBOLET found the same Loess on the adjacent mainland, and supposed that it might have been deposited by the water descending from small glaciers on the inland hills, but these are of small height and show no sign of glacial action. The other reasons I have applied to the Channel Islands with respect to its special and local origin, apply equally to the island of Bréhat.

One feature that I failed to notice in Guernsey occurs in marked distinctness in Jersey. This is the distance to which the "head" has been propelled from its base. The section at the islet of La Motte is even more illustrative than that at Godrevy in Cornwall, which I have before described.‖ This islet lies $1\frac{1}{2}$ mile south-east of St. Heliers, on a part of the coast where the shore is low, but rising gradually inland to a height, at Mont Ubé, of 149, and at Prince's Tower, $2\frac{1}{2}$ miles inland, of 200 feet. A rubble-drift descends the slopes of Mont Ubé and St. Clements (160 feet) and forms a small low cliff on the coast, while at the distance of about 1000 feet from the shore, and accessible at low water, is the small, flat islet of La Motte. It is only a few acres in extent, and consists of a base of diorite, capped by the remains of an old beach, overlaid by a mass of rubble-drift or *head*, the section of which is very similar to that represented in fig. 8. It consists of—

* At COPP's brickfield I found one to three feet of angular rubble under several feet of brick-earth, and at the base decomposed granite *in situ*.

† 'The Channel Islands,' p. 296; see also pp. 279–295.

‡ 'Quart. Journ. Geol. Soc.,' vol. 45, p. 118, 1889.

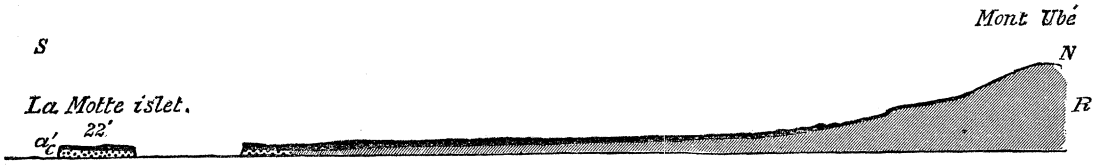
§ 'Ann. Soc. Géol. du Nord,' vol. 5, p. 100, 1878.

‖ 'Quart. Journ. Geol. Soc.,' vol. 48, p. 281.

1. "Head" of angular fragments and small blocks of diorite and syenite, passing down into débris of decomposed syenite or granite (chiefly at its base), mixed with more or less loam or brick-earth, and containing small flat calcareous concretions (*race*) and a few rolled pebbles derived from the beach.	6 to 8 feet.
2. Raised beach, formed of pebbles of diorite and red granite or syenite. There were no shells to be seen. Remains only in places.	6 to 12 inches.
3. Diorite	2 to 3 feet.

The syenite and diorite fragments in the rubble are derived from the hills of the adjacent coast, while the brick-earth which caps those hills forms the chief portion of the rubble matrix. Notwithstanding the slight difference of level and the very small gradient of the slope from the inland hills to La Motte, a considerable spread of rubble-drift has been propelled thus far out (fig. 9), which, I conceive, could only have been effected by a strong effluent current, passing from the mainland sea-ward during upheaval of the land. The hills are so low and distant that no snow-slide could possibly have effected this transport.

Fig. 9.—*Section from La Motte to Mont Ubé.*



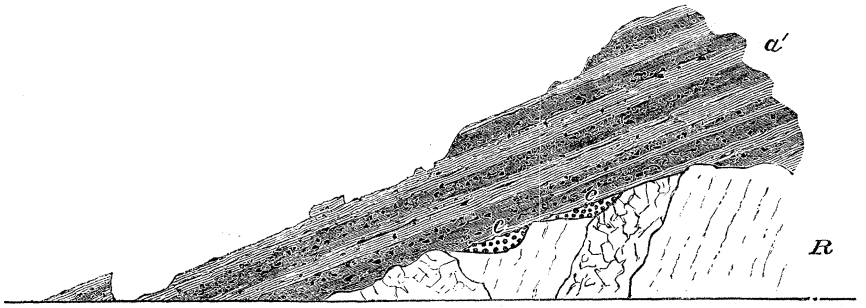
a′. Rubble-drift, composed of granitic and diorite débris in a brick-earth or Loess, covered by a sandy earth and soil.

c. Raised beach—only portions of this remain.

The phenomena, however, are readily explicable on the assumption that, as with the *head* at Brighton and Sangatte, the driving force was that of a superincumbent body of water, flowing outwards. As at Sangatte, the forcible impact of the *head* on the beach has led to the incorporation of fragments of the beach in the *head*.

Alderney.—I did not visit this island, but an unpublished section, taken many years

Fig. 10.—*Section on the Coast of Alderney* (De La Condamine).



a′, Rubble-drift or Head; *c*, Raised Beach. No description is attached to Mr. De La Condamine's sketch, but this drawing, compared with his other drawings, leaves me in no doubt of its meaning. The rubble seems partly consolidated.

ago by the Rev. H. M. De La Condamine, gives what seems to me a very correct representation of a rubble-drift on a slope, covering the remnants of a raised beach.

We have seen that after the deposition of the angular rubble the land on our Western Coasts was left considerably above the level at which it now stands, so that the land area was much enlarged. Such likewise appears to have been the case with the Channel Islands, which are fringed by submerged forests, like those rooted on the rubble-drift of Devon and Cornwall. On this surface, flint flakes and Neolithic implements, together with the remains of Deer, &c., are found, but no traces of Palæolithic Man have been discovered on or around the Islands.

Brittany.—M. Ch. Barrois has shown* that in Finisterre, the coast is fringed in many places by Raised Beaches at a height of from 10 to 30 feet above the present beach, and he describes one in particular in the Bay of Kerguillé, not far from Brest, which may be taken as a type of the rest. It lies against Silurian rocks and contains pebbles (elsewhere there are boulders) chiefly of Palæozoic and Plutonic rocks, with numerous pebbles of white quartz and some chalk flints. M Barrois considers that the pebbles and boulders of these Raised Beaches are derived in part from the local rocks, whilst others, which comprise a great variety of porphyries, are from rocks in the hydrographical basins of the adjacent rivers, which include the Loire, and he attributes their transport to the action of coast and river ice at the commencement of the Quaternary period.

I am not, however, satisfied that the drift of the shingle was altogether from that direction, for besides the pebbles of porphyry and of basalt foreign to the district, and which M. Barrois supposes may have come from the central plateau of France, there are upper chalk (Senonian) flints, showing a transport from the Coast of Picardy, or from the eastward, which would agree with that which then prevailed on the English coast. A current from the eastward would account also for the foreign boulders like those on the Sussex coast. Another point of resemblance between the French and English beaches, is the often enormous size of the pebbles, which form true boulder beaches.

M. Barrois traces the extension of these beaches, and of pebble banks derived from them, along the coast of South Brittany.† M. Durocher‡ has also figured a well-marked Raised Beach, 12 to 15 feet above the sea level, but apparently without any overlying detrital matter, and without shells, at the mouth of the River Vilain.

Thus far there can be no doubt of the synchronism of the land movements at the later Quaternary period, on both sides of the English Channel, but as we proceed further south, the breaks in the continuity of the beaches become longer, and the

* 'Soc. Géol. du Nord,' vol. 4, p. 186, 1877.

† A short notice by M. T. Héna ('C. Rend.,' p. 1370, 1874) indicates the presence of a Raised Beach and *head* on the shores of the Côtes du Nord.

‡ 'Bull. Soc. Géol. de France,' 2e sér., vol. 6, p. 212, 1849.

evidence less conclusive. This may be partly due to the fact that the coasts on the Bay of Biscay and of Portugal being more exposed to the severe westerly gales, the old beaches have generally been destroyed, and remnants only of detrital *head* or Rubble-drift left.

The Coast south of Brittany.—In the Island of Noirmoutier,* on the coast of La Vendée, the "Quartzite du Cobe" forms a low cliff, 15 to 20 feet high, against which abuts what from description seems to be a mass of angular rubble-drift rising to the height of 10 to 25 feet above the sea-level, but without a Raised Beach. On *the coast between Biarritz and St. Jean de Luz*, I saw no Raised Beaches, though at places there are traces of a Rubble-drift. This is well marked at the entrance of the valley at Bidart, where it forms a slope of angular débris derived from the local strata and from the plateau gravel. There is another section at the mouth of a small river south of Bidart where the débris forms a thick roughly stratified mass of gravel and loam (or Loess) inclined on the hill side.

The evidence, though slight, is sufficient to show that on the south-western coasts of France, the Rubble-drift is present, thereby indicating the operation of the same common cause which affected the coasts of the Channel. More striking evidence, however, to the same effect, but of a different class, exists in the interior of the country, and on the south coast, some of which we will now describe.

Inland Forms of the Rubble-drift in France and Belgium.

These embrace, 1st, the high-level or plateau Loess; 2nd, the angular drift or breccia on slopes; and 3rd, the ossiferous fissures.

The Loess.—Few questions in Quaternary Geology have given rise to more frequent discussion than the origin of the Loess.† It was suggestively considered by LYELL,‡ and a critical review of the various opinions concerning it has been given by Professor JAMES GEIKIE.§ The more general expressions of Continental opinion will be found in the works of M.M. DE LAPPARENT‖ and CREDNER,¶ and others. Here we need only consider its origin, and must refer for details to the original memoirs.

There is a general agreement amongst geologists that the Loess of the great river valleys is, up to the height to which the old rivers rose, due to floods connected with the melting of the ice and snow of the Glacial period. The Loess, however, is not

* 'Mém. Soc. Géol. de France,' vol. 1, p. 325.

† M. D'ARCHIAC has given an excellent summary up to the year 1848 in his 'Histoire des Progrès de la Géologie,' vol. 2, chapters iii.–vi.

‡ 'Antiquity of Man,' 4th edit., chapter xvi.

§ 'Prehistoric Europe,' chapters ix. and xi.

‖ 'Traité de Géologie,' p. 1084.

¶ 'Traité de Géologie et de Paléontologie,' French Translation, pp. 639–641.

confined to the limits of those valleys, but occurs on the watersheds which separate them, as, for example, on the pass above Ham, between the basins of the Somme and the Oise, at a height of 184 feet above the sea-level. Not only so, but deposits of Loess cover the plateaux between these and other river-valleys of the north of France and Belgium which rise to the height of 400 to 650 feet, whilst in central France the Loess on the hills and plateaux attains a height of 700 feet, and in the neighbourhood of Lyons of some 1300 feet (about 400 metres).*

But this is far from showing the limits of height which it attains in Central Europe. In the upper valleys of the Rhine and Danube it rises to altitudes of not less than 1500 feet, and even higher in some parts of Central and Eastern Europe. The Odenwald, the Taunus, and other upland tracts, are cloaked with Loess up to a considerable height. The Danube and many of its tributaries flow through vast tracts of it. Lower Bavaria is thickly coated with Loess, and it attains a great development in Bohemia, Austria, and Moravia—in the latter country rising to an elevation of 1300 feet. It is equally abundant in Hungary, Galicia, and Transylvania, and in the valleys of the Carpathians it stretches up to heights of 800 and 2000 feet.

That the great rivers of Europe were, during the Glacial period, laden in times of flood with fine sediment which they deposited to certain heights in the valleys through which they flowed, admits of little doubt. It is the view which, with other geologists, I have myself advocated.† It is impossible, however, to suppose that that Loess which lies spread in thick sheets over whole countries, covering them as though with a mantle, and rising to great heights, can, with the hydrography of those countries as it now exists, or as it existed in Glacial times, be the result of any ordinary river floods. The whole question is too large to be discussed here, but I would draw attention to some of the objections which attend its reference to river floods, with the river valleys and the land gradients in the form they now exist.

To meet the difficulties, two suggestions have been made. The one is that at the time of the deposition of the Loess "the amount of depression and re-elevation in the central (mountain) region was considerably in excess of that experienced in the lower countries or those nearer the sea, and that the rate of subsidence in the latter was never so considerable as to cause submergence or the admission of the sea into the interior of the continent by the valleys of the principal rivers."‡ It was supposed that the depression might have been at the rate of five feet in a century in the mountains, and only as many inches in the same time nearer the coast, and that the Loess was accumulated during subsidence and removed during the upheaval of the land. But there is nothing to corroborate this view, and even supposing that these movements might to some extent have equalized the levels, the height to which

* 'Bull. Soc. Géol. Franc.,' 2nd ser., vol. 16, p. 1057.

† 'Phil. Trans.,' 1864, p. 247.

‡ 'The Antiquity of Man,' p. 383.

the waters would still have been heaped up whilst wide valleys remained open with rivers offering ready channels of escape, is not easy to understand. Other objections to this view are urged by Professor J. GEIKIE.

The other suggestion is that the great rivers of Europe had been dammed back for a time by the advance* of the great northern ice sheet, or, as others have suggested, by the block caused by great masses of ice carried down by these rivers at the break up of the ice in spring, as now of frequent occurrence in Arctic regions. The former suggestion is inadmissible, because, whatever the cause was, it was one that affected the whole central area, whereas a northern ice sheet would only have blocked the rivers flowing north, and not those flowing south. The other suggestion of ice-dams in the rivers might answer to some of the conditions, but would scarcely meet the case where the areas covered are so vast and high. We should have expected also to find greater traces of destructive and transporting action. If the Loess had been confined to narrower valleys this cause might have been available, but the extensive plains and high hills over which it extends renders it difficult to imagine that river floods alone could have spread such a mantle over large portions of Europe. For these reasons, amongst others, I do not think that any land-flood hypothesis will satisfactorily account for all the phenomena.

[More lately the Eolian theory, proposed by the Baron F. VON RICHTHOFEN† to account for the origin of the loamy deposit which covers large surfaces in China and some adjacent districts, has been thought applicable to the European area. This deposit is described by the Baron as perfectly similar to the Loess of Europe in composition, structure, and mode of occurrence. It extends from the alluvial plains, only a few feet above the sea-level, to heights of 8000 feet and more; and, while thin in some places, it attains in others a vertical thickness of 500 to 1500 feet. It abounds in land shells, and contains also the bones of animals of the same genera, and mostly of the same species, as those that now live in steppes or on grassy plains. He ascribes this remarkable deposit to the action of the high winds that sweep over these parts of Asia and drive before them clouds of fine dust which in a few hours form thick dust-drifts, burying in them the land shells of the district and the bones of the animals left on the grassy surface. From this, I infer that the bones of the skeletons should be found not far apart, and sometimes in close relation to the skeleton, but whether or not this is the case, or whether any of them belong to extinct species, I cannot gather.

Of the power of these winds and the height of the country devastated by them, there is ample confirmatory evidence. A recent traveller in these regions‡ says that on the high plateaux of Thibet and North-Western China, the winds are often fearful,

* T. BELT, 'Quart. Journ. Geol. Soc.,' vol. 30, p. 490, 1874; 'Quart. Journ. of Science' for January 1877.

† 'Brit. Assoc. Rep.,' 1873, *Sect.* p. 86; 'China,' vol. 7, p. 97, 1877; 'Geological Magazine' for 1882 p. 293. See also R. PUMPELLY in 'Amer. Journ. Science and Arts,' 3rd series, vol. 17, p. 133, 1879.

‡ 'Across Thibet,' by M. BONVALOT, English translation, 1891.

and when the storm bursts, the valleys viewed from a height, disappear in the dust which forms into waves that the tempest hurls in all directions, building up mountains of sand. These vast sandy tracts are dotted with tamarisk trees, which serve to stay the moving surface of the desert. M. BONVALOT attributes these dust-storms which were experienced up to heights of 14,000 feet or more, moving enormous waves of the sand eastward, to the erosive power of the winds on low chains of crumbling marls.

The great height of the land, the vast thickness and the irregularity of the deposit, and the absence of river- or sea-shells, preclude, as RICHTHOFEN justly observes, our looking upon this deposit as due either to marine or fluviatile sedimentation, whilst the irregularity in its dimensions, the variable and great heights at which it occurs, and the character and position of its entombed organisms, are all such as might ensue from the action of devastating winds and overwhelming dust clouds. If we could suppose snowdrifts to be consolidated and remain in permanence, the annual increments would in a period comparatively short, fill up valleys and accumulate in vast masses in the more sheltered places, and it is in manner like this that I presume we are to understand that the so-called Loess of China has been formed.

But there are many conditions at variance with those of the European Loess. Amongst them, it may be observed, that the latter is generally but from 10 to 50 feet thick, and only occasionally attains a thickness exceeding 100 feet or attains the wind-devastating heights of the other. The European Loess also exhibits not infrequent traces of water action, and the organic remains are not in their original position and entirety, but are scattered and dispersed. The bones of the animals especially are almost always found single, often in isolated fragments, and are very few in number, whereas if buried by the dust, as we presume they were in China, on or near the spot where they died, the whole skeleton, more or less entire, should be found *in situ*. Further, the climatal conditions under which the two deposits were formed, seem to have been entirely distinct.

While, therefore, I would accept Baron VON RICHTHOFEN'S explanation for the remarkable wind-formed deposit of China and Central Asia, it does not seem applicable to the Loess of Europe.*

Dr. A. NEHRING† describes a Loess in Northern Germany which claims to have some points of analogy with that of RICHTHOFEN, but the evidence seems only of local application, and not to be generally conclusive. The Mammalia he names are mostly the ordinary species of the Quaternary fauna in Western Europe.—J.P., *April*, 1893.]

The plateau Loess in France‡ and Belgium is often divisible into two parts. In some cases this feature (which may be also occasionally seen in England) is due to secondary

* Other objections are stated by Professor JAMES GEIKIE in "Prehistoric Europe," 2nd edit., pp. 165, 244.

† 'Geol. Mag.' for 1882, p. 570, and various previous papers in German periodicals.

‡ Amongst the many other papers on this subject those of MM. HÉBERT and DE MERCEY for the north of France should be consulted.

causes and not to original structure. It is where a homogeneous bed of Loess, say from 10 to 15 feet thick, has, by the long continued action of the rainfall, been so modified in its upper part by the removal of all soluble matter, that the residual insoluble argillaceous and siliceous matter, with the iron oxide in an altered state, assumes the appearance of a separate bed. This upper division is known as the *terre à briques*, and the lower is the *ergeron* of the Belgian geologists. There are, however, cases in which the distinction is real, and the lower bed seems to be of a different age from the upper and may be due to an earlier glacial drift.

M. A. Briart* also points out that in Belgium, besides the ordinary river-valley Loess, there is a mid-level Loess, which he names *Limon des plaines moyennes*, as well as a high-level Loess, or the *Limon des hauts plateaux;* and, though he sees in these a great lithological analogy, he considers them distinct in point of time. He says that, whereas the plateau Loess is unfossiliferous, the Loess of the valleys and slopes contains abundant remains of the ordinary Quaternary Mammalia, together with land shells (*Helix*, *Pupa*, and *Succinea*†). He further states that this mid-level Loess frequently rests on an angular and sandy drift of débris derived from the adjacent local rocks. As these are the characters of one phase of the Rubble-drift, it is not improbable that the deposit to which M. Briart refers may be the equivalent of the Faversham, Upchurch, and similar beds in the Thames Valley.

I take this mid-level rubbly Loess to have been formed, like the "head" and the angular rubble on slopes, during the emergence of the land. The results during submergence were different. As the waters then gradually crept up the valleys they would have abraded portions of the softer strata and the older drift beds, including the river-valley Loess, and so become charged with sediment, which, as the turbid waters rose, would be carried to higher grounds, and there be deposited in intervals of rest and where the currents were weakest.

South of the Alps Professor F. Sacco‡ has also recognized similar divisions of the Loess in Piedmont. He describes (1) a Loess of the plains of fluviatile origin; (2) a Loess of the hills of meteorological origin: the latter, which attains a height of 400 metres and contains sixty-two species of land shells, he assigns to the close of the Glacial Period; (3) a high-level Loess of the mountains with remains of the Mammoth. In Spain, south of the Eastern Pyrenees, there is also a large development of Loess. The general conditions seem, in many cases, to point to some connection between the high-level Loess and Alpine ranges.

Let us now see what the consequences of this gradual submergence would be. The mountains of Europe were still loaded with the ice of the Glacial period, and the rivers surcharged with the silt from the great glaciers and abraded lands. The volume of

* 'Ann. Soc. Géol. de Belgique,' vol. 18, Mémoires, 1892

† M. Briart adds *Limnea* and *Planorbis*, on the authority of M. Ladrière, but M. Ladrière's correl - tions have yet to be confirmed.

‡ 'Bull. Soc. Géol. France,' 3rd ser., vol. 16, p. 229, 1888.

sediment with which the surrounding waters were charged became, as the flood waters advanced, gradually greater; while the height which the Loess reaches in the valleys of the great Alpine-born rivers would indicate that the submergence was probably not less than from 1500 to 2000 feet. It was, in any case, sufficient to cover all the lesser inequalities of surface over which the Loess spreads, and accords with the assumption that, whatever the cause was, it acted equally in all directions round certain central areas. It is also in accordance with the singularly homogeneous character of the Loess, which is such as would be due to the agency of a common fluid medium.

As the waters, on the upheaval of the land, retreated, they carried with them a portion of the sediment deposited on the heights, which again would be re-deposited at lower levels on the slopes and plains that were least under the influence of the effluent currents. I do not imagine that at any time this deposition of this Loess was sufficent to fill the great valleys of the Rhine and Danube, but only to drape their contours, while the scour of the effluent waters kept the main channels free. Not only have great valleys been thus scoured, but large tracts in the midst of Loess-laden countries have been swept bare by the great volume and more rapid flow of the retreating waters. For wherever the velocity of the effluent currents was less than 8 feet per second, the precipitation of fine sediments may have taken place, but where the channels were more contracted, and the currents exceeded 8 feet per second, no such deposit, or but little, need have been left on the land, so that under similar flood conditions, these deposits might cover certain large tracts, whilst adjacent tracts might remain bare of them.

It may be objected that the deposit of Loess is so great that it could not have been formed in the short time I would allow for the submergence. But it must be understood that I look upon the Loess, as a whole, as belonging to more than one period, in the sense that it was, in the main, primarily a valley deposit in time of floods; and, secondly, as just described, a reconstruction in great part of a more general character —the one the accumulation of long ages, and the other of brief time. The first is a case of ordinary sedimentation; the other, one of wider sweep and mainly of redistribution. It is well known how one heavy rainfall will remove and re-deposit many feet of an alluvial deposit like the Loess. Striking evidence of this is afforded by the changes in the valley of the Ganges and its tributaries, described by Mr. JAMES FERGUSSON.* Old channels have there been filled up and new ones formed with extraordinary rapidity; and, on the banks of the Brahmapootra, "hundreds of miles" of alluvial land are swept away every year and re-deposited lower down the river course. A few seasons suffice to form deposits 40 feet thick, whilst little addition is made in other places. We may suppose, therefore, that as the ocean waters, charged with silt, advanced up the great river valleys, and met the river waters laden with glacial mud, a vast homogeneous mass of sediment would be the result, and this would necessarily lodge over

* 'Quart. Journ. Geol. Soc.,' vol. 1,9 p. 321.

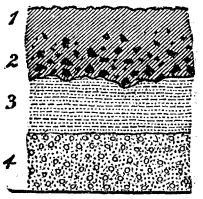
the areas most free from the scour of the varying currents and retreating waters, or in the more sheltered places.

The cause here assigned for the origin of this section of the Loess accords with that to which I have attributed other phenomena of a different class on heights in France and elsewhere, and with the facts we have noted in the Channel Islands. Like also these other divisions of the Rubble-drift this Loess contains only the débris of a land surface, consisting of *land shells* and the remains of the *later Quaternary Mammalia*, together with which there have been occasionally found a few fragments of the human skeleton.

Rubble-drift on Slopes.

The North of France and Belgium.—I have before referred to some of the more striking sections of this drift on the coast-line in the North of France. We may notice a few of the inland exposures and also one that occurs in a conterminous district of Belgium. The character and position of some of the Quaternary beds in the province of Namur, described by M. DUPONT, agree exactly with those of the Rubble-drift in the South of England. His "*Argile à blocaux*" and "*Limon homogène*" are counterparts of our angular drift and brick-earth, and, as with us, they vary accordingly as they are spread out in valleys and plains, or are massed on the slopes of the hills.* The following section (fig. 11) gives the succession in the valleys.

Fig. 11.



1. Loam, not stratified.
2. The same with angular rock-fragments.
3. Loam, stratified, fluviatile.
4. Bed of rolled pebbles, fluviatile.

M. DUPONT says of the bed No. 2, which constitutes his "*Argile à blocaux*," that it has deeply eroded the underlying beds, and when it has caught up pebbles from those beds, a great number are broken, and the fractured edges remain sharp. When overlying hard rocks these are unaffected by it. There is an absence of stratification, though in places there is a sort of rude (*torrentielle*) bedding. The angular fragments (sometimes including blocks of large size) are all of local origin, and there are none transported from a distance. The loamy matrix varies in colour and substance according to the nature of the local rocks from the surface of which it is derived. The loam No. 1 forms a brick-earth, and is

* 'Bull. Soc. Géol. France,' 2nd Ser., vol. 24, p. 77, 1866; and 'Bull. de l'Acad. Roy. de Belgique, 2nd Ser., vol. 21, No. 5.

intimately connected with No. 2, into which it passes by insensible degrees. It generally accompanies bed No. 2, but it also extends beyond it and attains to much greater heights, often covering the country like a mantle. This agrees exactly with some of the main physical characters of the rubble-drift in England. The organic remains are too variable a quantity to affect this conclusion. None, in fact, have been recorded in the rubble bed in this district, except when in connection with the caves; but *Helix concinna*, *H. hispida*, *Pupa marginata*, and *Succinea oblonga*, have been found in the loam (1). M. DUPONT further describes how intimately much of the Loess of Belgium is connected with these beds. The observations of M. BRIART (*ante*, p. 923) confirm this view, which is one I shall have occasion to develop more fully presently.

M. DUPONT also shows that in the neighbourhood of Dinant, the "*Argile à blocaux*" is frequently present, and forms a well-defined division between the cave beds and the deposits of the Stone Age. One of the most typical of these caves is that of the "Trou du Frontal"* on the banks of the Lesse, and which I had the opportunity of visiting with M. DUPONT, not long after its exploration. A copy of this section, and of his description of it, is given below (fig. 12).

M. DUPONT divides the cave deposits into two groups, assigning beds 3 and 4 to the Mammoth age, and No. 2 to the Reindeer age in consequence of the scarcity in this latter of the larger Quaternary Mammalia and the abundance of Reindeer remains. But is not this preponderance caused by the circumstance that during the deposition of the beds No. 3, the cave was frequently flooded and only occasionally inhabited by Carnivorous animals or visited by Man; whereas, after the deposition of those beds, the cave, or rather shelter, being then out of the reach of the floods, was often frequented by Palæolithic Man, and became consequently the floor on which were scattered the flint tools he used and the remains of the animals on which he fed, such as the Reindeer, Wild Boar, Ox, Horse, &c., and the other animals named by M. DUPONT?

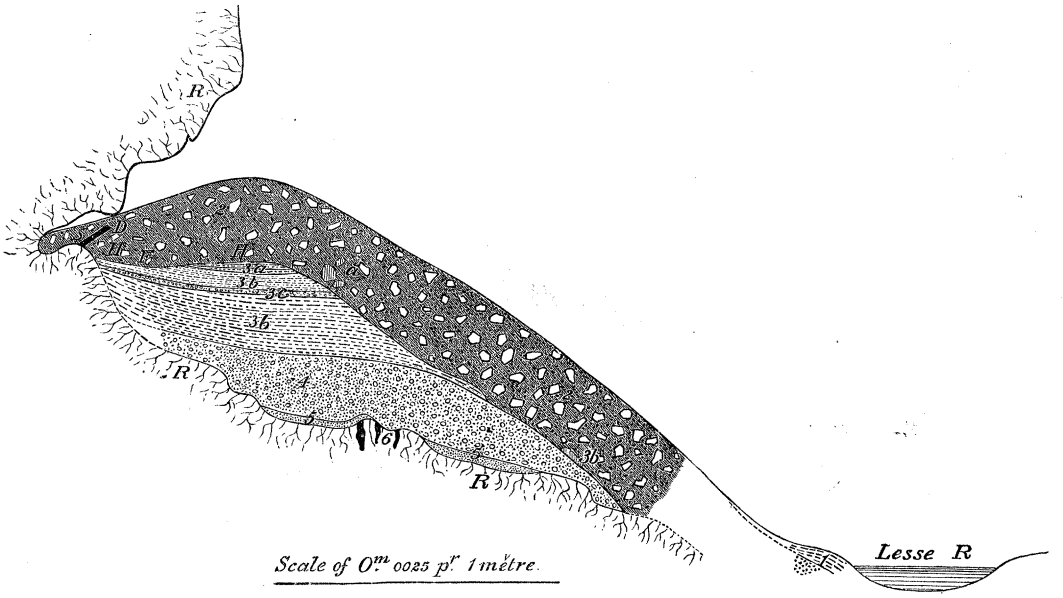
The contents of caves necessarily vary according to their occupants for the time being. The spoil of the Hyæna will differ from that of the Bear, and those, again, from that of Man. For this reason I doubt whether the caves afford a just means of classification. Outside the caves the same animals may have inhabited the woods and plains during the whole of the late Glacial or Post-glacial time, and that seems to me the conclusion to be drawn from the other evidence than that of caves. Certainly the Reindeer existed throughout that period, though its distribution may have varied; while the contents of the rubble-drift, when not connected with the caves, show that the Mammoth and other great extinct Mammalia were common at the time of its formation, and, therefore, at the time of the so-called Reindeer Age.

Though I should agree with M. DUPONT in considering the "*Argile à blocaux*" distinct from the cave beds beneath, I look upon the organic remains in that deposit

* 'Bull. Acad. Roy. de Belgique,' 2nd Ser., vol. 20, No. 13, Plate 3; and 'L'Homme pendant les Ages de la Pierre dans les Environs de Dinant-sur-Meuse,' 2nd edit., 1872.

as derived from an old cave floor and hearth (H) spread on the surface of the fluviatile beds No. 3, and caught up by the angular débris as it swept down from the heights above, just as in the same rubble (No. 2) there are fragments of clay and gravel (*a*, *b*) derived from the beds 3*a*, 3*b* beneath it. Not but that this rubble may, as elsewhere, have some remains proper to it, but their origin in this case appears to me to be clearly from the denuded beds. It is important to notice in connection with

Fig. 12.—*Section of the "Trou du Frontal"* (DUPONT).*



1. Recent alluvium.
2. Yellow clay and light grey earth, with angular fragments of limestone, containing at *S*, Human sepulchral bones, and at *H*, débris of repasts and industrial works of (palæolithic) Man; *D*, flagstone shutting the sepulture; *E*, hearth; *a*, *b*, fragments of clays from Bed 3, eroded at the time of deposition of No. 2 (*Argile à blocaux*; Reindeer age).
3. Stratified argilo-arenaceous deposits (fluviatile); 3*a*, reddish yellow clay; 3*b*, seam of gravel; 3*c*, grey clay alternating with yellow sands
4. Rolled pebbles derived from the Ardennes (fluviatile)
5. Greenish quartzose sands, with traces of peat

} Mammoth age.

6. Red clay in veins. *R*, rock.

(Bed No. 2 corresponds with our Rubble-drift, and Nos. 3 and 4 with our fluviatile valley-drifts.)

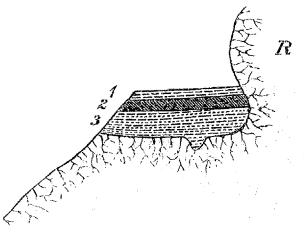
this section these clay fragments, *a* and *b*, for it shows, as I have had occasion to note everywhere with the Rubble-drift, that the movement has been from above downwards, and that it has been of such short duration that substances so soft as these should have been preserved intact in the body of the rubble. Had the agency been running water, or subaërial, these fragments must have been disintegrated and lost in the mass. Nor would ice have answered the purpose. The case is in some degree analogous to the Gower Cliff sections, where the Rubble-drift has masked the

* 'Cong. Int. d'Anthrop. et d'Archéol. Préhis. à Bruxelles,' 1872, Plate 31.

entrance to the caves, and destroyed portions of the "Raised Beach." I should therefore consider the remains of the animals here found in the "*Argile à blocaux*" to be foreign to that deposit, and as belonging to the Mammoth group. It was only near the base of this angular rubble (2) that these derived remains were found.

Another point of analogy rendered evident by the sections of M. DUPONT, is the abrupt transition from the Palæolithic to the Neolithic deposits. This agrees precisely with what we have witnessed on the English coasts, where the stanniferous gravel of Cornwall and the angular rubble of Devonshire sharply separate the Raised Beaches and sands of Quaternary age from the alluvial deposits and forest growth of the recent period. The following (fig. 13) is one of the sections,* where the two deposits are seen in superposition.

Fig. 13.—*Section of the Trou du Sureau, Montaigle* (DUPONT).



1. Débris with Neolithic flints, and animal remains of the same age.
2. Clay with angular fragments (*Argile à blocaux*).
3. Fluviatile beds with animal remains of Quaternary age.

[I am not prepared with evidence relating to the Rubble-drift eastward through Germany, or to the northward of Belgium, but I may mention that Dr. LORIÉ, of Utrecht, has called my attention to a deposit which covers some parts of North Holland, and is described by him under the head of "Phénomènes pseudo-glaciaires."* This drift, which seems to represent some phase of the Rubble-drift, is referred by Dr. LORIÉ to the warp of TRIMMER, and trail of O. FISHER.—J. P., *July*, 1893.]

The Paris Basin.—Several sections of this drift have been noticed in the Paris Basin where deep valleys cut through high plains of Tertiary strata. The steep slopes and escarped edges of these valleys are generally covered with débris or a talus of recent formation, but sometimes of Quaternary age. The latter occasionally contains Mammalian remains, as at Étampes and La Ferté-Aleps (Seine-et-Oise), to south of Paris, and at Auvers and l'Isle-Adam in the valley of the Oise to the north.

At Auvers and l'Isle-Adam the late distinguished geologist M. E. HÉBERT discovered remains of *Hyæna spelæa, Felis, Elephant, Horse, Ox, Irish Elk, Red Deer, Fox? Antelope? Hare* and *Rabbit*:† at Étampes there were *Rhinoceros* and *Bear* also. The bones, which were numerous, were generally much broken. The rubble

* "Contributions à la Géologie des Pays Bas," pp. 70–76. Extrait des 'Archives Teyler,' Sér. ii., Tome iii., Plate 2, 1re partie, 1887.

† 'Bull. Soc. Géol. de France,' 2nd ser., vol. 6, p. 604, 1849.

consisted of large blocks and fragments of the Calcaire de St. Ouen which crops out above, with loam and finer débris generally at the base, and in which the bones occurred. The drift lies in crevasses, hollows, or pockets showing, according to M. HÉBERT, strong water action. This agrees very much with what we see in the rubble (or *head*) overlying the Raised Beaches—beds of finer rubble due to currents of small velocity succeeded by a final current of greater force.

The "*Montagne de Genay.*"—An excellent description of this hill, and of the superficial drifts of the district generally, has been given by M. J. J. COLLENOT, with whom I visited the section, which presents some exceptional features.* It is situated a few miles to the north-west of Semur, and consists of horizontal Liassic strata, capped by beds of "*Calcaire à entroques*" (lower Oolite) covered by a drift of red earth, and is nearly isolated from the surrounding ranges. Extending for some distance along the south side of the hill, which rises to the height of 1430 feet above the sea-level, and of 526 feet above the valley, is a mass of breccia lying on the beds of the Upper Lias and descending, apparently, to nearly the base of the slope. It consists mainly of angular detritus of the "*Calcaire à entroques*" in a red earth, and has been in great part converted into a hard breccia by calcareous infiltration. In one place this breccia contains a large quantity of bones. The teeth and more solid bones are generally intact, but the other bones are broken, some transversely, and others in the direction of their length. They show no trace of wear, the angles being perfectly sharp, as are also the innumerable splinters. The bones longitudinally split, M. COLLENOT considered to have been broken by Man to get at the marrow, and others which are black, or partly black, to be carbonized by fire.† He also remarks that none of the bones showed any traces of gnawing, though remains of Carnivora were present. In some parts of the breccia he found land shells —*Pupa*, *Clausilia*, and *Cyclostoma elegans*. The Mammalian remains belong to—

Hyæna spelæa.
Canis lupus.
Elephas primigenius.
Sus scrofa.
Equus.
Bison priscus.
Bos primigenius.
Cervus elaphus.
„ *tarandus.*
„ *megaceros.*

In addition to these, Beaver and Wild Goat (Bouquetin) were mentioned at the Avallon Meeting.

M. COLLENOT also found in this breccia many flint flakes, some of them trimmed on the edges and weathered white, with round and angular fragments of granite and quartzite pebbles, which he believed may have been used as hammers and trimmers

* 'Description Géologique de l'Auxois,' Semur, pp. 444, 482, 1873. See also 'Bull. Soc. Géol. de France, 2nd ser., vol. 2, "Réunion Extraordinaire à Avallon," p. 721, 1845.

† This appeared to me doubtful.

The rubble is purely local and contains the remains of a land surface only. That its accumulation was an act of short duration, and considerable force is evident from the general fractured condition (admitting some to have been broken by man) of the bones, their innumerable splinters, and the absence of wear. It was suggested by M. NOLD* that the bones must have been fresh at the time of entombment, as he found that the thick end of a humerus, which had been shattered and flattened, still held together, in consequence, as he supposed, of the gelatine of the bone preventing the dispersion of the fragments. This, of course, is open to another explanation—that the bone was smashed in the descent of the rubble, and, being held in place by the matrix, was kept there in the general cementation effected by the subsequent calcareous infiltration. There is, I think, reason to believe, as I hope to show when describing the ossiferous fissures, that the bones found in this drift are those of animals which sought refuge on these isolated hills from the rising waters, and were eventually destroyed, their remains being afterwards swept down with the local rubble on the subsequent upheaval of the land.

These detrital taluses are not to be confounded with those later ones produced by the weathering of the rocks and the action of rain, so common on the steep slopes of the Jurassic valleys of Burgundy, and in the Oolite valleys of England. These, in the district we are speaking of, consist of finer débris, generally loose, and locally called *Arène* or *Trasse*.† They are inclined at steeper angles, and contain only recent remains—sometimes the skeleton of an animal with the bones entire and not fractured. On the other hand, the older rubble is coarse, often includes large blocks, has prolonged slopes, is frequently cemented so as to form a hard breccia, and contains remains of the extinct mammalia. The action of the one still continues, that of the other ceased with post-glacial times.

Mentone.—One more illustrative section of this breccia on the south coast of France may be mentioned. It was discovered in making the coast railway east of Mentone, at a spot where Jurassic limestone cliffs rise to the height of 260 feet on the sea-board. On the face of these escarped slopes are situated the several well-known ossiferous caves of Mentone‡ at an average height of 100 feet above the sea-level. According to the late Mr. MOGGRIDGE, "Below these caves a slope of about 180 feet descends to the edge of the sea. Through the upper part of this slope, at distances from the caves of from 0 to 10 feet, is a railway cutting 600 feet long, 54 feet deep, and 60 feet above the sea. The mass removed in making this

* 'Bull. Soc. Géol. de France,' 2nd ser., vol. 2, p. 722, 1845.

† For further instances and details, see the work of M. COLLENOT before quoted, p. 452 *et seq.*, and the elaborate work of M. BELGRAND, the late eminent engineer, entitled 'La Seine,' vol. 1, Chapters III and XVIII, 1869.

‡ 'Reports, Brit. Assoc.' Edinburgh, 1871, p. 156. I cannot agree with Mr. MOGGRIDGE in considering the cave of more recent date than the breccia. On the contrary, the breccia partially masked two caves.

cutting was composed of angular stones, not waterworn. Loose at the surface, it soon became more or less mature breccia, for the most part so hard that it was blasted with gunpowder. In this breccia and at various depths, some of more than 30 feet, the author has taken out teeth of the Bear (*Ursus spelæus*), and of the Hyæna (*Hyæna spelæa*), while with and below those teeth, he found flints worked by man." Bones and teeth of other various animals also occur, which Mr. G. Busk pronounced to be almost identical with those found in the Gibraltar caves. The analogy between these breccias of the south of France and the "head" and rubble-drift of the coasts of the English Channel is unmistakable.

[This slope of angular rubble was also noticed by M. E. Rivière,* who states that in 1870, when the railway was being carried in front of the caves of Baussi-Raussi, near Mentone, he found in the débris thrown out of the cutting "a number of bones —some entire and others broken—worked flints and flakes, shells, &c., the whole more or less cemented and forming a hard breccia with angular pieces of the adjacent rocks, and here and there carbonaceous matter." The specimens, however, are not specified.—J. P., *April*, 1893.]

The Sub-fossil Wood of Dixmont.—Near Villeneuve-sur-l'Yonne, between Sens and Auxerre, is a very curious deposit of which we have yet but a very insufficient description. I visited it some years ago, but too hurriedly to add much to the account of M. Forestier.† That gentleman termed it a subterranean forest. It is a clotted mass of stems and branches of coniferous wood, mostly fir trees, with some chestnuts, piled together in the utmost confusion, but in the part we saw, not compressed much more than an ordinary wood-stack, and the interstices not filled in. The river is at some little distance, but it is not apparently connected with it, and the district is flat. This heap of wood rises some 10 to 20 feet above the surface of the ground, and is said to be nearly 200 feet (60 metres) thick, with a length of about 3 miles (4 to 5 kilometres). It is overlaid by a bed of loam or sand, and under it is a bed of gravel. The lower part is said to pass into the state of lignite, whilst in the upper part, the wood, which has acquired the black colour of ordinary bog-wood, is so well preserved that it can be worked like ordinary wood. No organic remains of any sort have been found either in the overlying drift or amongst the wood. The mass seems to lie in a depression on the surface and not to be connected with a river deposit. The branches are broken into small fragments. Whether it can be connected with the rubble-drift is only a suggestion I venture to make. It resembles no ordinary deposit, and it has occurred to me that it might possibly be, like the land shells and Mammalian remains elsewhere, a portion of the wash of the old land surface.

* 'Paléontologie.' "De l'Antiquité de l'Homme dans les Alpes Maritimes," p. 12, Paris, 1887.

† 'Bull. Soc. Géol. de France,' 2nd ser., vol. 7, p. 388, 1850.

Ossiferous Fissures.

The South Coast of France.—The ossiferous fissures of France present phenomena of great interest. These fissures, which are more common there than in England, show the close connection between their contents and those of the rubble-drift forming the "head" over the Raised Beaches. The local character and condition of the detritus are alike, and the same organic remains are common to both—the only exception being that the land shells found in the "head" have not been recorded in the Devonshire fissures. This deficiency is supplied by the breccia in France, where these fissures are on a much larger scale, and present conditions pointing more definitely to a widespread and deep submergence (see Map).

Such fissures are especially common on the Mediterranean coast. They were described by Cuvier early in the century, but chiefly from the palæontological point of view,* and afterwards with a few additions by M. Marcel de Serres.† A more complete account of the bone caves and ossiferous fissures was afterwards given by Desnoyers.‡ Since then some important additions have been made of similar fissures inland.

The position of the ossiferous fissures of Plymouth offers no salient features. The hills on which they are situated are of small elevation, without any commanding points. At Catsdown and Oreston the limestone rocks rise to the height of 100 to 150 feet, and although they cannot be called isolated, yet they are sufficiently high above the surrounding valleys to render difficult the retreat of animals seeking refuge there from the rising waters. The position of the fissures on the Mediterranean coast is in marked contrast. They there occur on detached and isolated hills rising high above the surrounding plain, and from which no retreat would be possible in case of submergence.

At Nice, the Mont du Château rises 132 feet, and Mont Boron 436 feet, above the sea, and little less above the plains around. At Antibes the rock is 200 to 250 feet, and at Villefranche 450 feet high. But the most remarkable hill is that of Cette, which rises to the height of 355 feet, and bears in its physical features a strong resemblance to the Rock of Gibraltar, projecting like it into the sea, and separated from the mainland by a long and narrow tract of sands.

Some of the fissures are vertical, others are inclined at various angles, and they are very irregular in size. They are filled, as at Plymouth, with angular fragments of the local limestone, in a matrix of red earth or clay forming a breccia, which is in some places loose, whilst in others it forms a hard rock with a calcareous cement. Though there are no such well-marked Raised Beaches as those on the Devonshire coast, they are not altogether wanting. De la Beche mentions that the bottom of

* 'Recherches sur les Ossemens Fossiles,' vol. 4, chap. 4, 1823.

† 'Essai sur les Cavernes à Ossements,' 3rd edit., chap. 2, 1838.

‡ C. D'Orbigny's 'Dictionnaire d'Histoire Naturelle,' vol. 6, p. 343, 1849.

one of the fissures at Nice was filled by a conglomerate of rolled (beach) pebbles, while the rock on one side was drilled by Lithodomi. Above this conglomerate, the fissure was filled with a breccia containing bones and land shells.* This† indicates, therefore, the same relation of "head" or Rubble-drift to an old sea level that exists in the English Channel.

The greater number of the bones, which occur only in places, are broken and in fragments, only a few being entire. They are neither worn nor rolled, nor are they found in any relation to their order in the skeleton.‡ Nor is it recorded that there are any traces of their having been gnawed.

The bones which have been found at the several places here named belong to :—

Felis leo.
„ *pardus.*
Elephas primigenius ?
Rhinoceros leptorhinus.§
Hippopotamus ?
Sus ?
Ursus (*priscus ?*).§
Bos.
Equus (*caballus ?*).
Cervus elaphus.
Cervus dama.
Lagomys (*pusillus ?*).
Lepus caniculus.
„ *timidus.*
Antilope ?

Lizard (recent species ?).
Tortoise „
Serpent „

The shells are—

Helix nemoralis.
„ *algira.*
„ *vermiculata.*
„ *lapicida.*
„ *nitida.*
Helix cristallina.
Pupa.
Bulimus decollatus.
Cyclostoma elegans.

These land shells are all of recent species living in the neighbourhood.

Amongst the specimens sent to Cuvier from Nice was a portion of jaw which he recognised as human, though he felt doubt as to whether it was contemporaneous with the other bones. It was found, not in the undisturbed breccia, but in a talus of the breccia which had fallen from the exposed surface of an ossiferous fissure. Some portions of this breccia were hard and compact, and other portions were unconsolidated and earthy, and the bones in those parts were less stained and less well-

* 'Trans. Geol. Soc.,' 2nd ser., vol. 3, p. 171, 1835. The height of the perforated rock above the sea is not given.

† There is a similar instance of superposition near Mentone, but not so well shown.

‡ Cuvier, 'Ossemens Fossiles,' vol. 4, 2nd Edit., p. 172.

§ Mentioned by Falconer in 'Palæont. Mem.,' vol. 2, pp. 370 and 466.

preserved than in the solid parts. It was amongst this débris that the jaw was discovered. It was coated with the same film of stalagmite as the other bones of which the antiquity could not be doubted. CUVIER, however, thought that the unconsolidated part of the breccia, to which the jaw belonged, might be of more recent date than the consolidated portion, but this is no test, and it must be remembered that, at that time, the belief in the recent creation of Man was universal, and, like the later discovery of Man's works in the cave deposits of Kent's Hole, it led geologists to look with doubt at anything which was not in accordance with that belief. Apart from this cause of doubt, CUVIER'S own account affords reasonable evidence of the contemporaneity of the jaw with the other bones.

[Though M. RIVIÈRE'S work (*ante* p. 931), is devoted mainly to the description of the Mentone Caves, he touches incidentally upon the breccia of the ossiferous fissures of Nice,* which he considers to be analogous to the breccia on the Mentone slopes. He describes the Nice breccia as consisting of two parts, a lower one, red and compact, with land shells, and an upper one, less compact, of a brown or black colour, with sea-shells and bones sometimes black as if burnt, and some of them split longitudinally as if for the purpose of extracting the marrow. He concluded that the Nice fissures had served, like the Caves of Baussi-Raussi, as habitations for a prehistoric people, and that these people were of late Quaternary age (p. 314). The fissures of Nice may, however, like those of Gibraltar, have been only partly filled by the osseous breccia leaving, owing to the inequalities of their sides, cavities and open spaces, which were subsequently used as habitations by a later race of men and animals. This would be in accordance with the succession of deposits elsewhere—a succession forming three separate stages, namely :—

1st. The older Palæolithic bone-breccia of the caves.

2nd. The angular Rubble-drift and breccia of the slopes and fissures, with similar Quaternary animal remains.

3rd. The more recent cave beds of the Neolithic epoch.

When the Rubble-drift masks the caves, no Neolithic deposits are met with; but when, as at Baussi-Raussi, there is no stalagmite floor or Rubble-drift to separate the first and third of these deposits, they may then appear to pass one into the other. The reason of the small percentage of extinct species from the Mentone caves, noted by M. RIVIÈRE, seems to me to be owing to the circumstance that he takes the whole contents of the cave as belonging to one epoch, and does not give separate lists of the different beds. He thus obtains a total of 281 species (p. 529), consisting of 60 Mammals, 2 Reptiles, 42 Birds, 7 Fishes, 168 Mollusca, 1 Annelid, and 1 Polype, the result being that the average gives an undue proportion of recent species.† There is

* *Op. cit.*, p. 32.

† It is true that M. RIVIÈRE speaks of Lion and Panther in connection with this upper bed, but neither the depth from the surface nor the other conditions are given, and there are other ways of accounting for their presence.

an absence also, in the upper part of those cave deposits in which M. RIVIÈRE made his interesting discoveries, of flint implements of a special Palæolithic type, whereas those of well-known Neolithic types are common.

With regard to the human jaw (now lost) from Nice, M. RIVIÈRE does not agree with CUVIER that it was of a date more recent than the other bones in the breccia, although he considers that it came from his upper and newer bed. CUVIER only mentions that it was an isolated fragment and not attached to the breccia, and it must be remembered that the greater part of the bones examined by him were collected by the eminent naturalist RISSO* from the débris of a fissure that had fallen at the foot of an escarpment.—J. P., *April*, 1893.]

Inland Fissures.—Ossiferous fissures are not, however, confined to near the coast, nor to moderate heights, as on the coasts of France and England. They are found, on the contrary, in the interior of France at very considerable heights. Two of the most remarkable instances are those of Pédémar and Santenay.

The *Montagne de Pédémar* lies a short distance S.S.W. of St. Hippolyte (GARD), and has been described by M. MARCEL DE SERRES.† It is an isolated hill rising to the height of 1128 feet above the sea-level, and of 577 feet above the adjacent valleys It "has the form of a truncated cone, of which the contours represent an elongated oval. The greatest diameter of the oval is 984 feet and the smallest 460 feet." . . . "It is within this limited area that the strange phenomenon has happened of the accumulation of a large quantity of bones of diverse animals" in hollows or fissures on the south slope of the hill near the top. They are found in a red earth, with fragments of the subjacent Neocomian rocks, which cover the summit of the hill, but the bones occur only in the fissures. The rock fragments are perfectly angular, and there is not a trace of rolled pebbles. Almost all the bones are broken into fragments, and M. DE SERRES specially notices that they are scattered without order, without any relation to their position in the skeleton, and that they have *neither been gnawed nor rolled.* There is also an entire absence of coprolites. A few of the bones only were sufficiently perfect to be recognised as belonging to *Rhinoceros lunelensis,* GERVAIS (*R. leptorhinus ?*), *Bos ?*, *Capra ?*, and *Equus.*

MARCEL DE SERRES makes the significant remark that the detritus is such as could only have been derived from rocks on the summit of the hill, showing that the spread of the débris was due to a current originating on its summit, and not from a distance,—such a displacement in fact as would be caused by divergent currents during upheaval.

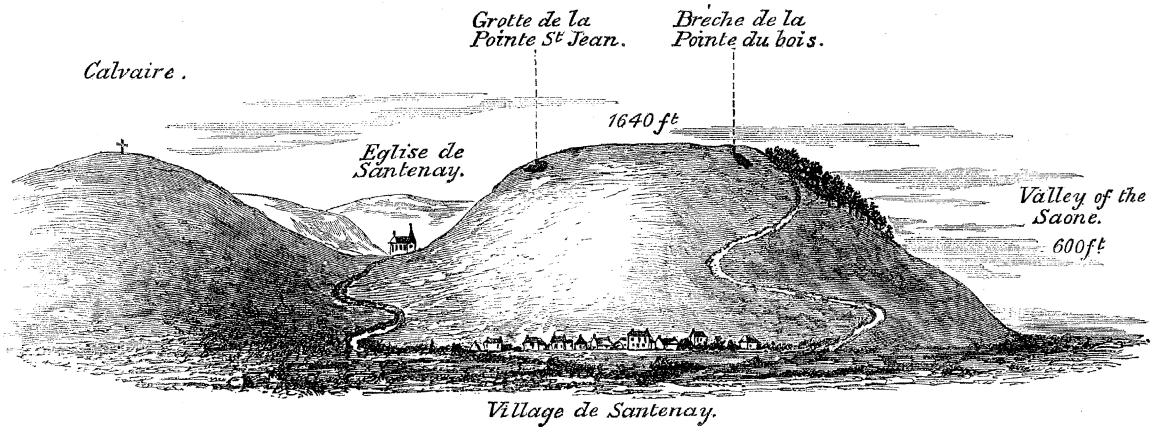
The "*Montagne de Santenay*" offers another singular instance of a high-level

* It is not probable that RISSO, who resided at Nice, would have sent CUVIER any specimens but such as he thought belonged to that deposit. He was of opinion that the fissures had not served as *caves for the habitation* of the animals whose remains are found in the breccia.

† 'Bull. Soc. Géol. de France,' 2nd ser., vol. 15, p. 233, 1858.

ossiferous fissure. It is situated on an isolated hill near the village of Santenay (Côte-d'Or), and was visited in 1876 by the Geological Society of France, on the occasion of the "Réunion Extraordinaire" at Châlons-sur-Sâone, when the questions to which it gave rise led to an interesting discussion.*

Fig. 13*.—*La Montagne de Santenay (after a sketch by* M. A. GAUDRY).



The hill is a few miles south of Châlons, and rises to the height of 1640 feet, its summit forming a nearly level platform, some 1030 feet above the surrounding plain. On all sides its slopes are steep, except on the one by which it is connected with the range of the Côte-d'Or. On the south side of the hill is an ordinary bone cave (Grotte de Saint Jean), in which M. HAMY found remains of—

Felis leo (*F. spelæa*).
Canis lupus.
,, *vulpes.*
Ursus (probably *U. ferox*).
Equus caballus.
Cervus elaphus (var. *Canadensis*).
Bovidæ of the size of *Bos taurus.*

There is another cave (Grotte de St. Aubin), on the opposite or northern side of the hill, containing the remains of *Bears, Horse, Elephant, Rhinoceros,* and *Ox.* In some sands outside the cave, large horns of *Cervus megaceros* were found.

Close on the summit of this hill, which consists of strata of the middle oolites, at a spot called La Pointe-du-bois, is a fissure† on the surface. It was filled with a breccia composed of the fragments of the adjacent rocks, embedded in a yellow or brownish earth, with bones which were determined by Professor A. GAUDRY to be those of—

* 'Bull. Soc. Géol. de France,' 3rd ser., vol. 4, pp. 681–695.

† It is not said whether it is a fissure of water erosion or a fissure of fracture. That does not, however, affect the argument.

Felis leo (*F. spelæa*).
Felis lynx.
Equus caballus (of large size).
Canis lupus (remains very abundant).
„ *vulpes.*
Meles taxus.
Ursus (intermediate between *U. spelæus* and *U. ferox*).
Lepus timidus.
Rhinoceros merckii.
Sus scrofa.
Bovidæ (size of *Bos taurus*).
Cervus elaphus (and var. *Canadensis*).

The bones were in a very broken state. M. GAUDRY observes that their accumulation could neither be attributed *to man nor to animals*, for the fractures in no way resemble those made by man for the purpose of extracting the marrow, and notwithstanding the abundance of Wolves, *none of the bones show traces of having been gnawed by Carnivora.* How then could this collection have been brought together? As M. GAUDRY justly remarks, "Why should so many *Wolves, Bears, Horses,* and *Oxen* have ascended a hill isolated on all sides?" M. GAUDRY further remarks that the deposit seems to have been formed by water precipitating the breccia and the bones into a fissure. "But whence," he says, "have come the waters sufficiently abundant to bring together the bones?" The fissure is so near the top of the hill that there is little gathering ground above it, and had the bones and fragments of rock been carried in by a stream or torrential rains, they must have shown more or less wear, and have lost their sharp angles. It was suggested by some members that the event took place during the height of the glacial period, when the Alpine glaciers are known to have advanced as far as Lyons, and might there have formed a barrier which would have greatly modified the conditions of the country through which the Saône flowed, but it is difficult to suppose that the glacier at that distance from its base, retained a magnitude sufficient to dam back the land waters to a height that would cover the hill of Santenay, though it is said that the glaciers of Savoy have left traces on the hills around Lyons, at a height of about 1300 feet; but even this would not have sufficed to cover Santenay, and on the hill itself no traces of glacial action are recorded.

To account for the presence of the bones it was pointed out that in winter snow would cover the ground and hide such fissures, which would thus serve as traps for the animals when pursued, or that on the melting of the snow the remains of those which had died would be washed into them. But as I explained in a former paper, it is impossible to admit that the remains are those of animals that had fallen into the fissures, for in that case all the bones of the skeleton must inevitably have been preserved, although they might have been scattered, whereas the presence of the entire skeleton,* or even of the bones of detached limbs in connection, is the rare exception. As a rule, the bones are without order and in no possible relative proportion.†

* Not a single such case is recorded of the fissures in France.

† That there are instances of open fissures in which animals are lost is not to be doubted. It is said

Nor is it easy to conceive that under extreme glacial conditions, herds of such animals should have resorted to high hills in the midst of ice and snow fields, instead of retreating before the ice and keeping to the open plains and richer pastures. That Wolves and Bears should, before the rising of the waters, have inhabited the caves of St. Aubin and St. Jean lower down the mountain sides, and carried to those caves the prey which they pursued in the plains around, is readily understood; but it is inconceivable that under any ordinary circumstances the predaceous animals and their victims should have congregated together on the summit of a high, steep, and isolated hill.

Another suggestion was that towards the close of the Quaternary period, the rainfall was so excessive that it flooded the plains and obliged the animals to seek refuge on the higher ground, where they congregated in great numbers, and eventually succumbed to the rain, cold, and hunger, or to the attacks of the predaceous animals of the caves below, their bones being then dispersed and carried by the diluvial rainfall into the open fissures. In support, however, of this suggestion it had to be assumed that the rainfall was one hundred times greater than at present, and that the waters rose at the rate of one metre daily, but although the rainfall during much of the Quaternary period was no doubt very heavy, it is a physical impossibility that without a change in the level of the land, the waters could ever have been piled up in the manner here required. It is evident also from the condition of the bones, that the animals whose remains are entombed in the breccia did not fall a prey to predaceous animals.

The general opinion amongst the members present was that the animals had fallen victims to floods, but whether caused either by dams of ice, the melting of snow-fields, or excessive rainfall, was left indeterminate.

The condition and position of the bones are, on the other hand, at Santenay and Pédémar, as they are at Oreston and Catsdown, such as might result from the effects of a gradual submergence of the land. For a submergence of the character I have described would naturally drive the animals in the plains to seek refuge on the higher hills. Flying in terror and cowed by the common danger, the Carnivora and Herbivora alike sought refuge on the same spot, and alike suffered the same fate wherever the hill was isolated and not of a height sufficient for them to escape the advancing flood. We may suppose the subsidence to have been so slow that there was no sudden rush of water to carry the bodies far away, so that as they decayed, the limbs fell and were scattered and dispersed irregularly on the submarine surface. When that surface was again upheaved, the bones and detached limbs, together with the detritus on that surface, were, as I have before explained,* carried

that even in extremely hot weather large fissures, in which the young game is lost, are opened in the ground in the south of Spain. It is also well-known that in many countries--Greece, for example—the remains of animals are sometimes carried down by the streams into large swallow holes. But special results attend all these cases, and the swallow holes are situated in low grounds and not on hill-tops.

* 'Quart. Jour. Geol. Soc.,' vol. 48, p. 340.

down by divergent currents to lower levels, or they fell into fissures of the rock over which the detrital matter passed, or else, when facing the coast, over the ledges of the old cliffs rising above the Raised Beaches. Swept down by the intermittent currents produced by the more or less rapid uplifts, and falling with the mass of detritus in a body over the old cliffs or into the open fissures, the bones, in the one case as in the other, were broken and smashed in the extraordinary manner we now find them. Added to this was the fall, caused by the earth tremors inevitable with such movements, of fragments of rock, some of large size, from the sides of the fissures, so that very few of the bones escaped whole. At the same time the action was of too short duration, and the transport was to too short a distance to wear down the sharp angles either of the rock or the bone fragments. Raised again to the surface, the rain waters, percolating through the calcareous rocks traversed by the fissures, and carrying down carbonate of lime, have generally cemented the débris of the fissures, and occasionally of portions of the "head" (Brighton), into a hard brecciated mass from which it is now difficult to extract the bones. Where, on the contrary, the débris remained loose on the surface and formed permeable superficial drift, the effect of water percolation has been to remove the calcareous matter together with the bones, so that where thus exposed, the rubble is more unfossiliferous than when it lies in fissures or hollows where the surface waters could not freely percolate.

Although the localities of Santenay and Pédémar are on levels so very different from those on the shores of the Mediterranean, the conditions which led the animals to congregate there were precisely the same. At Nice, at Antibes, and at Cette the fissured hills form, as before mentioned, high isolated rocks fronting the sea, and connected with the mainland by tracts of lower ground. In each instance these isolated hills would assuredly have been resorted to as places of safety from the rising waters by the animals of the adjacent plains, as well as by those living amongst the rocks and caves of the hills.

Other osseous breccias analogous to those on the Mediterranean coast have been noticed in the departments of the Doubs, Lot, and Haute-Saône, but those I have described are sufficient for our object. M. Desnoyers* also notices an ossiferous deposit on the slopes of the hill of Montmorency, near Paris, which he considered analogous in its character with the Mediterranean breccias. In it he found the remains of *Reindeer, Red Deer, Horse, Wild Boar, Lagomys, Hare, Spermophilus, Beaver, Pole Cat, Marten,* &c., together with land shells of recent species, but the identity with the true ossiferous fissures does not seem to me complete, though it is clear that the deposit was not due to fluviatile agency. The bones are better preserved than in the fissure-breccias, and there were several entire or nearly entire skeletons with the bones nearly in their natural position. M. Constant Prévost spoke of these cavities, which are in gypseous beds of Tertiary age, as pot holes or

* 'Bull. Soc. Géol. de France,' vol. 13, pp. 290 and 311, 1842.

swallow holes, and as the result of slow but intermittent rain action on lines of drainage, by which surface débris and animal remains were carried underground.

Spain and Portugal.—The Atlantic waves have left but few traces of Raised Beaches or of the "head" on the western coasts of Spain and Portugal. M. Ch. Barrois figures some broad platforms of marine denudation, apparently of the age of the Raised Beaches, at Cape Vidio, on the north coast of Spain,* but they were without any organic remains by which he could determine their exact age.

The Memoir, however, by Colonel J. F. N. Delgado† on "La Grotte de Furninha, near Cape Carvoeiro, the most westerly point of Portugal, and 49 feet above the sea level, leaves no doubt of the prolongation thus far of a beach in a position analogous to that on the Gower coast. This cave presented some very interesting features. At the bottom of the cave deposits was a bed of rolled pebbles, 3 feet thick, with *Patella vulgata* and *Littorina littorea*. Above this beach were a series of ossiferous deposits, having a total thickness of 31 feet. The lower of these contained the remains of the *striped and spotted Hyæna, Cave Bear, Lynx, Wolf, Felis, Rhinoceros* (*tichorhinus?*), *Deer, Ox, Horse, Hedgehog, Badger, Weasel, Hare, Bird, Fish*, &c., with flint implements of the type of those of St. Acheul. A fragment of a human maxillary bone was also found on the lower beds at a depth of 20 feet. The upper beds contained remains of the Neolithic period. M. Delgado considered that the violence of the waves at this spot had worn back the cliff for a considerable distance, which may be the reason why there is an absence, seemingly, of Rubble-drift.

Besides some interesting glacial phenomena described by M. Fred. de Vasconcellos‡ on the west coast of Portugal, there are some great taluses on slopes, which may possibly represent the Rubble-drift. Mr. D. Sharpe,§ in his paper on the Geology of the neighbourhood of Lisbon, says that the valleys near Lisbon are often lined with detritus washed down from the hills enclosing them, but whether this is of recent date or belongs to the Rubble-drift he gives no information to show.‖

The late Señor Carlos Ribeiro¶ has alluded to the occurrence of a Raised Beach near Capes Espiches and Sines, as well as other places, but no particulars are given. He also alludes to a conglomerate (breccia?) which occurs in places on the sides of hills, and is composed of the débris of rocks higher up the slopes; this may possibly represent one form of the Rubble-drift.

* 'Recherches sur les Terrains Anciens des Asturies et de la Gallice,' Lille, 1882, p. 619, and Plate 20, fig. 17.

† 'Congrès Intern. d'Anthrop. et d'Archéol. Préh.,' Lisbonne, 1880, p. 207.

‡ *Ibid.*, p. 155, and 'Trabalhos Geol. de Portugal,' vol. 1, p. 189, 1887.

§ 'Trans. Geol. Soc.,' 2nd ser., vol. 6, p. 130, 1842.

‖ Mr. G. Maw alludes to the traces of a high-level beach clinging to the Rock of Lisbon at a height of 150 to 180 feet above sea-level, 'Quart. Journ. Geol. Soc.,' vol. 28, p. 87.

¶ 'Descripcão do Terreno Quaternario,' pp. 2, 15, 17, 22, *et seq.*, 1866.

On the south coast of the peninsula there is more distinct evidence of Raised Beaches and Rubble-drift. General De la Marmora* mentions that at Cadiz the remains of a Raised Beach, with foreign pebbles overlaid by a drift of red earth, are to be seen, and that traces of a similar beach are again met with at Cape Trafalgar and Tarifa. Mr. G. Maw gives some further particulars, stating† that in "the neighbourhood of Cadiz long ranges of low cliffs occur, closely resembling the Raised Beaches of Devon, and like them composed of a hard concrete of sand and shells" of recent species, implying an elevation of the coast of 40 or 50 feet.

Little is known of these beds on the east coast. Professor Ansted‡ speaks of Raised Beaches, at a height of about 40 feet above the sea at various points of the coast (of Malaga), consisting generally of fragments of slate, for the most part angular, and often of a large size. In one of them "fragments of copper ore were found derived from a vein cropping out on the hill above." Similar deposits of angular gravel exist a few miles up on the banks of the Guadalmedina at a rather higher level. He did not observe any shells or fragments of shells in these beds. It would seem from his description that these deposits represent a Rubble-drift or *head* rather than a Raised Beach. In the neighbourhood of Barcelona Professor L. Molins Foti§ states that there is an extensive development of Loess. A Raised Beach above the sea-level has also been noticed on that coast.

Scanty as is this information, it is in accordance with the general characters of the Rubble-drift, while the absence of intervening links is of less importance, as the phenomena we have noticed at Pédémar and Santenay, and those we are about to notice at Gibraltar, bridge over the intermediate area, and lead us to infer that it must have shared in the submergence which affected high hills on its borders.‖

Gibraltar.—The well-known Rock¶ is an isolated hill, separated from the mainland by a few miles of flat ground about 10 feet above the sea-level, and is composed of hard limestones of Jurassic age, forming a high scraggy ridge rather more than $2\frac{1}{2}$ miles long, from 550 to 1550 yards broad, and rising at the north end to the height of 1349 feet,

* De la Marmora's 'Voyage en Sardaigne,' p. 370, 1857.

† 'Geol. Mag.,' vol. 7, p. 553, 1870.

‡ 'Quart. Journ. Geol. Soc.,' vol. 15, p. 599, 1859.

§ 'Atti della Società Italiana di Scienze Naturali,' vol. 12, fasc. 3, 1869.

‖ M. Marcel de Serres speaks of an ossiferous breccia of Concud, near Teruel, in Aragon, but gives no particulars and no references.

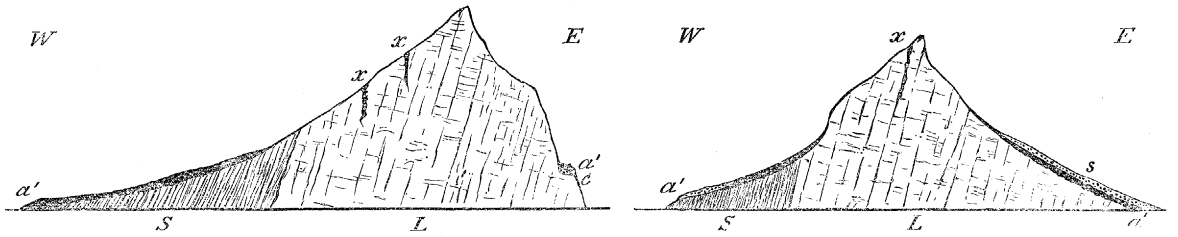
¶ Cuvier gives an account of the organic remains of the Gibraltar breccia in his 'Ossements Fossiles.' The general geology, and especially the Raised Beaches, were described by Mr. J. Smith, of Jordanhill, in 1844 ('Quart. Journ. Geol. Soc.,' vol. 2, p. 41); the caves and their contents, by Dr. Falconer and Mr. Busk in 1865 ('Quart. Journ. Geol. Soc.,' vol. 21, p. 364; 'Palæon. Mem.,' vol. 2, p. 556, 1868; and Congr. Preh. Archæol., Norwich Meeting, 1868); the fossil fauna, by G. Busk in 1877, ('Trans. Zool. Soc.,' vol. 10, pt. 2); and the solid and superficial geology by Sir A. Ramsay and Professor James Geikie in 1878 ('Quart. Journ. Geol. Soc.,' vol. 34, p. 505).

and at the south end of 1370 feet above the sea-level. From the O'Hara Tower, at the south end, the Rock falls rapidly to the Windmill Plain (400 feet), and again to the Europa plain (150 feet). These are plains of marine denudation. The strata dip at a high angle to the west. On the east side the Rock forms an almost sheer precipice: on the west side it slopes rapidly to the sea level, as shown in the following sections by Messrs. RAMSAY and GEIKIE, which have the advantage of being drawn to a true scale. The interpretation of the drift beds is, however, my own. At the foot of the west slope is the belt of lower ground on which the town is situated.

Fig. 14.—*Transverse Sections of the Rock of Gibraltar* (after RAMSAY and GEIKIE).

A. Section across Sugar Loaf Hill, O'Hara Tower, 1370 *feet.*

B. Section across Middle Hill, St. Michael's Gate, 1138 *feet.*



s, sands; *a'*, limestone breccia or rubble-drift (the agglomerates of the authors—their older agglomerate is that on the left and their newer one that on the right side of the sections); *L*, limestone; *S*, shale; *x*, ossiferous fissures (not in original sections*); *c*, Raised Beach.

The Rock has been extensively faulted and fissured. Large rents, some perpendicular, and others inclined at various angles, and extending to great depths, traverse it in different directions. They are met with at all heights up to 1100 feet (St. Michaels).† In the course of constructing fortification works, ossiferous fissures have been discovered from time to time. Amongst the most important is the one known as the Genista Cave on Windmill Hill explored by Captain BROME (1862 and 1868), and investigated palæontologically by Dr. FALCONER and Mr. G. BUSK in 1865. This hill forms a plateau 400 feet above the sea at the south end of the rock.

Many of the fissures have been only partly filled up by the breccia, leaving large open spaces at various depths, some of which have been occupied as caves and places of refuge up to comparatively recent times. Owing to the untimely death of Dr. FALCONER it fell to Mr. BUSK to complete the investigation of the fossil fauna, commenced by the former.‡

The following is Mr. BUSK'S revised list of the Mammalian remains :—§

* These I have merely put in approximately to indicate their general position, but not their depth.

† Sea-caves and beaches also exist at various heights. (See Mr. JAMES SMITH'S paper.)

‡ 'Palæontological Memoirs,' vol. 2, p. 554.

§ 'Trans. Zool. Soc.,' vol 10, p. 53, 1876.

Ursus fossilis sive priscus.
Hyæna crocuta.
Felis pardus.
,, *pardina.*
,, *caligata.*
Equus caballus.
Rhinoceros hemitœchus, Falc. (*R. leptorhinus*, Owen, vel *R. Merckii*, Lartet).
Cervus elaphus.
,, *dama.*
Capra ibex.
Bos primigenius.
Sus scrofa.
Lepus caniculus.
,, *timidus.*
Canis vulpes.

Cuvier mentions *Lagomys*, but with doubt.

The bones were much broken and splintered, and Dr. Falconer states that in no instance did they observe "fossil bones *attributable to one complete skeleton* of any one of the larger Mammalia," nor does he or Mr. Busk allude to any of the bones having been gnawed. Had they been so, it would certainly not have escaped the notice of such experienced observers. At the same time they remark that the bones in the newer or prehistoric caves were *gnawed.*

Mr. Busk tells us that "wherever the surface is exposed it is seen intersected by ramifying fissures which occasionally widen into extensive caverns either empty or filled with bone breccia and crystalline spar."* Sometimes the fissures are very narrow, at other times they are many feet wide and extend to great depths; the one on Windmill Hill was followed to a depth of 290 feet from the surface, and another on St. Michael's Hill to a depth of 288 feet. Owing to the size of the blocks in some cases, and in others to the contraction of the sides of the fissures, large open spaces have often been left at various depths.

Human remains, including entire skeletons, together with fragments of pottery, stone implements, worked bones and remains of recent animals, were discovered in many of these spaces or caverns, but they were all of Neolithic and recent date, and do not come within the scope of our inquiry.† Besides these, however, traces of Palæolithic Man were met with. At the depth of 53 feet, in one of the fissures on Windmill Hill, the workmen came upon a quantity of red breccia in which were found two teeth of *Rhinoceros.* In the same mass there was a *human tooth*, which Mr. Busk identified as a molar that had never been cut, together with a *flint knife*, and numerous large pieces of flint.‡

To account for the bones in the breccia, two explanations have been suggested. 1st, that of Buckland and De la Beche, which attributes the ossiferous débris to the remains of animals that had fallen into open fissures. To this I have already

* Many of the later caves were beautifully furnished with stalactites.

† They are described by Mr. Busk in the paper just quoted.

‡ Land shells are also said to have also been found.

stated objections which must, I think, be considered fatal.* 2nd, that suggested by Dr. FALCONER, who supposed that "the wild animals above enumerated, during a long series of ages, lived and died upon the rock. Their bones lay scattered about the surface, and in the vast majority of instances crumbled into dust, and disappeared under the influence of exposure to the sun and other atmospheric agencies, as constantly happens under similar circumstances at the present day. But a certain proportion of them were strewed in hollows along the line of natural drainage when heavy rains fell; the latter, for the time converted into torrents, swept the bones with mud, shells, and other surface-materials, into the fissures that intercepted their course; there the extraneous objects were arrested by the irregularity of the passages, and subsequently solidified into a conglomerate mass by long continued calcareous infiltration."†

Although this last explanation gets rid of some of the difficulties attached to the first, it gives rise to others which seem insuperable. In the first place, it is improbable that all the various wild animals, of which the list is given above, could have at any time, or habitually lived together on the rock. The crags and caves may have been the resort of *Hyænas* and other predaceous animals, but the *Deer*, and other ruminants, the remains of which were numerous, could never have lived in the neighbourhood of these Carnivora. They would naturally have frequented the surrounding plains and forests, where they could have found food, shelter, and water, rather than scrags—dry and in great part barren. It is true that the predaceous animals might have carried there some portions of their prey, but had they done so, either the bones would have been devoured, or such as remained must inevitably have shown marks of the animals' teeth.

In the second place, no animal remains left on the surface could possibly have escaped destruction in the proximity of ground frequented by Hyænas and other Carnivora; or, supposing any bones had escaped, they would have decayed under ordinary atmospheric agencies, and exhibited more or less weathering; had they also been washed down by streams and amongst rocks, they would have been rolled and worn. But there is no evidence of weathering or wear, nor is it shown that the fissures are connected with old watercourses. The bones have clear and sharp fractured edges. Only in two instances it is mentioned that the bones present the appearance of being weathered and sun-cracked, and this seems to refer to those found with human remains and works of art, and not to the older breccia.

For these reasons I think this explanation cannot be accepted, and would again revert to the hypothesis of a submergence of the land. This affords a *vera causa* for the association of animals otherwise so little likely to be found together. It could only have been, as in the cases I have before named, a great and common danger, such as that of the gradual encroachment of the sea on the land, that could have so

* *Ante*, p. 937, and 'Quart. Journ. Geol. Soc.,' vol. 38, p. 336.

† 'Palæontological Memoirs,' vol. 3, p. 537.

paralyzed their natural instincts as to have driven those various animals to flock together in search of a common place of refuge from a catastrophe which threatened all alike. Under such circumstances the Ruminants would naturally flee from the plain to the higher hills, and when these were isolated, as in this and the other cases I have named, whenever the waters rose above those hills, they were drowned and their limbs dispersed in the manner I have before described.

The conclusions I would draw from the important paper of Sir A. RAMSAY and Professor JAMES GEIKIE, on the Geology of the Rock,* correspond with those formed on the palæontological evidence, though they differ from those of the authors of that paper; but I speak with reserve from want of personal knowledge of the ground. They describe the superficial deposits as consisting in ascending order of—

1. An older Limestone-agglomerate.
2. Bone breccias in caves and fissures.
3. Raised Beaches and calcareous marine sands.
4. Alameda and Catalan sands.
5. A later Limestone-agglomerate.

Beds 1 and 5 are true *breccias*, but the authors adopt the term *agglomerates* for these beds, to distinguish them from the bone-breccia of the caves and fissures (No. 2). They say: "The oldest (1) of all the superficial accumulations is the remarkable agglomerate or breccia which covers so large an area in the district of Buena Vista and Rosia, and in the neighbourhood of the South Barracks. Similar accumulations are met with in other parts of the Rock; but these, as we shall afterwards point out, belong to a later date (5). In caves and fissures, as is well known, breccias also occur, but these are distinguished from the others by the presence of abundant Mammalian remains." They proceed to say that this older breccia (*a'*, on the left of the sections, fig. 14) is quite unfossiliferous, and rests on the main limestone or on the overlying strata. For these reasons they thought it "better to restrict the term *breccia* to the true cave-and-fissure-accumulations, leaving the term *agglomerate* for the great superficial masses."

In the neighbourhood of Rosia and Buena Vista, this agglomerate or breccia "attains a thickness in some places of not less than 100 feet, and occasionally shows a well-marked dip, . . . as a rule, however, the mass is quite amorphous and devoid of stratification. The matrix is sometimes grey, sometimes reddish, and the included fragments (of the limestone) are almost invariably quite angular, no rounded waterworn stones being visible. The agglomerate is of all degrees of coarseness, the stone varying in size from mere grit up to blocks 12 feet and more in diameter;† and larger and smaller fragments are all rudely heaped together without the slightest reference to

* 'Quart. Journ. Geol. Soc.,' vol. 34, p. 505.

† They add, "Some of the larger blocks must weigh 20 or 30 tons at least."

size or shape, so as to present an appearance as tumultuous and confused as that of a coarse volcanic agglomerate."

This description might be applied almost word for word, to the "head" over the Raised Beaches of Brighton and Devon. There is the same absence of wear and the same local character of the component fragments; the same various degrees of coarseness and occasional inclusion of massive blocks; and the same occasional dip or appearance of bedding; to which may be added the same general rarity of organic remains. Bones, however, have been met with, though very rarely, but when that is the case the authors assign it to a later period. But even at Brighton the greater part of the Elephant-bed is unfossiliferous, and it is only occasionally that bones are found, whilst in Devon,* owing to various causes, they are almost unknown. In the fissure breccia likewise there are large portions (probably the largest) in which no bones are found. The presence or not of bones cannot therefore be considered a character of any fixed value, and alone is insufficient as a test of comparative age.

Messrs. RAMSAY and JAS. GEIKIE state, that the bone breccia of Rosia Bay occupies a "vertical fissure of erosion in the unfossiliferous *limestone-agglomerate*," and hence that the latter must be of older date. But Major IMRIE,† who was there when the first excavations were going on, says, that it was a cave (with the ordinary cave bone-breccia) that had been "filled up with the concretion" (agglomerate), and Mr. SMITH merely says that it was a fissure in the face of the cliff. Unfortunately no sections are given to assist us in our conclusions. If this breccia (the older agglomerate) were, however, older than the Raised Beaches, we should expect to find portions of it *under* some of those beaches, but *none such are recorded.* On the contrary, a section given by the authors shows an agglomerate or breccia *overlying* a beach (see fig. 17). They explain this section by supposing this agglomerate (their No. 5) to be of later date than the agglomerate or breccia of Rosia and Buena Vista on the west side of the Rock, but the evidence of superposition is wanting, and it is difficult to suppose that the breccias on the east and west side of the Rock, shown in the two sections in fig. 14, are otherwise than contemporaneous.

The authors themselves say "there is no perfectly conclusive evidence to show that any of them (the agglomerates) are older than the marine platforms at Europa and lower levels," and again, "the agglomerates (No. 5) now referred to (those resting on marine deposits, or Raised Beaches, and eroded platforms on the east side of the Rock), are similar in most respects to the older accumulations (No. 1) in Buena Vista. Like them they are made up of angular fragments of limestone of all sizes up to blocks several yards in diameter, set in an earthy matrix which is either red or grey." Another section‡ (fig. 15) is described by them at p. 527, fig. 10. They consider

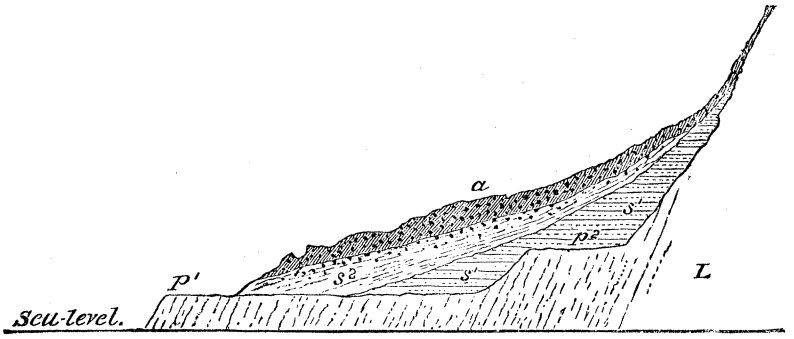
* I am not aware of any except the tooth of Horse, which I found at Hope's Nose, as mentioned in my first paper to the Geological Society.

† 'Trans. Roy. Soc. Edinb.,' vol. 4, p. 191; 1779.

‡ This is described somewhat more fully by Professor J. GEIKIE in 'Prehistoric Europe,' p. 326.

that the agglomerate here overlying the marine sands (a littoral deposit) is newer than that of Buena Vista and Rosia. I do not, however, see sufficient reason for this conclusion, and would suggest another interpretation (see fig. 16).

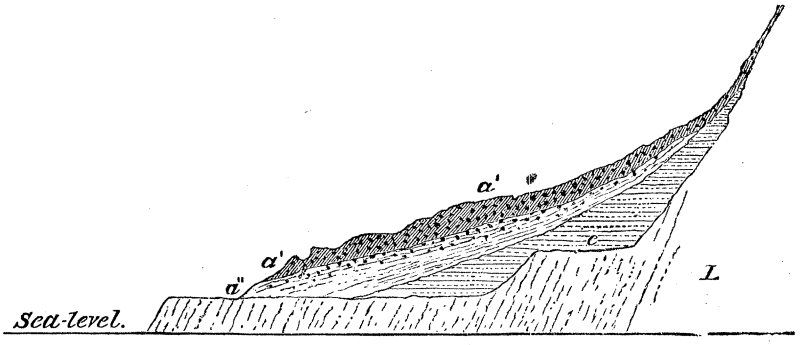
Fig. 15.—*Section from near Windmill Hill Barracks to the sea near Monkey's Cave-road* (Ramsay and Geikie).



L. Limestone.
p^1. Platform of marine erosion 160 feet above the sea.
p^2. Platform of marine erosion 260 feet above the sea.
s^1. Calcareous sandstone, horizontally bedded, marine.
s^2. Calcareous sandstone dipping away from cliffs, the weathered and rearranged upper surface of s'.
a. Unfossiliferous limestone agglomerate (the later agglomerate).

Presuming, therefore, that the surface breccia on both sides of the Rock is all of the same age, my reading of this section would be as under.

Fig. 16.—*Alternative reading of Section No.* 15.



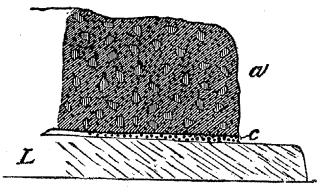
Rubble-drift { a'. Coarse limestone detritus.
a''. Composed mainly of the débris of the marine sands, *c*, with fragments of limestone in its upper part.
c. Marine sands = Raised Beach.

I take it that during upheaval the first effect of the effluent waters has been to denude the marine sands *c*, forming, with the limestone débris from higher up the slopes, a finer mixed detrital bed, which should be connected with the breccia or Rubble-drift a', and not with *c*.

In another section (their fig. 12), the agglomerate is again shown directly over-

lying the shelly grit, while in fig. 17 (their fig. 11) it rests on a remnant of a Raised Beach, lying on a platform of marine erosion.

Fig. 17.—*Section at Princes Lines* (the sketch only is after RAMSAY and GEIKIE).



a', Limestone Rubble-drift or *head* (Newer agglomerate, No. 5, of the authors).
c, Raised Beach (Gravelly conglomerate of the authors).

Why this agglomerate is taken to be more recent than that in Rosia Bay, is that it contains fragments of Mammalian bones, which the other is supposed not to do. But it seems to me rather a reason to prove that that breccia (No. 1) is occasionally ossiferous, and also that it is newer than the Raised Beach. The uncertainty of the occurrence of bones is, as before mentioned, one of the features of the Rubble-drift. Mr. SMITH speaks only of one breccia with remains of the extinct Mammalia, though he considered that there was a re-constructed breccia of modern date formed by the washings and débris of the older breccia, which it consequently closely resembles, that resemblance being aided by the continued deposition of carbonate of lime and cementation of the mass. This differs, however, from the older cave breccia and from the agglomerates of the authors in containing the remains of later Man and his handiwork, and of recent animals. The distinction has been well shown by Mr. BUSK.*

With respect to the origin of the breccia, Messrs. RAMSAY and GEIKIE attribute their older agglomerate on the western slopes to severe cold at the time "when the Rock had a wider area of low ground at its base, and when, so far as we know, it was not tenanted by land animals." They justly, however, observe, "something more than the mere action of strong frost is needed to account for the presence of the wide-spread and massive agglomerate of Rosia and Buena Vista." How, then, is the transport of large blocks and the accumulation of the débris in so large a volume over the small incline of 8° to 9° (in places not more than 2° to 3°) for a distance of at least 550 yards from the base of the main slope, to be accounted for? Winter torrents will not suffice. A cone of dejection spreads out fan-shaped, and would not extend so far beyond the foot of the main slope, and the débris would show symptoms of wear and rolling, as well as a gradation from coarse to finer materials. "But in the great limestone-agglomerates, not only are the stones all more or less sharply angular and arranged generally without any reference to size or figure, but the agglomerate at the foot of the Rock is not sensibly coarser than that which occurs at Rosia Bay, a distance of 500 or 600 yards away." It is, therefore, impossible to look upon the rubble as a talus, or as thrown out by cones of dejection.

* 'Trans. Inter. Congr. Prehis. Archæology,' Norwich Meeting, 1869.

From these and other considerations, the authors conclude that there seems to be in this agglomerate "evidence not only of the former action of frosts severe enough to wedge out large blocks of limestone, but also of more or less sudden meltings of thick snow, such as would saturate heavy trains of débris, and cause them to move *en masse* down the steep slopes and over the lower grounds beyond." This might be a true cause if the gathering ground had been larger and higher and the terminal slope less, but with so limited a gathering ground I do not see that it would be possible for snow, even if frozen, to have accumulated in sufficient quantity as to be able to propel so vast a mass of débris, with blocks 12 feet in diameter, over the lower slope, which dips at the small angle of 8° to 9°.* Even were it possible, would not the friction have been such as to cause the blocks to lose their sharp angles? I have shown, also, that this projection of débris with blocks, occurs even where the gathering ground was of much smaller extent, the height less, and a snow-slide improbable. The later agglomerate they suppose to have been formed under similar cold climatic conditions after a long interval, during which the Rock had become inhabited, and the cave and fissure breccias had accumulated under the influence of a genial interglacial climate.

The view I would take respecting the origin of the breccia may be briefly stated. First, however, with regard to the remarkable series of marine terraces, described by Mr. SMITH, of Jordan Hill, at various levels up to 600 feet. Of these we have very insufficient information. We only know from his general statement that in the beach at Europa Point, on the level of 70 feet, he collected nearly 100 species of recent shells said to be such as now inhabit the Mediterranean, but no list is given. At a higher level he makes mention of an oyster bed and of *Pectunculi*, and then of a shelly bed, and of a bed with recent shells at the 600 feet level. But, with the exception of *Pecten maximus* and *Patella ferruginea*, no species are named. Although we cannot assign a date to these several terraces, it is probable that the one at Europa Point is of the same age as the one in the Channel. The others may go back to earlier Quaternary or Tertiary times and correspond with similar traces at high levels in different parts of the Mediterranean coasts. To determine their age we must wait for a better knowledge of their Molluscan fauna.

On the emergence of the Rock, after the formation of these beaches, it became inhabited by wild animals, but there is nothing to show that this took place at an earlier date than the later Glacial or Post-glacial period, for the Mammalia are—with a few exceptions, due to the more southern situation of the Rock—of the same species as are common in the more northern caves. The predaceous animals found ready shelter in the caves and amongst the crags of the Rock, and there they may have carried the remains of the ruminants found in the older bone caves; but it is difficult to suppose that the numerous *Red Deer*, *Fallow Deer*, *Oxen*, and the vast numbers of *Ibex* spoken of by FALCONER—the bones of which show con-

* A more detailed section is given in 'Prehistoric Europe,' p. 217.

clusively that they had not been devoured by the Carnivora—could have inhabited the Rock at the same time. When, however, the submergence took place, the animals living on the surrounding plains sought refuge on the Rock in face of this unprecedented danger, and there shared in the common doom. Such of their remains as fell on the submerged surface of the Rock were subsequently carried down with the local detritus and their fragments incorporated, as the Rock emerged from the waters, here and there in the general mass of breccia.

The highest point on the west side of the Rock which the breccia is shown to reach is about 500 feet, and on the east side about 700 feet. But, considering the volume of detritus and the denuded state of the upper portion of the Rock, we may presume that the greater part, if not the whole of the Rock, was submerged. On its upheaval divergent currents swept down, in the manner I have described in speaking of the "head" at Brighton and Sangatte, the great body of limestone débris disintegrated by the cold of the earlier glacial period, and propelled it *en masse* over the flatter ground at the base of the long slopes. With the necessary velocity blocks of 12 or more feet in diameter would be easily moved under such a volume of water, while the friction would be comparatively small. Raised above the sea level the surface waters, after percolation through the calcareous rocks and débris, would rapidly effect the consolidation of the brecciated rubble, as on the slopes of Mont Genay, the coast of Mentone, and in the fissures of Nice and Cette, of which this deposit at Gibraltar is a counterpart on a larger scale. After the final rise of the land the caves and open spaces left in the fissures became the resort of the more recent wild animals and of Neolithic Man.

On this view the superficial deposits would be comprised in three stages or epochs. First and oldest, that of the later Raised Beaches and Quaternary Bone-caves. Second, that of the Breccia on the slopes and in the Ossiferous fissures (or Rubble-drifts). Third, and latest, that of the Neolithic caves.

I have dwelt thus long on Gibraltar not only on account of the extensive scale on which the phenomena are exhibited, but also because the other explanations of the facts being by geologists of high authority and of competent local experience, I did not deem it prudent to advance further on what is still debateable ground, and leave, without an attempt to capture, so important a position in the rear. We can pass more rapidly over Italy and some of the Mediterranean Islands.

Corsica.—It would seem that there are here several Raised Beaches some of which attain a considerable height.* The lowest of them is from 15 to 20 feet above the sea-level, and contains species of shells now living on the coast. To the north of Bastia stretches the promontory of Cape Corso, formed by a mountain range from 2000 to 3000 feet high and intersected by transverse valleys. Fringing this promontory on the eastern side, are numerous quarries of limestone of Cretaceous

* M. D. Hollande, 'Bull. Soc. Géol. de France,' 3me sér., vol. 4, p. 86, 1875.

age, traversed by a large number of ossiferous fissures, 250 to 450 feet above sea-level, that have been described by M. A. Locard.* These fissures are generally crooked and narrow, and extend the whole height of the quarries. When the sides of rock come near together at the top, the fissures are sometimes empty, but more generally they are filled with an ochreous and ferruginous earth or loam containing sharp angular fragments of the adjacent rocks, some of large size, with bones and land shells, heaped together without any order. In some places the breccia is concreted and forms a hard rock. M. Locard gives the following list of the fauna that have been found in the breccia :—

Homo.	*Lacerta.*
Lagomys Corsicanus, Cuv.	*Ovis musimon*, L.
Myoxus glis, Schreber.	*Lepus.*
Mus sylvaticus, L.	*Testudo.*
Canis vulpes, L.	*Perdix.*

The predominant remains are those of the *Lagomys*, those of the other Rodents are also numerous; of Birds only a few bones have been found. All the bones are much broken and there are no large ones. A very few fragmentary bones of *Man* have been found in association with the bones of *Lagomys*. The condyle of the left upper maxillary, and a fragment of the sphenoid bone were determined by Dr. Lortet. A few species of marine shells were discovered, but M. Locard considers that these were introduced by later Man (?). He further gives a list of thirteen species of *Helix*, three of *Zonites*, two of *Pupa*, and one of *Clausilia*. They are all species now living in Corsica, except one referred to as an Egyptian species.

As the *Lagomys* still survives in Siberia, and its remains are found elsewhere associated with the Mammoth and Woolly Rhinoceros, M. Locard concludes that these ossiferous fissures are of late glacial age, and that Corsica was then separated from the mainland.

Sardinia.—The work of General De la Marmora† gives many interesting details of the Quaternary deposits of this island. He shows that at several places on the coast there is a Raised Beach (or littoral deposit) like that of Gibraltar, composed of sand and grit (Grès Quaternaire), with occasional layers of pebbles and shells. The list is useful as affording a term of comparison with the Raised-Beach shells of the English Channel. Like them they are, with few exceptions, all of species now living in the neighbouring seas. There is, therefore, no reason why the Sardinian beach should not also be of late glacial age, although the stratigraphical evidence is not so clear as in the other case.

* 'Arch. Mus. d'Hist. Nat. de Lyon,' vol. 1, p. 37, 1873; and 'Bull. Soc. Géol. de France,' 3me sér., vol. 1, p. 232.

† 'Voyage en Sardaigne,' Paris, 1857.

The Raised-Beach Shells of Sardinia.

Cerithium vulgatum, Br.
Conus Mediterraneus, Brüg.
Murex plicatus, Broc.
,, *Sedgwickii*, M.
,, *trunculus*, L.
**Nassa reticulata*, F.

Patella Lamarckii, Lk.
,, *scutellaris*, Lk.
Tritonum nodiferum, Lk.
Turbo rugosus, L.
Vermelia triquetra, L.

Arca Noæ, L.
**Cardium edule*, L.
,, *papillosum*, Poli.
,, *rusticum*, L.
* ,, *tuberculatum*, L.
Donax trunculus, L.
Lucina fragilis, Ph.
,, *lactea*, Lk.
Lutraria rugosa.
**Mactra stultorum*, L.
**Mytilus edulis*, L.
**Ostrea edulis*, L.
,, *lamellosa*, Broc.
,, *plicatula*, L.

**Pectunculus glycimeris*, L.
,, *pilosus*, Lk.
Petricola fragilis, L.
,, *lithophaga*, Retz.
Pinna rudis, L.
,, *tetragona*, Broc.
**Scrobicula piperata*.
Solen vagina, Lk.
Spondylus gardropus, L.
Tellina planata, L.
**Venus chione*, L.
,, *decussata*.
* ,, *gallina*, L.
,, *multilamella*, Lk.
,, *verrucosa*, L.

Those with a star are found also in the glacial deposits of England.

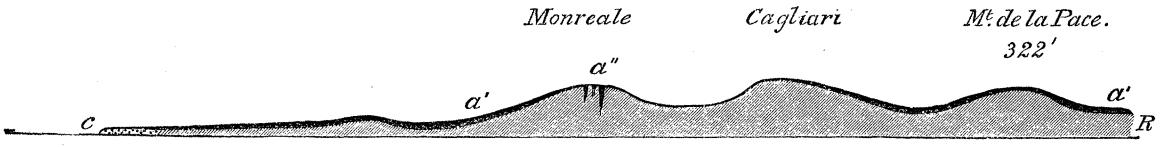
In some cases the shells are whole and with both valves united, but more generally they are broken, and with the colour often preserved as in the Channel beaches. *Ostrea* and *Mytilus* sometimes form entire beds. On the coast the beach is generally about 20 feet above the sea-level, though sometimes less, and is of small thickness, but it is said that as it extends inland it increases in height and thickness, attaining at Fontana, one mile from the sea, a height of 90 feet, and at Marmorata, two miles inland, a thickness of 60 feet, whilst at Alghero it is said to rise to a height of 100 metres.† At one place the so-called beach was found three miles inland. This deposit is, as at Gibraltar, generally consolidated by a calcareous cement, and has been quarried as a building stone from time immemorial. The beds are generally nearly horizontal, and sometimes show oblique lamination.

On the summit of the hill of Monreale, near Cagliari, there are fissures (a'', fig. 18), filled with breccia containing an enormous quantity of bones of *Lagomys*, *Myoxus*, *Arvicola*, and other small animals, but without any of the larger extinct Mammalia.

† I should imagine these to be not one but separate sea-levels, like those of Gibraltar.

The breccia extends down the slope of the hill on the seaward side, where it seems to impinge on a Raised Beach, as in the following diagram, but the author's description of them is not very clear.

Fig. 18.—*Generalized Section near Cagliari (J.P.).*



a', Breccia; *a''*, Ossiferous fissures; *c*, Raised Beach.

The breccia on the slopes contains no bones, but land shells have been found in it. In the plain, to the west of Cagliari, the rubble attains a thickness of several metres and contains blocks derived from the neighbouring higher hills inland, in a matrix of cemented red earth.

On the whole, these Quaternary beds accord perfectly with those of Corsica, and also in their essential features with those we have noticed on the Mediterranean coast of France. The projection of the angular local débris to a considerable distance (over the flat land towards the shore) from the base of the hill slopes, is likewise a feature common with the Rubble-drift.

Minorca and Majorca.—General De la Marmora describes similar recent marine beds skirting the coasts of those islands at heights of 30 to 100 feet, and M. Jules Haime* names some of the shells, but further details are wanting of the coast deposits in these islands; they seem identical with those of Sardinia.

Italy.—The phenomena on the coast of Italy are in close agreement with those on other parts of the Mediterranean shores, both with regard to the position of a low level beach and to the position, condition, and contents of the ossiferous fissures. General De la Marmora notes the occurrence of *Lithodomus* perforations on the rocks near Genoa at a height of 82 feet above sea level,† and of a consolidated Raised Beach about 25 feet above sea level in the neighbourhood of Leghorn.‡ At Ischia, also, are well-known marine beds at different, and mostly, high levels. In one of them, the fact was noted, that it abounds with Foraminifera of a species which M. Ernest Van den Broeck found to indicate closer relations with the northern oceanic fauna than with that of the warmer Mediterranean.§

There is also a concreted Raised Beach containing recent shells at Capri, about 30 feet above the sea-level. Other former higher sea levels are indicated by zones of rock with *Lithodomus* perforations.

Osseous breccia is said to occur in several places near Verona, and Vicenza, and

* 'Bull. Soc. Géol. de France,' 2nd ser., vol. 12, p. 742.

† 'La Sardaigne,' vol. 2, p. 345.

‡ In places it is quarried as a building stone, termed *Panchina*.

§ A. W. Waters, 'Quart. Journ. Geol. Soc.,' vol. 34, p. 196.

in Tuscany. Near Pisa, a red breccia, not distinguishable from that of Gibraltar, lies in vertical fissures of a light coloured limestone. It contains, like the other, remains of Carnivora, Ruminants (especially *Deer*), with species of *Helix* and *Cyclostoma elegans*. In the south of Italy, ossiferous breccias, with remains of various Ruminants, occur in fissures of the limestone at Cape Palinura.

Professor CAPELLINI gives a more special account of a bone-breccia discovered a few years since near Spezzia.* On either side of the bay are promontories of Jurassic limestone. The headland of the one on the south side forms, as at Nice, an almost isolated hill. In the course of constructing a fort on this point, a fissure or cavity in the rock was met with at a height of 246 feet (75 metres) above the level of the sea. It was filled with a red ferruginous breccia, cemented by calcite, in which were a great number of bones belonging to *Hippopotamus amphibius* (*H. major*), and *Cervus capreolus*, chiefly the former. A great number of the bones were however dispersed and lost before the attention of Professor CAPELLINI was directed to the spot. The discovery is interesting, as it points to the existence of a fauna similar to that on the Sicilian coast.

Sicily.—On the Atlantic coast, where the successive changes of level have been due to earth movements extending over wide areas, there has been little to interfere with the comparative uniformity in the level of the beaches. But in the Mediterranean area volcanic action has introduced a disturbing element, which no longer allows of uniformity of level being accepted as contributory evidence of contemporaneity of upheaval; and where we have no other evidence, altitude alone cannot be taken as a proof of age. This renders the age of some of the beaches in Sardinia and Corsica uncertain.

In Sicily there is, in fact, proof of considerable uplifts in recent times. According to Signor GEMMELARO,† there are on the coast of Catania several zones of sea-levels on lava-streams of known date. In one case, the lava-stream of the year 1169 has "adhering to it a coarse shelly sand, in which may be distinguished, almost in a normal position, *Cypræa lucida*" and other shells, at a height of 6 to 7 feet above the sea-level. At another spot he found blocks of lava encrusted by *Serpulæ*, at a height of 45 feet.‡ This he considered to be the greatest elevation the coast had undergone during the present period.

Of bone caves there is one with traces of a Raised Beach 70 feet above sea-level, two miles north of Syracuse. The cave contained remains of *Elephant*, *Hippopotamus*, &c. A bone breccia, which Dr. CHRISTIE classed with that of San Ciro, extended from the entrance to some distance at the base of the cliff.

* "Breccia Ossifera della Caverna di S. Teresa," 'Mem. dell' Accad. di Scienze dell. Ist. di Bologna,' ser. 3, vol. 10, 1879.

† 'Quart. Journ. Geol. Soc.,' vol. 14, p. 504.

‡ The age of the lava at this spot is not mentioned.

But the caves which more especially bear upon this inquiry are those in the neighbourhood of Palermo that are connected with an ossiferous breccia of a very remarkable and unique character, and which we must therefore describe at greater length. This breccia has been associated with the breccia of the ordinary older bone caves, but, though occurring in front and close to such caves, I think the association accidental, and that the two are independent. Without this disconnection its origin appears unintelligible.

Palermo stands in a plain, encircled, at a distance of about 2 to 4 miles, by an amphitheatre of hills from 2000 to 3000 feet high (fig. 21). Pliocene strata rise very gradually from the shore to the height of about 200 feet, when they abut against highly inclined limestone strata of Cretaceous and Jurassic age, which present a precipitous front towards the plain, while in places a thick accumulation of limestone breccia lies at their base.

There are several caves in the limestone escarpment a little above the line of junction with the Pliocene plain, but the one which most particularly claims attention, from the extraordinary quantity of *Hippopotamus bones* found in connection with it, is that of San Ciro, or Mardolce, situated about 2 miles to the south-east of Palermo, at the foot of Monte Grifone. This cave is 130 feet long, 10 feet wide at the entrance, 30 feet in centre, and 21 feet high, measured from the surface of the cave deposits. It is situated near the base of the escarpment, with ground sloping from its entrance down to the church of San Ciro, a distance of 266 feet (see fig. 19). But the breccia extends apparently beyond this. The cave was described by the Abbate D. Scinà* in 1830, and by Dr. Turnbull Christie in 1831.† It was visited afterwards by Dr. Falconer, who included it in his description of the Maccagnone Cave.‡ Owing to the way in which the cave deposits inside and out had been ransacked for bones, first by the peasants and afterwards by order, no systematic exploration was then possible.

When first discovered many hundred quintals of bones were dug out by the peasants. According to Scinà the breccia was *crammed with bones, so fresh* that they were cut into ornaments and polished, and that when burnt they gave out ammoniacal vapours. The quantity, however, was so great, that when afterwards exploited for commercial purposes, 20 tons were shipped in the first six months to Marseilles and England, where it is said they were used for the manufacture of lamp black§; if this were the case they could have lost very little of their animal matter. The bones were mostly those of *Hippopotami*, with a few only of *Deer*, *Ox*, and *Elephant*. In a weight of nearly $1\frac{1}{2}$ tons, all except six were bones of two species of

* 'Rapporto sulle Ossa Fossili di Mardolce,' Palermo, 1831.

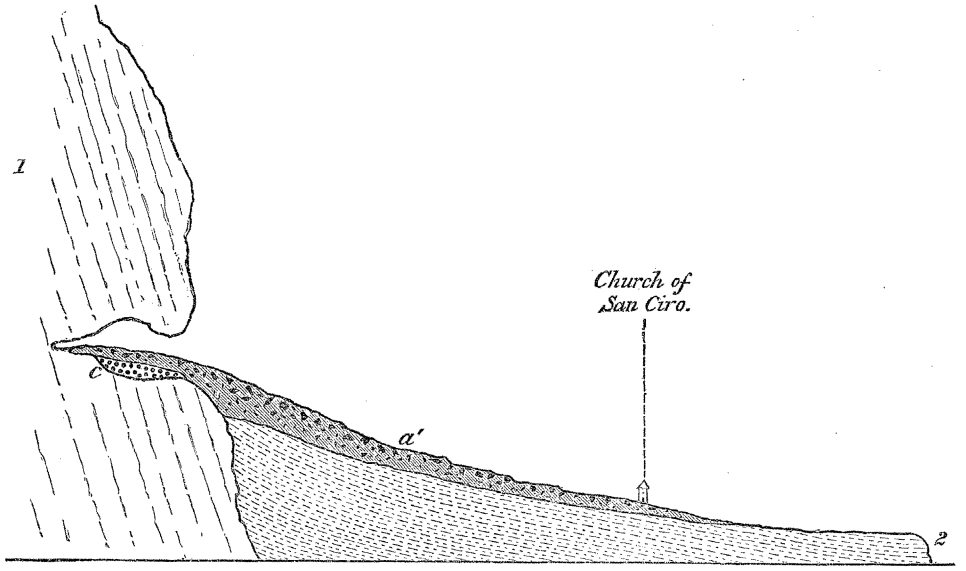
† "On the Newer Deposits of Sicily." 'Phil. Mag.' for October, 1831, p. 1.

‡ 'Quart. Journ. Geol. Soc.,' vol. 16, p. 99, 1860; and 'Palæontological Memoirs,' vol. 2, p. 543, 1868.

§ Or more probably of animal charcoal for the sugar factories. In the rubble-drift at Chilton, near Oxford, the bones likewise retained a large proportion (above 17 per cent.) of animal matter.

Hippopotamus; amongst them were 300 astragali of that animal. Scinà also collected 76 astragali for the Museum of Palermo, together with 14 jaws with teeth, besides numerous single teeth,* and specimens of almost all the bones of the body belonging to *animals of all ages down to the fœtus.* The following diagram section (fig. 19) gives the chief features, as described by the above writers. It is not drawn to any scale.

Fig. 19.—*Restored diagram section of the Cave of San Ciro (J.P.).*



1. Hippurite limestone. 2. Pliocene sands and marls.

a′. Bone breccia { Red clay, with angular blocks of limestone, passing down into reddish clay, with smaller fragments and some pebbles of limestone and quartz. (The latter may be derived from the sea-bed, *c*) . . . } 20 feet ?

c. Sand, with sea-shells and corals (?) of recent species. The walls to some height above *c* were perforated by *Lithodomi* † . . . . . 1 to 2 „

With respect to the position and condition of the bones, the evidence is conflicting. Scinà says that the bones were without order, and those of the different animals were mixed together, that they were broken, shattered, and dispersed in fragments. Speaking of the Elephant remains, he remarks that no entire tusks were found, and that the fangs of the teeth and epiphyses of the vertebræ were gone, whilst some of the bones were so reduced by wear as to be scarcely recognisable. Two teeth of

* These were still so numerous on the surface of the ground between the cave and the church of San Ciro, at the time of Dr. Falconer's visit, that the women and children of the neighbourhood picked up the teeth and brought them to him in handfuls. Whether these were ploughed up, or had been rejected at the time of the diggings, is, however, uncertain. They were not worn.

† It is possible that there may have been a distinct bone-breccia of the cave age between *c* and *a′*.

Elephant had been worn down to the state of pebbles. It is evident, however, that these are the exceptions; they may have been derived from the old beach- or cave-beds.* CHRISTIE merely says that the breccia contains "a prodigious number of fragments of bones with some rolled pieces and blocks of limestone." Dr. FALCONER makes no allusion to the wear of the bones, and the specimens deposited in the College of Surgeons have neither been worn or gnawed. Speaking also of the analogous breccia at the Grotta di Maccagnone, he says that the bones were all broken and splintered, and that *none of them bore marks of gnawing.*

To obtain the bones, a cutting 6½ feet wide, and apparently about 20 feet deep, was made from the mouth of the cave to the slope outside, but no particulars of the section have been preserved. In the interior of the cave the upper part of the breccia was loose and pulverulent,† and the bones light and adhering to the tongue, but the greater part of it, both in the cave and outside on the slope, was extremely hard.‡ SCINÀ, however, says it was more compact in the cave, and that the bones in it were petrified and solid, carbonate of lime being the cementing and solidifying material. The same writer speaks of the breccia inside and outside the cave as one mass, whereas CHRISTIE thought there was a want of continuity between the two.

Looked upon as a whole, the mass of débris which, near the entrance of the cave had a thickness of from 20 to 30 feet, closely resembles in its general character the Rubble-drift on slopes or over some of our Raised Beaches. CHRISTIE says that it "has some appearance of being divided into strata as if deposited under water," and here, as at Brighton and Sangatte, the coarsest bed lies on the top. According to the same writer, a similar calcareous conglomerate or breccia attains at the foot of Monte Pellegrino, a thickness of 40 to 50 feet, and contains blocks many yards in circumference. In this respect it resembles the breccia on the slopes at Gibraltar. CHRISTIE also remarks that "This bone-deposit has more analogy to the bone-breccias that occur in various parts along the shores of the Mediterranean than to the bone-caves of the more southern parts of Europe."

The traces of old occupation of the cave of San Ciro by predaceous animals is more obscure than in the case of the Gower caves. If an old cave floor existed, it has been swamped under the great mass of breccia with the Hippopotamus bones. That there were, however, dens of Hyæna fringing the declivities of that range of hills is certain. One was discovered by Baron ANCA DI MANGALAVITI§ between Palermo and Messina, in which a large number of bones and Coprolites of Carnivora, with Deer horns, and astragali of other animals, bearing the marks of gnawing, have been found. The Baron also points out that, whereas in these caves bones of Carnivora and Deer are

* Nine Elephants' teeth were found *in the cave.* It looks as though the cave beds and the angular rubble (Rubble-drift) formed two distinct deposits, as in some of the Belgian caves (see fig. 12).

† Apparently there was no stalagmite.

‡ It was quarried outside as a building stone.

§ 'Bull. Soc. Géol. de France,' 2nd ser., vol. 17, p. 680.

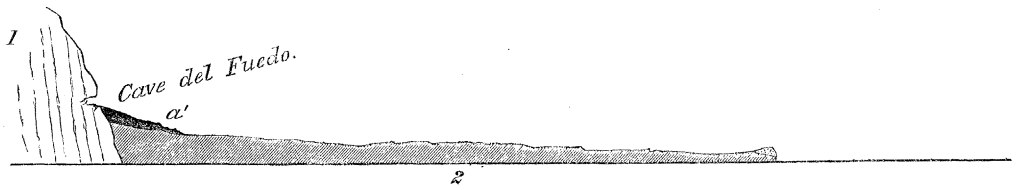
common, in the caves of San Ciro and Maccagnone such bones are scarce, whilst those of Hippopotami abounded.

The bones found in the San Ciro breccia belong, according to FALCONER, to—

Hippopotamus major.	*Sus.*
„ *Pentlandi.*	*Bos.*
Elephas antiquus.	*Cervus.*
Felis (a large sp.).	*Ursus.*
Canis.	

There are two other caves about four miles westward of Palermo where this breccia has been observed. Both are situated at the foot of Monte Belliemi, and at a height of about 100 feet above that of San Ciro. In neither of them was there any evidence of marine action. In that of Ben Fratelli, which is 320 feet above sea-level, the breccia occurs both inside and outside the cave, whilst in the other, or that of del Fuedo, 332 feet above sea-level and distant one-third of a mile from the former, the breccia is confined to the *exterior* of the cave (fig. 20). SCINÀ states that both the bones and soil here gave out ammoniacal vapours.

Fig. 20.—*Section from the slope of Monte Belliemi to the Bay of Palermo* (CHRISTIE).



1. Limestone rocks.
2. Pliocene strata.

a' Bone breccia (= Rubble-drift ?), outside the cave.
::: Gravel (of uncertain age).

The upper beds of the cave of Maccagnone, near Carini, which is situated in a similar amphitheatre of hills, have been fully described by Dr. FALCONER, but there the same uncertainty exists with respect to the character of the lower beds as at San Ciro. There is also the same profusion of Hippopotamus bones in the breccia on the slope in front of the cave. Dr. FALCONER says that he "dug up an enormous quantity of these remains within an area of 12 or 14 feet square." Amongst them were a very large number of astragali. There, likewise, the "bone breccia was strewed over with huge blocks of limestone which had fallen since its deposition."

With regard to the origin of this extraordinary accumulation of Hippopotamus bones, we may at once discard the idea that they were brought to their present position by predaceous animals, as were the bones in the breccia of true bone-caves. In these, the evidence of their having served for food is unmistakable, as traces of the animal's teeth are conspicuously apparent upon the bones, but the bones in this

breccia show no traces of gnawing. Besides, in one case, the breccia is confined entirely to the outside of the cave, where it is not probable that the Hippopotamus remains would have escaped destruction by the Hyænas which frequented the same district. Nor could the bones have been washed and transported by river- or sea-action, for they are mostly splintered and in fragments, and are neither worn or rolled.* It is evident also that the animals must have died on or near the spot where their bones are found, and that their accumulation is due to causes other than the foregoing.

It was suggested by Dr. FALCONER, that the bones were those of successive generations of Hippopotami, which went there to die. But this is not the habit of the animal. Sir SAMUEL BAKER, in his many years' experiences in the Soudan, and on the borders of Abyssinia, where Hippopotami live in large herds, makes no mention of such an instinct,† nor does he allude to any circumstances which could possibly, under the *ordinary* conditions of life, have led to such local accumulation of their bones. Under ordinary circumstances, their dead bodies, like those of other wild animals, are devoured by Carnivora, or rapidly disappear from the surface under atmospheric and other agencies. Even supposing the accumulation of the bones to have been effected in some way by successive additions, the usual weathering would have caused great inequality in their state of preservation, whereas, as a rule, all the bones in the breccia seem to have been in the same almost fresh state, with the exception of the specimens near the surface, which have lost more of their animal matter. Besides, as the bones are those of animals *of all ages*—including the unborn —this fact is, I think, conclusive against this explanation.

The circumstances, therefore, which led to these remarkable accumulations of the remains of the Hippopotami must have been *extraordinary*, and I see no hypothesis which meets the case, so well as the one that I have suggested to account for the bones of Mammalia in the Rubble-drift and in the ossiferous fissures, though the local conditions in this case are peculiar.

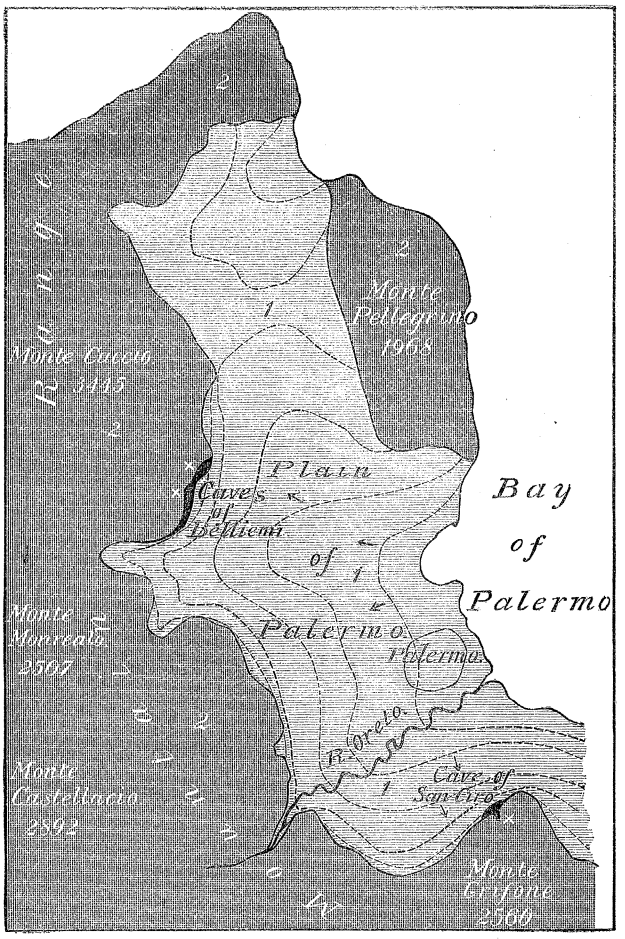
On the submergence of the Sicilian area, the wild animals of the plains would, as in the case of Santenay, Cette, and Gibraltar, be driven to seek refuge on the nearest adjacent high ground and hills. In the instance before us, the animals must have fled to the amphitheatre of hills which encircle the plain of Palermo on all sides except the sea, and on the slopes of which the Cave of San Ciro and the others are located. As

* SCINÀ was of a different opinion. He thought that the bones had been transported from a distance —drifted in by marine currents. But, in that case, all the bones together with the limestone fragments should have suffered equally, whereas, it is evident from his remarks, as well as those of CHRISTIE, that the rolled fragments constitute the exception. These may have been formed when the sea entered the cave (*c*, fig. 19), and caught up afterwards in this Rubble-drift as were the beach pebbles in the *head* at Sangatte and La Motte. Or weathering by the percolation of water may have had something to do with the removal of the angles of the limestone fragments and of some of the bones.

† Mr. HUDSON, however, mentions one instance of an animal resorting to a given spot to die. It is that of the Huanaco: 'The Naturalist in La Plata,' p. 318, 1892. This was also noticed by DARWIN.

the waters rose, the area of this plain became more and more circumscribed (fig. 21), and retreat more and more impossible, except through a few rare passes in the range of hills, until, at last, the animals were driven together at the base of the hills, where they were stopped by mural precipices impassable to the larger and heavier animals, though some of the more active and agile Ruminants and Carnivores may have, and, judging by the rarity of their remains, probably did escape to the

Fig. 21.—*The Plain of Palermo with its Amphitheatre of Hills.*



▬ Ossiferous breccia. × Caves.

1. Pliocene strata (with a narrow belt of Eocene beds in places).
2. Cretaceous and Jurassic strata.

The boundary line between 1 and 2 gives approximately a contour line of from 150 to 200 feet above sea-level. The slope thence to the sea is very gradual. Above the Pliocene plain, rocks of Hippurite limestone rise abruptly, forming steep cliffs and mural precipices, with breaks in the direction of Monreale and in the course of the River Oreto. The dotted lines are supposed to represent roughly the portions of the plain gradually occupied by the advance of the sea. These are merely for illustration and are ideal, but the boundary lines and heights, given in feet, are taken from the Geological Survey Map of Sicily.

mountains behind. Retreat entirely cut off by projecting promontories on either side, the only paths yet open to the imprisoned herds were those that led to the caves, which were a little above the general level of the plain. Hither the animals must have thronged in vast multitudes, crushing into the caves and swarming over the ground at their entrance, where they were eventually overtaken by the waters and destroyed, and, as their bodies decayed,* a confused mass of their remains were left and scattered on and near the spot where they had finally congregated.

For reasons before given, the land could not have remained long submerged. As it rose intermittently from beneath the waters, our supposition is that the rocky débris on the sides of the hills was hurled down by the effluent waters on to the pile of bones below, breaking them into fragments, and forming, together with them, the heterogeneous mass of bones and rubble constituting the breccia. The last more rapid uplift, the effects of which are so frequently seen in many sections of the *head*, brought down the larger blocks of rock that now lie on the top of the whole. Scinà, an independent witness, inferred from the character of the rock fragments, and from the red clay in which they are imbedded—and which comes from decomposed rock surfaces on the hills above—that, in the case of the Belliemi breccia, both the detritus and the bones had been washed down from Monte Belliemi. All this must have been effected in a space of time comparatively so short, that, though the bodies of the animals decayed, the bones underwent but little change, nor, encased as they became in an almost impermeable breccia, has the change they have since undergone been great.

Thus there is, in all the essential conditions, a close agreement between this Sicilian breccia and the Rubble-drift of the south of England, as likewise with the rubble on the slopes of Mont Genay, of the Rock of Gibraltar, and of other places mentioned in the preceding pages. In all, the débris consists strictly of local materials; the fragments are angular and sharp; the bones are mostly in fragments, and are neither gnawed nor worn; and the faunal remains are those alone of a land surface, and of species such as then were to be found in the district.† This rubble, also, forms in all these cases the last of the drift beds. The only apparent difference arises from the circumstance that, in the Sicilian area, the geographical configuration was that of a land-locked bay with many minor bays or embrasures in the front of the hill-range, so that, as the waters rose, the animals of the plain were driven together, as in a seine, into those bays, where, as a last resource, they sought shelter under the mural precipices and in the more accessible caves. As these precipices were nearly vertical, they formed, as the land rose again, a partial protection from the effluent currents, which otherwise might have carried the débris to a greater distance outwards. Under no other circumstance that I can conceive could the animal remains have been massed as they are at the foot of the escarpments encircling the plain of Palermo.

It may be asked how could large herds of Hippopotami have existed in so limited

* Some may have floated and so been carried to a distance and lost.

† Scinà seems to imply that on the slope of Belliemi land shells are associated with the breccia.

a plain as that of Palermo. It needed then to have had much greater extent and larger rivers. I have shown that the present height of the Raised Beaches on the English Coast does not give the initial upheaval, but is the sum of the differences of several earth-movements—that the primary upheaval of the beaches was not less than 100 to 150 feet greater than the altitude at which they now stand, and that this led to the conversion of a considerable extent of the area of the Bristol and English Channels into dry land. What little evidence we have on the coast of Malta (*postea*, p. 965), and of Greece,* points to similar elevations of the coasts of the Mediterranean, so that large tracts of dry land may then have existed between the Sicilian and Italian shores, and formed suitable pasture grounds for the Hippopotami. With increase of the land area, so would the rivers also have had increased size, and though they may not have been very large, yet as Sir S. BAKER has shown, perennial waters are not indispensable to the Hippopotamus, for in the Settite and other rivers of the Soudan, these huge animals tide over the dry season, by resorting to the few pools left in the dried-up channels of the rivers.

On this interpretation of the origin of the San Ciro breccia, the reason of the uncertainty as to its position relatively to the cave deposits, felt by FALCONER and CHRISTIE, becomes apparent, for it is obvious that in that case it was formed subsequently to the cave bone-breccia, and fronts the deposits in the same way that the angular rubble ("Argile à blocaux") masked the "Trou du Frontal" (*ante*, fig. 12).

Malta.—There does not appear to be any well-marked Raised Beach on this island, but of bone-caves of the same age as those of Sicily there are several, and their contents are of a very remarkable character. The independence of the caves and the ossiferous breccia of Malta is also more clearly shown than in Sicily. These caves have been described by Dr. LEITH ADAMS,† Admiral SPRATT,‡ Dr. FALCONER,§ and Mr. G. BUSK.‖

The island, which is extremely bare, consists entirely of Tertiary strata, covered by a red earth, derived partly from their decomposition. The drift beds lie on the slopes and in the valleys. The island is hilly, but there are no hill ranges like those of Sicily, the greatest heights being under 800 feet.

It is not necessary to give any descriptions of the caves, as they are to be found in the memoirs quoted, but I may give the list of the remarkable cave fauna, which was in occupation of the island at the time of the Rubble-drift. The variation of

* MM. BOBLAYE and VIRLET mention the occurrence of a submarine cliff off the Greek Coast.

† 'The Nile Valley and Malta,' pp. 161–238, 1870; and various papers in 'Geol. Mag.,' and in 'Reports, Brit. Assoc.'

‡ "On the Bone Caves near Crendi Zebbug and Melliha," 'Quart. Journ. Geol. Soc.,' vol. 23, p. 283. It was in these that the dwarf Hippopotamus and pigmy Elephant were first discovered.

§ 'Palæontological Memoirs,' vol. 2, p. 292.

‖ 'Trans. Zool. Soc.,' vol. 6, p. 119. See also a short notice by Professor F. W. HUTTON, in 'Geol. Mag.,' vol. 3, p. 145; and Dr. JOHN MURRAY'S "The Maltese Islands," in 'Scottish Geographical Mag.' for September, 1890, p. 449.

this fauna from the contemporaneous fauna of Sicily and the mainland was probably due to long isolation of the island during the Quaternary, and possibly the later Tertiary, periods. According to the last summary of Dr. LEITH ADAMS, it consists of:—

Elephas Mnaidra, ADAMS . . .	*The large Elephant of Malta.*
„ Melitensis, FALC. . . .	*The dwarf Elephant of Malta.*
„ Falconeri, BUSK . . .	*The pigmy Elephant of Malta.*
Hippopotamus Pentlandi . . .	*The small Hippopotamus.*
Myoxus Melitensis, PARKER . .	*The gigantic Dormouse.*
„ Cartei, ADAMS . . .	*The hollow-jawed Dormouse.*
Arvicola pratensis, BAILLON . .	*The Bank Vole.*
Cygnus Falconeri, PARKER . .	*The great Swan.*
„ Olor, GMELIN	*The mute Swan.*

With these were found bones of a large fresh-water Turtle, and the tooth of a Carnivorous animal.

The *Hippopotamus Pentlandi* occurs in the caves of Sicily; the *Arvicola pratensis*, a recent species, is found in caves in this country; the *Cygnus Olor* is a North African bird, and a winter visitor to Malta. The absence, or extreme rarity, of the ordinary cave animals and of Ruminants is another feature of the special insular character of this fauna.

The land shells of the drift beds are not given, but those found in them in the adjacent island of Gozo are all of recent species.*

The breccia is, as it is elsewhere, of a date immediately subsequent to the caves, and contains, in the few instances where it is fossiliferous, the same Mammalian remains. It occurs under three conditions: 1st, in the rock fissures; 2nd, in cavities or hollows in the surface; 3rd, on the slopes of the hills and under escarpments. As instances of the first are the Gandia and Shantiin fissures, met with in quarrying the calcareous sandstone near the village of Micabba. Dr. L. ADAMS describes them as rents of small size, crammed to the top with red earth and angular fragments, from a few inches to 2 or 3 feet in circumference, of the adjacent rock, with which numerous bones were interspersed in the greatest confusion. He observes that "the broken and splintered condition of the long bones was remarkable," and that none of them showed traces of having been rolled. He also remarks that "throughout the mass were strewn abundant remains of Elephant bones with the teeth entire or broken, together with fragments of bones of very large aquatic birds and those of the Dormouse, just as if numerous decayed carcasses of Elephants, large Water Birds, and

* Mr. J. H. COOKE enumerates:—

Helix Pisani, MÜLL.	*Helix esoperata?* MONT.
„ *striata*, DRAP.	„ *vermiculata*, MÜLL.
„ *virgata?* MONT.	*Pomatias melitensis*, SOW.

Rats, scattered about on the surface, had been suddenly swept pell-mell into the gaping rent" with the detrital matter of the rocks. In the Shantiin fissure upwards of fourteen Elephant molars were discovered, while the Gandia fissure was estimated to contain the remains of no fewer than sixteen individual Elephants. The breccia is coloured red by the red earth derived from the hill tops, and is generally cemented by carbonate of lime, like the Gibraltar and Nice breccias.

Elsewhere Dr. ADAMS says that some of the bones have the appearance of having been partially devoured by Carnivorous animals, but the specimens in question are uncertain as no particulars are given, and they may have been derived from the old bone caves.

The Mnaidra and Berghisa gaps seem to be more in the nature of pot-holes or depressions in the surface, into which the local detritus and carcasses of animals had been swept. There, "among the large blocks of freestone, either impacted or strewn in a heterogeneous manner were lying seemingly entire skeletons of Elephants, some of the skulls and jaws furnishing good evidence of the rough usage they had sustained by being broken and crushed flat by blocks, which, with the force of impact, had cracked the others on which they had impinged." Dr. ADAMS also mentions that at these places seams of rolled pebbles are intermingled with the breccia. These may have been derived from an old watercourse or beach.

Admiral SPRATT and Dr. ADAMS both notice the large accumulation of angular and sub-angular débris in red earth at the mouths of the valleys, and on the slopes of some of the hills. One such bed of special interest is to be seen at Malak, on the south coast of Malta, where for some miles a steep escarpment, 200 to 300 feet high, formed by an old line of fault, fronts the sea. The lower part of this escarpment is covered by a red breccia, hidden in places by a modern talus, sloping down to the water's edge, where it forms steep banks that are being gradually worn away by the waves. In this breccia, which consists of red earth derived from the hills above, and of angular and worn fragments of the overhanging calcareous sandstone and lower limestone, several molars and part of the skull of a *Pigmy Elephant* were found *in situ*.* Dr. ADAMS has given a sketch and section of these cliffs, of which the following diagram-section (fig. 22) is a reduction.

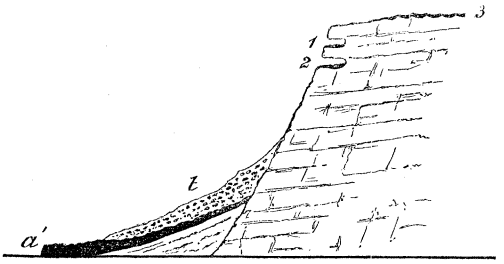
The breccia bears a close similarity to the Rubble-drift or "head" over the "Raised Beaches" in the English Channel. There is the same local origin† of the detritus with remains of the animals then in occupation of the land. The main difference is that at Brighton and Sangatte the old cliffs are low, so that they are entirely masked by the rubble, whereas the escarpment at Malak is so high, that the

* In addition, Professor HUTTON mentions *Sus*, *Arvicola*, and land shells; 'Geol. Mag.,' vol. 3, p. 145, 1866.

† Dr. ADAMS supposed that fragments of a black limestone, found in the breccia, were foreign to the island, but Mr. COOKE has recently shown that a bed of this character does exist in the Lower Coralline Limestone; 'Geol. Mag.' for August, 1892, p. 361.

mass of débris has only sufficed to cover up the base of the cliff. I also take this breccia to be the equivalent of the breccia on the slopes of Gibraltar (the presence of Mammalian remains being a local condition), and of the breccia on the Mentone Coast. They all testify to the débris of a land surface, carried from higher to lower levels by a force acting vertically.

Fig. 22.—*Section showing the position of the Bone Caves and Bone Breccia on the Coast at Malak.*



t, Modern Talus.
a', Ossiferous Breccia.
1, Malak Cave, with remains of *Hippopotamus Pentlandi*, and *Pigmy Elephant.*
2, Melleha Cave, with remains of *Hippopotamus.*
3, Red clay on surface.

A fact mentioned by Admiral SPRATT* tends to confirm the opinion I expressed when speaking of the Sicilian coast, that, previously to the submergence, the land stood at a higher level than at present, for in excavating the naval docks at Valetta, the breccia of red earth, with fragments of surface débris and *land shells*, were found in fissures and crevices of the rock at 20 feet and more below the present sea-level.

Judging from the height at which the Rubble-drift is found it is probable that the island was wholly submerged. It is a significant, though not conclusive, fact, also, that not one species or even a single genus of its Quaternary Mammalia are now living on the island, the only indigenous quadrupeds, according to Dr. LEITH ADAMS, being the *Weasel*, *Hedgehog*, and *Rabbit.*

Carniola and Istria.—Some remarkable facts have been noticed in connection with the mines of Carniola.† The hills around Kropp, which rise to the height of several hundred metres above the sea level, are traversed by large fissures filled with a breccia, with which is associated a hydrated oxide of iron in grains from the size of a pea to that of a nut. This breccia contains, as usual, angular fragments and large blocks of the adjacent limestone rocks. The greater number of these fissures are unfossiliferous, but in a few the teeth and bones of *Ursus spelæus* have been discovered, and in one the tooth of a carnivorous animal was found at a depth of about 250 feet. BRONGNIART classed these fissures, some of which have been worked to the depth of

* *Op. cit.*, p. 296.

† A. BRONGNIART, 'Annales des Sciences Naturelles,' August, 1828 and 1829.

720 feet, with those of Nice and others on the Mediterranean coast, and considered them all to be due to a common cause. Ossiferous breccias are also found in parts of Istria, and there are large accumulations of red drift and loam filling cavities in the neighbourhood of Trieste ; but without further details it is not possible to judge with certainty of the exact relations of these deposits. So far as known to me, the explanation I have suggested in the other cases might possibly apply to these districts, but the great height of the ground, and the peculiar local conditions, render further investigation necessary.

Dalmatia.—The travels of ALBERTO FORTIS in Dalmatia* furnish some incidental notices of the ossiferous breccia on the Adriatic coast, and especially on the islands of Charso and Ossero, which consist of ranges of limestone hills of some height either bare or covered by red earth. The cliffs on the coast are traversed by numerous fissures filled with breccia, and containing, FORTIS says, an extraordinary abundance of bones, but beyond these facts there is no reliable statement as to the character and nature of the bones or breccia.

Dr. F. LANZA,† who visited this coast long subsequently, adds little to our information, except that some of the bones belong to a species of Deer, and that the breccia contains land, but no marine, shells. These instances, however, help to show the generality and common characters of the phenomena over all this area.

Ionian Islands.—Except a few incidental notices by ANSTED‡ and STRICKLAND,§ such as that the valley of Signies in Cephalonia is covered by an alluvium full of angular flints, I can find no mention of anything referable to a Rubble-drift.

I am unable to extend this inquiry through central and south-eastern Europe, as it would involve many large and separate questions upon which I am not at present sufficiently informed, still, I should wish to call attention to a few points which may be found to bear upon the general subject. The great height of the plains and the vast extent of the area over which Loess deposits are spread in south-eastern Europe, is, as observes‖ Professor JAMES GEIKIE, "fatal, not only to every form of the lacustrine hypothesis, but also to the ingenious view supported by LYELL, as it is to that of BELT."¶ Marine and fluviatile hypotheses are equally inapplicable, though in some districts, as in Roumania,** the Loess, as in Western Europe, belongs both to the valley and plateau types. In other districts it cannot be so referred. Loess is very largely developed in Southern Russia,†† and with it some geologists associate

* English Translation, London, 1778, p. 440.

† 'Bull. Soc. Géol. de France,' 2nd ser., vol. 13, p. 127, 1855.

‡ 'The Ionian Islands.'

§ 'Memoirs,' by JARDINE, p. 68.

‖ 'Prehistoric Europe,' p. 160.

¶ 'Quart. Journ. Geol. Soc.,' vol. 30, p. 490.

** STEFANESCU, 'Mémoire relatif à la Géologie du Indet, &c.

†† MURCHISON'S 'Geology of Russia,' chap. 19.

the Black Earth or Tchernozem of the Steppes. Whatsoever may be their origin, it is evident from the heights at which the Loess and the black earth are found, that the waters in which they were deposited reached to considerable altitudes, and the general character, both of the Loess and of the black earth would accord with a sedimentation from the turbid and barren waters of a temporary submergence. Like the Loess, the black earth occurs at all heights, and covers the valley drifts. From its uniformity and wide extent MURCHISON supposed it to have been deposited under water, and considered that it might have been in great part derived from the black Jurassic shales which are largely developed in Southern Russia, so that its origin, as with other forms of the Rubble-drift, would be local.

The area covered by these deposits is so vast—larger than that of some European countries—and so nearly flat and open, that the waters during emergence must have flowed off less rapidly than they would in more restricted channels, and therefore allowed of a greater sedimentation. As in Western Europe, the organic remains of the Loess are all those of a land surface, and though none have been found in the black earth, its highly nitrogenous character is a singular feature, and indicative of the presence of organic if not of animal matter.

Greece.—Since the great work published by the French Government,* in which the extent and physical characters of the Quaternary deposits were treated with a fulness unusual for the time at which it was written, I am not aware that anything has been done to throw much additional light upon these drift beds of Greece. MM. BOBLAYE and VIRLET placed these deposits, which they term "Alluvions anciennes," between the Tertiary formations and the last upheaval which marks in Greece the commencement of the present period. The latest of these is composed of a red earth containing angular fragments of the local rocks, some of which are more than *a metre long*, but as the deposit approaches the sea, to the level of which it descends, the fragments became less angular. This drift covers the valleys of the Morea and rises to a considerable height up the sides of the adjacent hills, of which it follows the slopes, and is in places cut off on the coast by cliffs 15 to 20 metres high, while in the valleys, the torrents have cut into it to considerable depths. Though the deposit is unstratified in the upper parts of the valleys, on the coast it becomes interstratified with seams of sand and gravel. Previous to the spread of this drift, there had been an elevation of the coast to the extent of 20 to 25 metres, as shown by lines of *Pholas* perforations. An instance occurs on the cliffs near Nauplia. In other places traces of a Raised Beach exist. Over one of these was a drift bed with *Helix algira.*†

The authors say that this ferruginous and argillaceous drift "fills the valleys and

* 'Expédition Scientifique de Morée; Géologie et Minéralogie,' par MM. DE BOBLAYE et T. VIRLET, vol. 2, 2nd part, pp. 316–375, 1833.

† In an overlying bed some rude pottery was found.

forms taluses on the old coast lines . . . . . and seems to be contemporary with the osseous breccia with which it becomes confounded." It is quite distinct from the detritus carried down by the present streams which, though large in quantity, is not spread out in sheets, but forms cones of dejection at the mouths of the valleys.

This old angular drift, which is often cemented by calcareous infiltration into a hard, rocky mass, forms taluses or banks 40 to 50 metres high against the escarpments of Dolomite at the foot of Mount Taygetus, and is also found at the foot of the escarped shores of the lakes and of the sea-cliffs. The authors state that this drift is prolonged into historic times, with precisely the same characters, but this means I presume, no more than that the more recent deposits formed by the wear and erosion of the older drift, retains very much of the same character and aspect. The limestone hills are covered up to their highest summits with a red earth, due to the decomposition of the rock by atmospheric agencies. It is from this that the matrix of this deposit and of the osseous breccias, and which fills certain caves, is derived.*

Though it is stated in one place that the breccia forms a slope at the foot of the hills inclined at an angle approaching 45°, which might lead to the inference that it was a sub-aërial talus, this statement does not agree with what the authors say about its extending into the plains, nor with the sections they give, which represent the breccia with slight and variable slopes (Plate 2, fig. 2; Plate 3, fig. 4; Plate 6, figs. 4, 5; Plate 7, fig. 2), while it attains in some places in the valleys a thickness of from 50 to 60 feet or more. They also tell us that in some places "the breccia has been nearly denuded away, and all that remains in proof of its existence, is the *osseous breccia* which fills the fissures of the rock, and has acquired great solidity." This drift also blocks the entrance of some bone caves.

No particulars are given of the organic remains. It is merely stated that in this respect they resemble all the others on the coast of the Mediterranean, and that not only is there an absence of marine remains, but that land shells (*Helix algira*) occur in the breccia.

A few miles off the south coast of Greece is the island of Cerigo, which at an early date attracted attention in consequence of the reported occurrence of human remains in the ossiferous breccia filling fissures on the summit of a flat-topped hill near the sea. Amongst these were a jaw and part of a skull. CUVIER discredited the report, but without seeing the specimens, and the discovery was not followed up. Nor were any particulars given of the animal remains. A breccia is said also to lie on the slopes of the hills, while the ossiferous fissures are situated on an isolated hill, where, as at Cette and other places, the animals were likely to have sought refuge from the rising waters.

This *Old alluvium* of the Morea is identical in many of its features with the Rubble-drift of the South of England. There is (1) the same derivation of the detritus from local rocks; (2) the same angularity of the fragments; (3) the same general absence

* This red colour of the ground is common in all the western Mediterranean area.

of stratification, though, as in England, with an occasional appearance of rough bedding; (4) the same transport from the higher ground behind to the sea-level; (5) the same fall over the old line of cliffs, and the same cutting back of the rubble slope since the present sea-level has been established; (6) the same blocking of the mouth of caves and filling up of fissures as the rubble swept over the surface; (7) the same powerful propulsion forward of the rubble, and its spread in wide sheets instead of in the cones of dejection formed under ordinary sub-aërial agency, and (8) the same limitation of the organic remains to those of a land surface.

What differences there are are due merely to the different character and colour of the strata. Soft rocks with light colours prevail on the south coast of England, whereas on the Mediterranean coasts, the red earth, due to the decomposition of the limestones gives, as in the Plymouth district, a general red colour to the ossiferous breccias and Rubble-drift.

With these many points of resemblance there is, I consider, good reason to believe that in both countries these drifts are due to a common cause—one that we have already seen equally affected the intermediate area. These drift beds require, however, further investigation, and may prove as rich in Palæolithic remains as the ground above them has proved to be in prehistoric remains.

Crete.—From M. Victor Raulin's work on Crete* I gather that there is evidence of the elevation of the island within the historical period to the extent of 15 to 25 feet, and further, that at a height of about 65 feet, a Raised Beach of Quaternary age is met with at many points of the coast. In the absence of sections and exact details, we can only surmise that the Rubble-drift is present there from the mention of two facts—(1) that at one place the Raised Beach is overlaid by a calcareous breccia (*brèche calcaire*) or "*Head*;" and (2) that at the foot of the great escarpments of the interior there are immense accumulations of angular detritus. Some of these (*terrains détritiques*) are recent, but some seem more widespread and older. They are traceable up to heights of 200 to 300 metres. A red earth, as in Greece, covers much of the surface.

Admiral Spratt has shown,† that within recent times there has been a subsidence of the east coast of Crete, whilst the west side has been elevated to the extent of 26 feet. Anchor blocks have been found 11 feet above the sea level, and the port of Kissamo has been raised 18 feet out of the sea within Christian times. The two piers of the port of Phalasarna, a city of late Hellenic date, and described by Strabo, are now 22 feet above their original level. Spratt also found *Pectunculi* of recent species 40 feet above the shore, and indications of another Raised Beach or old sea level at 100 feet. At about the same height he discovered a bone-cave with remains of *Myoxus, Goat, Roebuck,* or *Deer*, in a breccia under stalagmite. Remains of

* 'Description physique de l'Ile de Crète, partie Géologique,' pp. 616-656, 1861; and 'Bull. Soc. Géol. France,' 2nd ser., vol. 13, p. 439.

† 'Travels and Researches in Crete,' London, 1865.

Hippopotamus have been found on the north-west side of the Lasethe Mountains, but their age is doubtful and more particulars are wanting.

These facts prove how prolonged earth movements have been in this area. They show also that drift deposits of the same character as we have noticed in Greece and Malta are clearly traceable thus far eastward.

Turkey.—What little is known of the superficial deposits of Turkey confirms the impression that the later geological changes we have described, affected that country equally with Greece. On both sides of the Dardanelles there are the remains of a marine deposit with recent species of *Ostrea* and *Cardium*, at a height of about 40 feet above the present sea-level;* and STRICKLAND† says that a thick mass of drift consisting of a ferruginous earth with pebbles and boulders skirts the southern flanks of the lesser Balkans, and extends to the neighbourhood of Constantinople, but he gives no details.‡

M. DE TCHIHATCHEFF§ tells us that in Roumelia there are immense deposits of angular detrital matter sometimes loose, at others agglutinated, covering like a mantle a great part of the country, and especially developed in the neighbourhood of Constantinople. The only fossils he names are land shells—species of *Pupa* and *Clausilia*.

M. VIQUESNEL‖ says that in Macedonia the Tertiary and Cretaceous strata are covered by a drift (*Alluvions anciennes*), over which, in the Plain of Doubnitza, is a loam with fragments of Palæozoic and crystalline rocks, derived from the adjacent hills. This drift forms slopes resting against the hills to the height of 200 to 300 feet. A similar deposit flanks the hills in the Rodonia valley, and again in some of the valleys of Albania.

Although exact particulars and sections are wanting, we recognize in these general descriptions many of the characters of the Rubble-drift.

Asia Minor.—Admiral BEAUFORT,¶ who surveyed the south coast of Asia Minor, speaks of a "petrified beach" as of common occurrence, but from his description it appears to be recent. It contains angular fragments in places. He also incidentally notices that in the Island of Rhodes there is a pudding-stone (breccia ?), considerably elevated above the sea, which was not distinguishable from some he saw on the shores of Greece, except that it was more solid.

* 'Quart. Journ. Geol. Soc.,' vol. 13, p. 81, 1857.

† 'Memoirs,' Part 2, p. 8, 1836.

‡ Mr. F. CALVERT mentions the finding of two Palæolithic flint implements "like those from Suffolk," in a valley running into the Dardanelles, with boulders, on a ridge 100 to 300 feet high. 'Journ. Anthrop. Inst.,' vol. 10, p. 428, 1881.

§ 'Bull. Soc. Géol. France,' 2nd ser., vol. 8, pp. 307, 311.

‖ "Un Voyage dans la Turquie d'Europe," 'Mém. Soc. Géol. France,' 2 ser., vol. 1, p. 291.

¶ 'Karamania,' 2d edit., pp. 182–5, 1818.

SPRATT and FORBES,* and BOTTA also refer to a consolidated beach of recent formation; while BOTTA† notices a bone cave on the slopes of the hills near Beyrout, in which he found a breccia with numerous bones and some shells, but it is apparently of Neolithic age, though he likens the breccia to that of Dalmatia. Mr. J. W. HAMILTON‡ speaks of a breccia covering the sides of the hills near Cnidus, but does not enter into details.

M. DE TCHIHATCHEFF in his great work§ on Asia Minor remarks that Quaternary deposits are much less common than in Europe. He found traces of a Raised Beach in the Troad, and again in the Gulf of Smyrna, but the height above the sea-level is not given. It contains fragments of pottery.‖ Near Mermeridjé the limestone cliffs are drilled by *Pholades* at a height of 10 metres above sea level. In the plain of Tchoukour are some isolated hills capped by beds of gravel, sand, and clay, containing a number of recent marine shells, probably Quaternary, of which a short list is given, but without the height above the sea.

There are detrital deposits of local origin on the slopes of the hills, but M. DE TCHIHATCHEFF was uncertain whether they were Quaternary or modern. Elsewhere, in speaking of the detrital deposits in the plain of Smyrna, he says that they may probably be of the same age as the cave deposits. He remarks on the absence of organic remains in the superficial drift of Asia Minor, and on the fact that the detritus is always derived from the neighbouring hills, as a reason for believing that it is of local origin (*formé sur place*) when the country had assumed its present configuration.

Although these observations leave much to be desired, they seem to indicate the presence of a Rubble-drift and its comparatively recent origin.

Cyprus.—Monsieur A. GAUDRY has shown in a valuable paper¶ on the geology of this island, that a Raised Beach or sea bed (*Cordon littoral*) of Quaternary age may be traced nearly all round the island at a height from 3 to 30 feet above the present sea level.** In places it forms a belt of some width, occasionally penetrating up the valleys and abutting against hills of Pliocene strata. It consists of shelly sands 3 to 15 feet thick, with seams of pebbles, frequently agglutinated, and is used, like the *Panchina* of Leghorn, as a building stone.

* 'Travels in Lycia, &c.,' vol. 2, pp. 164–209; 1847.

† 'Mém. Soc. Géol. France,' vol. 1, pp. 148–159; 1833.

‡ 'Proc. Geol. Soc.,' vol. 3, p. 293; 1840.

§ 'Asie Mineure,' part 4, "Géologie," vol. 3, 1869, pp. 382–524.

‖ In western Europe it is not certain that any pottery has been found in beds of Palæolithic age. But I see no reason why this should be the case in southern Europe and the coasts of the Mediterranean. if, as we advance towards the old centres of civilization in the East, Palæolithic man had there been in a more advanced state than in the more western area.

¶ "Géologie de l'Ile de Chypre," 'Mém. Soc. Géol. de France,' 2nd ser., vol. 7, p. 149, 1859.

** In places there is apparently a newer upraised beach of recent date. There are also places where there has been subsidence within historic times.

This deposit is overlaid in places by a fine sandy bed, like "Loess," but in none of the sections given by M. GAUDRY is there the appearance of an overlying Rubble-breccia or "head." Only in three sections are breccias figured, and these are inland and at no great height, lying at the foot of hills, whence the blocks they contain are derived. The matrix is a marl derived also from the adjacent soft Tertiary strata.

Nor is any mention made of osseous breccias or of fissures with angular detritus, which, had they existed, could hardly have escaped M. GAUDRY'S notice. I infer from these facts that the submergence of this island was comparatively slight, and resulted only in a small settlement from the superincumbent turbid waters of the Loess-like deposit which covers much of the lower grounds, where it attains in places a thickness apparently of about 20 feet.

Northern Syria.—Near Lattakia, on the coast opposite Cyprus, Dr. POST* discovered at a height of 150 to 250 feet above the sea-level, a bed of marine shells, supposed to be a Raised Beach; but in the absence of a list of the shells, its exact age cannot be settled. It may correspond with the Pliocene beds of Cyprus.

Palestine.—Amongst the incidental geological notices of Canon TRISTRAM† are some bearing upon the question before us. In passing over the promontory south of Beyrout, he found a mass of bone breccia with fragments of "flint chips" in crevices in the limestone rock, some feet above the level of the road, but below the level of the old Egyptian track. He traced this bed for a distance of about 120 feet, and it probably extended as far as the face of the cliffs, as blocks of hard breccia with bones were found on the shore. The Canon describes the flints as "elongated chips with sharp edges" (flakes), and says that the teeth were referred by Professor BOYD DAWKINS to *Bison*, probably *Red Deer* or *Reindeer*, and *Elk*. He was of opinion that this breccia formed the flooring of an ancient cavern, but his description agrees as well with the characters of an ossiferous breccia or of breccia on a slope. The height above sea-level is not mentioned.

Allusion is frequently made to the stones of all sizes, from small gravel to large blocks—all angular or but slightly worn—scattered over the surface of the country. Canon TRISTRAM also alludes to the huge hillocks of a soft conglomerate, quite unlike sedimentary beds, containing land shells of existing species, which fringe the plain of the Jordan and stud the sides of the valleys under the hills, but he refers these to freshwater floodings from the Upper Jordan.

The geology of Palestine has been the subject of special investigation by M. LOUIS LARTET‡ and Professor E. HULL.§ They inform us that raised beaches or sea-beds

* 'Nature,' for August, 1884.

† 'The Land of Israel,' London, 1865.

‡ 'Essai sur la Géologie de la Palestine,' Paris, 1869, pp. 224–290.

§ 'The Survey of Western Palestine: Memoir on the Geology and Physical Geography,' 1886, pp. 69–90.

are of frequent occurrence on the coast of Syria, but that it is difficult to fix their exact date. M. LARTET says that some of them may go back to the Quaternary period, while some may date from historic times. There is a Raised Beach on the coast near Beyrout, and another at Jaffa, in which were found *Pectunculus violacescens*, LK., *Purpura hemastoma*, LK., *Murex brandaris*, L., *Columbella rustica*, LK., identical with those on the present beach. He also speaks of clastic and erratic deposits, but does not show whether there is any relation between them and the beaches. Some of these deposits may, he thinks, be of Tertiary age, whilst others seem to be subaërial and due to long atmospheric disintegration. They form vast taluses in the interior.

The bone-cave in the valley of the Nahr-el-Kelb near Beyrout, discovered by BOTTA (*ante* p. 971), was more fully examined by LARTET, who found in it the remains of

Cervus dama.	*Capra Sinaitica.*
Antilope (a small species).	,, (like that of Crete).

On a platform of rock above the cave there was a calcareous breccia with similar remains (some of the bones calcined) mixed with flint flakes and scrapers.* He concluded that this was a rock shelter of the same age as those of the Dordogne in Central France, in which the flint implements are of the same character. But this correlation is doubtful, as the implements consist only of flakes and scrapers which are equally characteristic of Neolithic as of Palæolithic times. Besides that he mentions, on the authority of M. E. LARTET, that *Cervus dama* is still found in the Lebanon, the *Capra Sinaitica* abounds in Arabia Petræa, and the other species is closely allied to the Wild Goat of Crete, whilst the Antelope is probably the Gazelle so common in some adjacent districts.

Remains of extinct Mammalia are extremely scarce in these regions, though the remains of a fossil Elephant and of a species of Hippopotamus have, it is said, been found on the southern confines of Palestine. M. LARTET states also that stone implements of a true Palæolithic type have been found in some parts of Palestine. One from near Bethlehem has the discoid form resembling some of the Abbeville implements. Others have been found in Arabia Petræa and Babylonia. One from Boucher-Ain resembles in every respect the specimens of the spear-head (*hache*) type found in the Quaternary drifts of the Somme and Thames Valleys. They appear to have been found on the surface, but the exact sites are not well determined.

Professor HULL considers that, throughout the eastern end of the Mediterranean, there is evidence of a submergence after the Miocene epoch to the depth of about 220 feet,† as compared with the present sea-level. He describes a number of Raised Beaches or sea-beds, but in his several sections no overlying angular débris (or *head*)

* See also 'Bull. Soc. Géol. France,' 2nd sér., vol. 22, p. 537.

† The higher sea-levels or beaches are anterior to the changes I am considering, which date from the lower-level beaches.

is shown. One noticeable sea-bed is exhibited in the plain of Philistria, where a large tract, little above the level of the Mediterranean, and running some distance up the main valleys, is covered by marine sands and gravels. The raised beach in the neighbourhood of Jaffa was found by the Professor to stretch far inland, and to attain a height of over 200 feet. But this height is open to the objection I have before stated. On the coast these beaches are generally covered by blown sands.

If we may be allowed to judge from these brief notices, made independently of this special inquiry, it would seem that the Rubble-drift and osseous breccia, so largely spread over Western Europe and Greece, and again in Crete, become less frequent as we proceed eastward, and are but slightly developed in Syria.

Still more significant is the absence of those Fissures filled with local débris and often ossiferous, so common in limestone districts of Southern Europe. They are uncertain in Syria, and seem to be wanting in Cyprus and Palestine,* notwithstanding that Tertiary and Cretaceous limestones of the same characters are largely developed on the coast-lines. I can only infer that the more eastern areas were less affected by the great physical disturbances accompanying the submergence and re-elevation of the land than was the westward area, and that the submergence was of less depth or approaching its outer limits. To this point I shall have occasion to refer again (see Map).

The Coast of North Africa.—Facing Gibraltar there is evidence of upheavals corresponding with those on the Spanish side. At Tangiers, Mr. G. Maw† found horizontal beds of sand and clay resting on nearly vertical strata of the older rocks "at about 40 feet above the sea-level." He did not discover any organic remains, but concluded that this deposit was probably of post-Tertiary age, and synchronous with the Raised Beaches which he had met with near Cadiz. He also noticed a concreted sand, with recent shells, to the south of Cape Spartel, and at Saffe, forming cliffs about 50 feet high.‡

At Tangiers Messrs. Ramsay and Geikie§ observed two lines of marine terraces of elevation. In the lower one, which consists of "semi-consolidated coralline and shell sandy beds, with small pebbles," they discovered at its base, which is on a cliff 12 or 15 feet above high-water mark, a tooth of *Elephas antiquus*. No mention is made of angular rubble at top.

M. Coquand‖ speaks of large ossiferous fissures near Tetuan, in which he found several species of Helix still living in the neighbourhood such as *H. lactea*, *H. lapicida*, *H. naticoides*, *H. erycina*, &c.

* Unless the breccia near Beyrout should prove to belong to an ossiferous fissure; but, in any case, it is at no great height.

† "On the Evidences of Recent Changes of Level in the Mediterranean Coast-line," 'Geol. Mag.,' vol. 7, p. 548.

‡ 'Quart. Journ. Geol. Soc.,' vol. 28, p. 87.

§ 'Quart. Journ. Geol. Soc.,' vol. 34, p. 514.

‖ 'Bull. Soc. Géol. Franc.,' 2nd ser., vol. 4, p. 1246.

Oran.—MM. Bayle and Ville* give a short list of the shells (all recent) found in the Raised Beach on this part of the coast, and state that Quaternary drifts are largely developed in the province, but the particulars given are insufficient to identify the several stages, though the presence of a detrital drift is indicated. Nor is there any very definite account of the Ossiferous breccia discovered in the fissures in that neighbourhood. It is said to present the same characters as those of Nice and Gibraltar, and contain the remains of *Bear*, *Ox*, *Horse*, and several ruminants.†

This is probably the breccia referred to by M. Renou, who says that the rocks at Santon, near Oran, are traversed in all directions by enormous fissures filled with breccia and a few bones. He also states that the adjacent cliffs of Tertiary black limestone are drilled at a height of about 100 metres by boring shells, whilst, at Arzen, there is a raised beach, 16 to 20 feet above the sea-level, remarkable for the profusion of shells, and in places concreted into a hard mass. *This beach is overlaid by a breccia composed of fragments of slate and limestone.* The thickness of these beds, which, from description of a section near Oran, would seem to correspond with the Raised Beaches and "Head" of our south coast, is not given.

Mr. Maw mentions, on the authority of Canon Tristram, that on the coast, to the west of Oran, there is a series of raised concreted sea-beaches, at heights of 200 to 600 feet. From fragments found in one of these, at a height of 400 feet, Dr. Gwyn Jeffreys determined *Pecten opercularis*, *Pectunculus glycimeris*, *Cardium edule*, *Venus gallica*, *Turbo rugosus*, and *Fusus corneus*, all common Mediterranean and Quaternary species.‡ Mr. Maw also remarks upon a fact he had noticed on the coast-lines of Morocco, Corsica, and the Riviera, "that the hill- and valley-system of the land shelves under the adjacent sea without the intervention of distinct escarpments, indicating as he believes that the existing coast-level is so recent that the sea has not yet had time to excavate a cliff-boundary."§

Algeria.—In the important governmental work of scientific research in Algeria, M. Renou‖ gives a few interesting particulars of the Quaternary beds. He mentions that there are several lines of sea-levels—one in particular, general all along the coast, is marked by a horizontal belt 1 foot broad of holes drilled by boring shells, and about 5 feet above the present sea-level. Another bed is composed of a gray clay full of *Cardium edule* and other recent species, with a few fragments of pottery in places, and is about 20 feet above sea-level. This bed is covered by a thickness of 150 to 180 feet of dunes. The higher sea-levels are not described.

At a height of 132 metres, a bone cave was discovered, the entrance to which was

* 'Bull. Soc. Géol. France,' 2nd ser., vol. 11, p. 505, 1854.

† Desnoyers in C. D'Orbigny's 'Dict. d'Hist. Nat.,' vol. 6, p. 383.

‡ He states that remains of Pleistocene animals had been found in the neighbourhood of Algiers, but only mentions *Bubalus antiquus*, which was found in rearranged débris of Tertiary beds.

§ 'Quart. Journ. Geol. Soc.,' vol. 30, p. 106.

‖ 'Exploration Scientifique de l'Algérie,' Paris, 1846; 'Géologie,' par M. E. Renou.

blocked by a mass of breccia containing *Helix aspersa*, and a *Bulimus*, while the interior was filled by a bed of clay with Mammalian remains covered by washed-in earth. Three other caves are noticed, one of which seems rather to have been an ossiferous fissure. In this, at a depth of 33 feet and under a mass of stalagmite, was a concreted red breccia containing numerous bones, amongst which M. RENOU discovered a worked flint* flake, very thin, circular in shape, and $2\frac{1}{2}$ inches in diameter. In another cave or fissure, which was also blocked by a mass of breccia with *Helix aspersa*, he found an isolated human molar tooth, with a few Mammalian remains. The bones found in these several caves belonged to *Hyæna*, *Rhinoceros*, *Felis*, *Canis*, *Bos*, *Ovis*, *Capra*, *Sus*, and *Antilope*, but the species are not named. As these discoveries were made in 1840–1842, M. RENOU, though correctly noticing that the species were somewhat dissimilar to those of the present day, came to the conclusion that the caves were synchronous with the Raised Beaches, and that both belonged to the human period as then understood,—that they were pre-Roman, or, as we should now say, pre-historic. Owing to the prepossession then prevailing on this subject, this find failed to attract further attention.†

Non-osseous breccias seem to be widely spread in Algeria, but they have been only incidentally noticed. There is also in places an angular rubble with *Helix* and *Cyclostoma* resting on an uneven surface and overlaid by a bed of red earth. These may be a form of Rubble-drift.‡

Constantine.—In an argillaceous bed, underlying a deposit of Travertine, on the plateau of Mangourah, remains of *Hippopotamus*, *Bos*, *Equus*, and *Antilope*, considered by M. BAYLE§ to be of Quaternary age, have been found. No caves and no ossiferous fissures have, however, been recorded in this province. We are not in possession of sufficient evidence to say whether or not a conglomerate (or breccia) which M. H. COQUAND‖ describes as varying from 2 to 50 metres in thickness, should be classed with the Rubble-drift. It resembles it in many respects, overlying all other beds except the travertine, and consisting of débris of the local rocks, of older drift gravels and sands, and of the red surface clays, confusedly mixed together, besides containing occasionally blocks of large size (exceeding 1 metre cube).

Tunis.—A Raised Beach north of Monastir attains a height of 20 metres, decreasing in level southward to 5 or 6 metres. It contains a Strombus (*S. coronatus*) not found

* This material is foreign to the district.

† [Of the occurrence of Palæolithic flint implements there can be no doubt, Sir JOHN LUBBOCK having picked up one on the surface, near Algiers. He mentions also the discovery of one by Dr. BLEICHER in a rock shelter, near Oran. 'Journ. Anthrop. Inst.,' vol. 10, p. 316, 1881.—J. P., *July*, 1893.]

‡ 'Bull. Soc. Géol. de France,' 2nd ser., vol. 11, p. 343: *ibid.*, 3rd ser., vol. 16, p. 877, 1888.

§ M. BAYLE remarks on the extent inland and on the coast of Quaternary drifts, and states that some beds contain, in places, numerous *Helices*.

‖ "Description Géologique de la Province de Constantine," 'Mém. Soc. Géol. de France,' 3rd ser., vol. 6, p. 219, 1878.

in the adjacent sea, but occurring in the Raised Beach at Arzen, near Oran, and living on the Atlantic coast.*

Further to the south M. POMEL† describes the country as consisting of rolling hills of Cretaceous rocks in a sea of Quaternary drift composed of a loam more or less sandy, often of a red colour, and with but slight traces of bedding, though in places showing intercalated beds of sand. Fossils are of very rare occurrence, and consist of fragments of land shells, including specimens of *Zonites candidissimus*, a shell still common in the district. This deposit forms in places low cliffs on the coast. Elsewhere it plunges under the sea. The Island of Karkenna, opposite Sfax, is entirely composed of it. Inland it rises, as a Rubble-drift might do, on the slopes of the hills to heights of 60 metres. Its thickness is not given. Near Gabès a conglomerate, of which the materials are derived from the adjacent hills, caps the gypseous loam, but there is no mention of any breccias or of ossiferous fissures in that district.

Tripoli.—Judging from a remark of M. POMEL, I should imagine that the Quaternary loam of South Tunis ranged into Tripoli, and eastward toward the Lybian desert, but details are wanting.

The evidence thus far on the North African coast, imperfect as it is, shows the persistence of the Raised Beaches; while, as we proceed from west to east, we have to note the increasing rarity of Ossiferous Fissures so characteristic of the submerged areas. Though of frequent occurrence in the neighbourhood of Oran, and not uncommon in Algeria, there is no record of them in the provinces of Constantine and Tunis. Ordinary surface breccias continue, however, into the former province. These facts would seem to imply that, as on the coast of Asia Minor, the depth of the submergence decreased eastward, but closer investigation is needed (see Map).

Egypt.—It may be a question whether the submergence extended beyond the Lybian desert. There is no well-defined evidence in proof of it in Egypt, for the breccia described by General PITT-RIVERS near Thebes,‡ and in which he found chert or flint implements, does not appear to be a Rubble-drift, though it possesses some of its characters. It is composed of débris of chert and limestone derived from the adjacent hills, cemented together by carbonate of lime. In this, worked chert flakes occurred at a depth of from 6 to 10 feet from the surface. That these implements are of great antiquity is evident from the fact that there are tombs excavated in the breccia which are supposed to be not less than 3500 years old. There is, however, nothing in the shape of the implements to indicate their age, and no organic remains of any sort were found. The hardness of the breccia is no criterion, for, as we have before mentioned, the recent beach on the coast of Syria

* DE LA MARMORA states that near Tunis and Carthage a "Panchina," like that at Leghorn, and about 8 metres above the sea-level, is worked as a building-stone.

† 'Bull. Soc. Géol. de France,' 3rd ser., vol. 6, p. 219, 1878.

‡ 'Journ Anthrop. Inst.,' vol. 11, p. 382, 1881.

also forms a perfectly hard conglomerate, as do some of the recent breccias in Greece. Besides, the deposit is said to have been washed down a valley and "spread out on the plain in a fan-shape between the gorge of the valley and the Nile," which is not the usual form assumed by the Rubble-drift. It seems more probably to be a detrital bed carried down from the adjacent hills at a time when a heavy seasonal rainfall, like that which now takes place in Abyssinia, prevailed in this part of Egypt, and is not necessarily of geological antiquity.

In the many accounts we have of the geology of Egypt no mention is made of any deposit that corresponds with the Ossiferous Breccias and Fissures of the Mediterranean coasts, though limestone rocks have been largely exploited and exhibit great lengths of mural escarpments. It would seem that these proofs of submergence are wanting in Egypt. The earlier stages, however, or those corresponding with the period of some of the high-level beaches of the Mediterranean are represented in Egypt by the terraces of the Lower Nile valley, described by Sir J. W. Dawson.* One of these terraces on the Mokattam Hill, near Cairo, is about 200 feet above the sea level, and associated with it have been found recent species of *Ostrea*, *Pecten*, *Terebratula*, *Lithodomus*, and *Balanus*. Other terraces are mentioned higher up the valley, and likewise in the neighbourhood of Alexandria.

The Mokattam beach possibly corresponds also with the river terrace above Assouan, about 120 feet above the level of the Nile, described by Dr. Leith Adams.† In the river drift on this terrace he found several freshwater shells, and amongst others the *Corbicula fluminalis* so common in pre-glacial and post-glacial times in England. If, as in Western Europe, the valley gravels and Raised Beaches had been covered by a Rubble-drift, it should have shown in some of these sections, but none have been recorded.

Again, in the European area, the Quaternary deposits are separated from the alluvium of modern or Neolithic date by beds of coarse gravel, as in the valleys of the Thames and Somme, or by the stanniferous gravel in the valleys of Cornwall. In the valley of the Nile no such drift beds have been found at the base of the alluvium of that river, though the numerous deep borings‡ that have been made, both below and above Cairo, offered unusual facilities for their detection. In all cases, where the boring was of sufficient depth, the alluvium was found "to consist of variable proportions of blown sand and alluvial mud," and nothing to represent a Rubble-drift was met with. Nor were any marine beds encountered.

We may, therefore, assume that before the deposit of the alluvium over the Nile valley, a land surface existed which would seem to have subsided gradually to an extent corresponding with the thickness of the Nile sediments. Although, therefore,

* 'Geol. Mag.,' Dec. iii., vol. 1, p. 289, 1884; and "Egypt and Syria," chapters 2 and 4, 1887.

† 'Quart. Journ. Geol. Soc.,' vol. 20, p. 6, 1864.

‡ Leonard Horner in 'Phil. Trans.' for 1855, Part I., p. 105, and for 1858, Part II., p. 53, and Prof. Judd, in 'Roy. Soc. Proc.,' vol. 39, p. 213, 1885.

Egypt may not have felt the full effects of the great earth movements which told upon the lands to the westward, it would appear not to have altogether escaped.

As the rate at which the Nile sediment accumulated admits of a rough approximation, we may in this way possibly get a clue to the date when this change of level took place, and though Mr. HORNER'S estimate of 13,500 years* cannot claim entire reliance, it may serve as a starting point subject to correction.† A secular addition of sediment, uniform throughout, cannot be admitted, for as the sediment results from the persistent seasonal rains of the Abyssinian uplands, the quantity of sediment carried down annually must be a diminishing quantity in proportion as the rocks become gradually denuded and barer by the loss of surface and disintegrated soil.

Judging by analogy, it is most probable that Palæolithic Man did exist in Egypt, for flint or chert implements of the precise type of those found in the river drifts of the Thames and Somme Valleys have been found there, but apparently *only on the surface.* Sir JOHN LUBBOCK‡ has discovered them on the hills and lower plateaux of the Nile Valley. Three pointed flint implements which he found at Abydos, and are stained chocolate colour, might be matched with specimens from the high-level gravels of St. Acheul. General PITT-RIVERS figures one of an elongated pointed shape, 4 inches in length, which was found on the surface near Koorneh. In the collection made by Professor H. W. HAYNES, there are specimens of the long pointed form so common at Amiens, and in the British Museum there is another specimen of pointed type also common in the valley of the Somme. It was found by Mr. W. M. FLINDERS PETRIE on the surface of the spur of a hill about 200 feet above the Nile level, near Esneh, 18 miles south of Thebes.§ He describes it as river-worn and rolled. To me it, however, seems to have suffered more from sand- than river-wear, for although on one side the sharp angles are rounded off, and the surface of the flint has received a bright polish, on the other side the chipped surface retains its sharp angles and the flint its dull aspect.

Another circumstance, which may be merely a coincidence, or may have a collateral bearing on the question, is that several of the animals which lived in the South of Europe prior to the time of the Rubble-drift and Ossiferous fissures, disappeared in that area after that event, whereas they survived in the Nile Valley to Historic times; such, for example, are—

Lion.	Spotted Hyæna.	Hippopotamus.
Panther.	Caffir Cat.	African Elephant.

* *Op. cit.*, p. 74; and LUBBOCK'S 'Pre-historic Times,' p. 320.

† M. MORLOT'S estimate, based on the growth of the delta of the Tinière, gives 8000 to 11,000 years as the lapse of time since the commencement of the Neolithic epoch in Switzerland, thus agreeing approximately with the age assigned by Mr. HORNER to the alluvium of the Nile.

‡ 'Journ. Anthrop. Inst.,' vol. 4, p. 215, 1874.

§ 'Ten Years' Diggings in Egypt,' p. 79, 1892.

These reasons, although not conclusive, and requiring corroboration, afford some grounds for supposing that the submergence did not extend to Egypt.

Conclusion.

The seemingly confused accumulations of superficial débris, lying on the surface of the land without apparent order or stratification, led the early geologists to conclude that they were all due to the transient action of water and had a common origin, but the explanation wanted the necessary geological data and definition.* Subsequent research has introduced order, and discovered agencies adequate to the explanation of most of the phenomena. Glacial, fluviatile, and meteoric action have claimed a large share of the work, and accounted for much which was then obscure. Nevertheless a residue, which supports to a certain extent the contention of the early geologists, remains, and which, as I have already explained, cannot be placed to the account of any of these agencies. It is to the various forms that this residue assumes, that I have applied the general term of "Rubble-drift." The reason why I have not retained the original term of "Diluvium," is that this has been, and still is on the Continent, so widely applied to fluviatile, subaërial, and other drift beds, that it is desirable to avoid a term so variously used, whilst, at the same time, it does not embrace some of the more important phases of the Rubble-drift.

I am well aware that several objections, more or less formidable, may be raised to the hypothesis which I have suggested to account for the origin of this drift. A few of these I may allude to here, though it would not be possible to discuss in these pages the wide and important general questions involved. Those who hold uniformitarian views will object to the want of known precedents and to the exceptional character of the agency proposed. In this difficulty I cannot share. I must repeat what I have long contended for,† that it is impossible to suppose that our very limited experience—say of 2000 years—could furnish us with standards applicable to the comparatively illimitable past. In fact, those that are relied on depend upon unstable conditions and are liable to vary with every passing century. While admitting the *permanence of the laws of Nature*, it is impossible, under the conditions through which this globe has passed, to suppose that at all former periods the effects, which have resulted from the operation of those laws, though equal *in kind*, were *equal in degree*. As in other similar questions, we must judge of the hypothesis not by an *à priori*

* A very complete and valuable body of references to, and abstracts of, these early opinions will be found in Sir HENRY HOWORTH'S 'The Mammoth and the Flood,' and in his various papers in the 'Geol. Mag.' for 1882. It must, however, be borne in mind that the larger proportion of the phenomena upon which those opinions were based have since been shown to be referable to glacial and fluviatile agencies, so that some of them are no longer applicable to the conditions as they were then interpreted. Sir HENRY also adopts an hypothesis somewhat analogous to my own, but based on different grounds, and treated from a different point of view. It relates also to a different area.

† 'Inaugural Lecture,' Oxford, p. 33, 1875.

assumption, but by the agreement of the consequences which it involves with the facts, and by the extent to which it satisfies the various conditions of the problem.

Another objection may be raised on the grounds that the thickness of the Earth's crust is such as to render the movements spoken of improbable; but there again the physical data upon which that thickness has been estimated depend upon observations of such extreme delicacy that they scarcely yet afford a sure basis for calculation,* whilst the geological facts are antagonistic to the great thickness and rigidity contended for. No conclusion can, at all events, be correct which does not satisfy the *geological* as well as the *physical* conditions.

[Whatever may be the present rigidity of the crust of the Earth, the facts I have briefly alluded to in the preceding pages respecting the presence of Raised Beaches at many different levels and at great heights on the shores of the Mediterranean, show how great its mobility must have been throughout Quaternary times, and up to the date of the Rubble-drift. The latter merely marks the last stage of a long series of earth movements of variable intensity and duration.—J. P., *June*, 1893.]

Though some geologists may not admit that the presence of marine shells at the height of 1300 feet, on Moel Tryfaen, is a proof of upheaval of the sea-bed, none deny that the terraces and shell beds in Norway and Sweden, at heights of from 200 to 600 feet, have been caused by elevation of the land during the same Quaternary times with which we are now dealing. The main question for consideration in connection with these great earth movements is the rate at which the upheavals have been effected. Here again, for reasons before stated, I cannot hold that the present affords a just criterion for the past; but as these are questions which I have discussed elsewhere,† I merely refer to them here that the geological argument may not be overruled by postulates that are not founded on a more certain basis.

Other, and to my mind more serious, objections may, however, be raised, which will require careful investigation, such, for instance, as that there is nothing to show, in the absence of marine sediments, the occupation of the land by the sea waters. But, if that occupation were of short duration, it would not have been possible for ordinary sedimentation to have taken place; it could only have been such sedimentation as might have fallen in a limited time from the turbid superincumbent waters —like that which now forms the beds of brick-earth or Loess in the Channel Islands and in certain continental areas. Nor would there, for the same reason, have been time for the migration and establishment of a marine fauna on the submerged area. I can only conclude from these and other circumstances that the submergence of the land was of short duration, in which case this objection would no longer hold.

The questions, also, which arise in connection with the effect that such a widespread submergence would have upon both the land and the marine life of the period, present many difficulties. How far both the land and sea faunas would suffer, and in

* It is also a question on which physicists have arrived at very different results.

† 'Roy. Soc. Proc.,' vol. 41, p. 158, 1885; and 'Geology,' vol. 1, p. 2, 1886.

what way could their re-occupation of the emerged lands and uplifted sea-bed have been established, are matters for much consideration. In certain areas, where the waters rose above the highest summits of the land, entire faunas must have been destroyed, but where the higher summits were not submerged, room for the escape of large sections of both the fauna and flora existed, and local centres were left for their subsequent redistribution. Then, again, how far would a marine fauna be able to withstand the changes of level and pressure; or would its survival depend upon immigration from adjacent unsubmerged areas? But these are questions for naturalists. No answer can be given at present, as the occasion for their discussion has not hitherto arisen. I have necessarily confined myself to the geological phenomena.

Whatever phase of the Rubble-drift we may examine, we recognize in all of them physical and faunal conditions referable to the agency of one and the same cause. Whether we look at (1) the débris in one section of the Loess, (2) the Breccia on slopes, (3) the "*Head*" over the Raised Beaches, (4) the Basement gravels of many valleys, or (5) the Ossiferous fissures, we discern a complete absence of that wear which results from maintained river, sea, or ice action. Nor is there any indication of that transport of débris from a distance which attends river or tidal action. On the contrary, all the component materials are of *local origin*, derived from the adjacent slopes or hills, and they are *all unworn*. The evidence of the organic remains is to the same effect, in that they are those of *a land fauna alone*, with an entire absence of marine and fluviatile remains. The bones found in the Rubble-drift are not only in the same unworn condition as the rock fragments, but they are *free from all marks of gnawing*. This is a proof that the animals had not, as in the caves, fallen a prey to Carnivora, but must have met their death in a way which was unusual—such as from drowning,—for had their bodies remained on a land surface after death, they would have been subject to being devoured by predaceous animals, or else the bones would have shown traces of weathering and wear. At the same time the *sharply* fractured state and dispersion of the bones show that they must have been subjected to considerable violence and displacement. These conditions, as well as the mode of distribution of the rubble from many independent centres, accord in all points with the results that would ensue from the submergence and re-elevation of a land surface from beneath deep waters after a temporary submergence.

These conclusions, startling though they may appear,* have been forced upon me, not only by my own observations in the South of England, and parts of the Continent, but also by the independent evidence of other geologists, though their interpretation of the facts may be different. Looked at in all its aspects, I see no alternative that equally well answers to all the conditions of the problem. Other

* Viewed by our own standard the depth of submergence appears excessive, but in dealing with a body of the volume of the globe and with a surface length of 3000 miles or more, the deflection of the crust would appear really comparatively slight.

explanations* may satisfy some of the conditions in particular cases, but none of them satisfy all, whereas I think it will be found that the submergence hypothesis not only meets the requirements of each particular case, but that it also shows them all to be concordant, and such as would pertain to one common and general cause.

Another important conclusion hinges upon this question. I have before† pointed out the bearing that the position of the Rubble-drift should have in limiting our estimate of the time elapsed since the close of the Glacial period. In a paper already referred to I had shown cause why that time was not to be measured by Dr. CROLL'S reckoning of 80,000 years, as not being supported by the facts of geology. The position and character of the Rubble-drift show that the transition from the so-called Post-glacial beds to the recent Alluvial deposits is very abrupt, and that there is an absence of sedimentation or of anything indicative of lapse of time between those two series. This conclusion is confirmed by the sections of the Belgian caves. There, as we have seen (*ante*, pp. 927, 928), the Quaternary cave deposits are separated by only a few feet of Rubble-drift from deposits of the stone or Neolithic age. Nowhere are there any intervening sedimentary beds, or any deposits requiring length of time for their accumulation—the only subsequent work requiring time being comprised in the alluvial accumulation of our great rivers.

Besides, on CROLL'S hypothesis, Man must have remained comparatively stationary during a vastly long period. But how does this accord with the facts. Take the earliest works of Man with which we are acquainted—the rude implements of the Chalk plateau—and note the difference between them and the implements of the later Valley gravels. The former consist of rude flints picked up on the surface, and given only such an amount of trimming as to bring an angle to a point, or to form a cutting edge out of a blunt natural fracture, or else the stones, just as they were found, were used as hammers and trimmers. The valley implements, on the other hand, comprise flint tools and implements carefully worked all over and trimmed to certain definite patterns, the workmanship, apart from the want of grinding, being in some cases so fine as almost to equal that of the implements of the Stone age.

The caves of Central France and of Belgium afford still clearer evidence of the progress made by early Man in the interval between these two stages. His work in the last Quaternary stage exhibits an intelligence higher than that of many modern savages. His harpoons and bone implements were skilfully made, and that he possessed some artistic taste is shown by the sculptured bones and horns, and by the rude, but sufficiently accurate representations, of the contemporary fauna. How can we, then, believe that Man, who had showed himself thus progressive early in the Quaternary period, could towards its close have remained for say 70,000 years without further progress than that shown by Man of the early Stone period.

* These have been considered *seriatim* in a former paper, 'Quart. Journ. Geol. Soc.,' vol. 48, pp. 325–328.

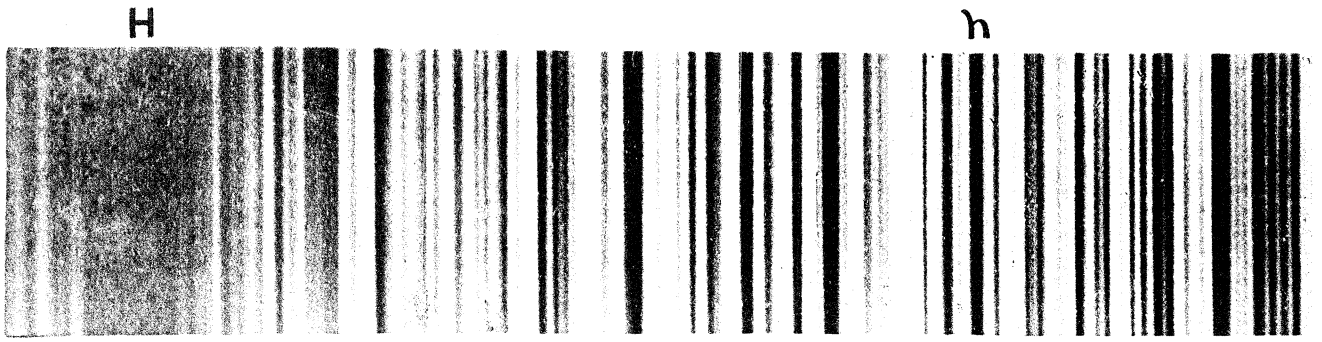
† 'Quart. Journ. Geol. Soc.,' vol. 48, p. 342.

There is certainly nothing to represent geologically that long period of time, nor have biologists been able to detect any essential structural differences between Palæolithic Man and Neolithic Man in support of such a conclusion. All the evidence tends, on the contrary, to prove that late glacial (or post-glacial) Man, together with the great extinct Mammalia, came down approximately to within some 10,000 to 12,000 years of our own times,* and that the Rubble-drift marks the stroke of the pendulum when the Glacial period came to a close, and the Neolithic age commenced.

Explanation of Map (Plate 33).

This map merely gives the position of the typical sections of the Rubble-drift and Raised Beaches mentioned in the text. They indicate the extent of the submerged area, but not its limits, and may serve as points of departure for more extended and detailed work. Pending the delimitation of the two divisions of the Loess, I have not attempted to apportion the areas they respectively occupy. A line, however, drawn from Brest to Odessa may be taken as a median line of a broad and irregular belt traversing the countries in which the high-level Loess as a whole is most largely developed—not continuously, but in certain areas and at certain heights.

* This point is discussed at length in my paper on "The Glacial Period and Antiquity of Man," in 'Quart. Journ. Geol. Soc.,' vol. 43, p. 393, 1887.



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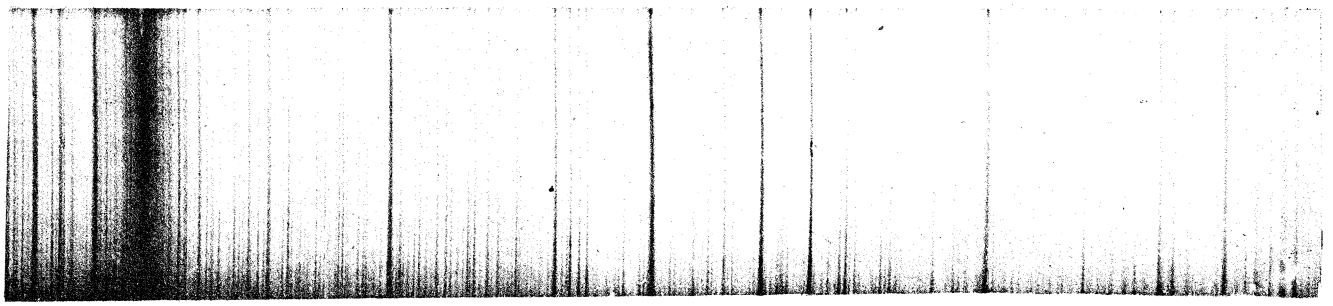

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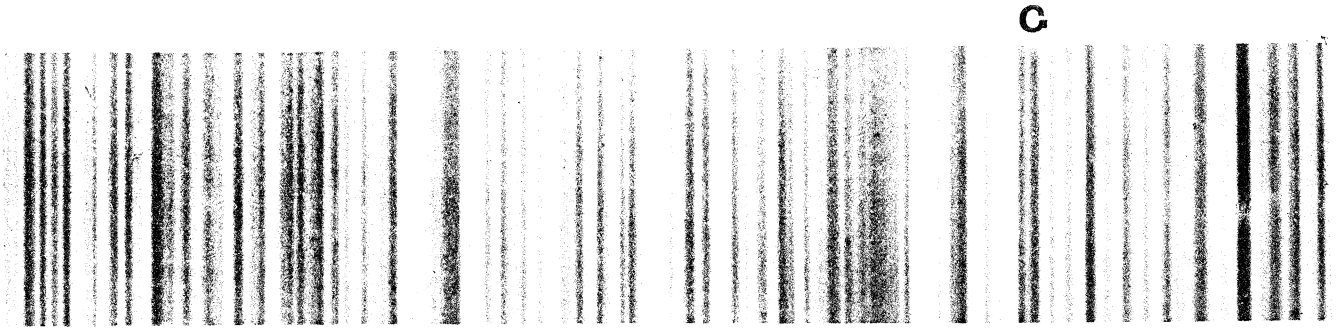

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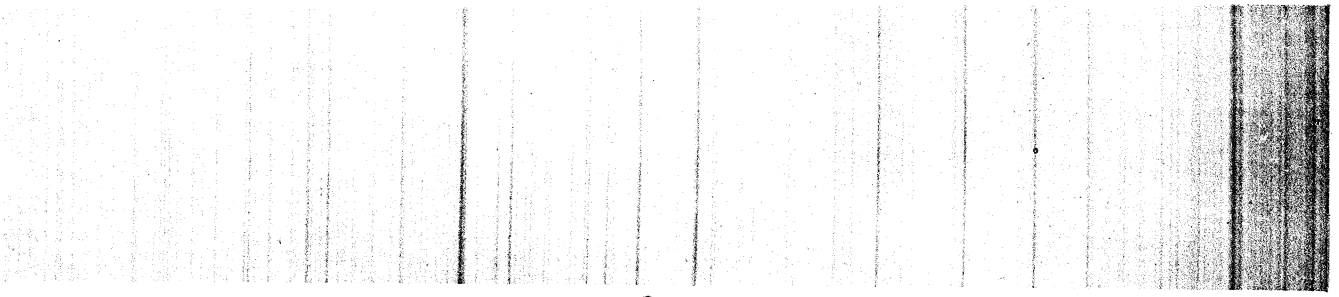

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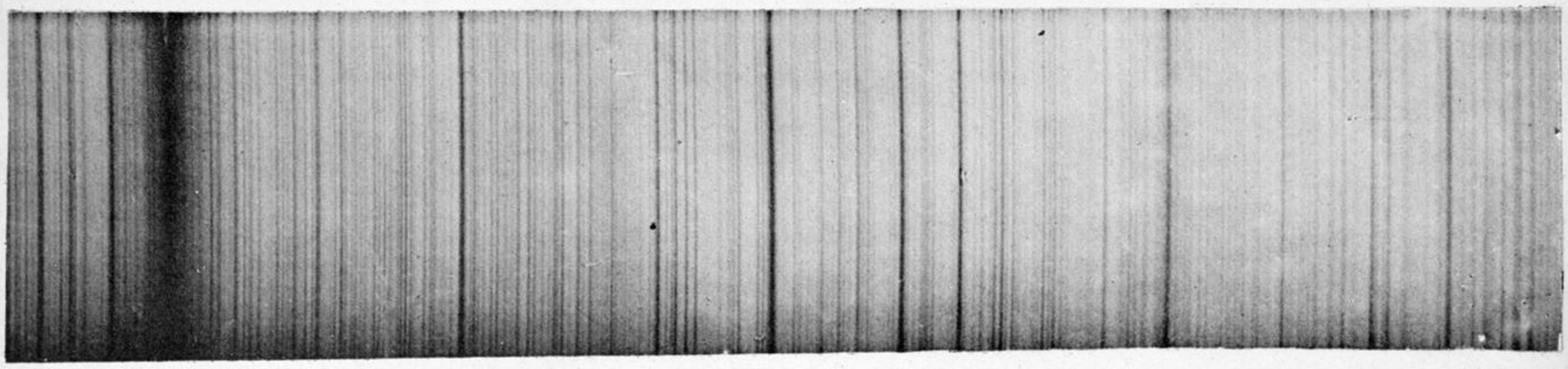

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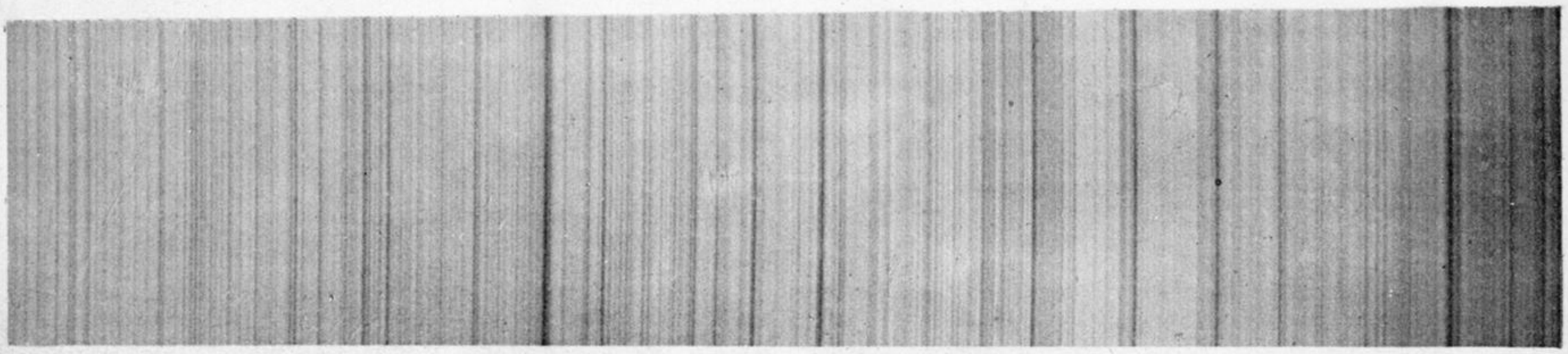

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