The Antiquity of Man

Charles Lyell

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THE ANTIQUITY OF MAN BY CHARLES LYELL.

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I WILL GO WITH THEE
& BE THY GUIDE
IN THY MOST NEED
TO GO BY THY SIDE.

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SCIENCE.

LYELL'S ANTIQUITY OF MAN

WITH INTRODUCTION AND NOTES BY R.H. RASTALL, M.A., F.G.S.

HOC SOLUM SCIO QUOD NIHIL SCIO.

THE GEOLOGICAL EVIDENCE OF THE ANTIQUITY OF MAN

BY

SIR CHARLES LYELL, BT., F.R.S., ETC. ETC.

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INTRODUCTION.

The "Antiquity of Man" was published in 1863, and ran into a third edition in the course of that year. The cause of this is not far to seek. Darwin's "Origin of Species" appeared in 1859, only four years earlier, and rapidly had its effect in drawing attention to the great problem of the origin of living beings. The theories of Darwin and Wallace brought to a head and presented in a concrete shape the somewhat vague speculations as to development and evolution which had long been floating in the minds of naturalists. In the actual working out of Darwin's great theory it is impossible to overestimate the influence of Lyell. This is made abundantly clear in Darwin's letters, and it must never be forgotten that Darwin himself was a geologist. His training in this science enabled him to grasp the import of the facts so ably marshalled by Lyell in the "Principles of Geology," a work which, as Professor Judd has clearly shown,* contributed greatly to the advancement of evolutionary theory in general. (* Judd "The Coming of Evolution" ("Cambridge Manuals of Science and Literature") Cambridge 1910 chapters 6 and 7.)

From a study of the evolution of plants and of the lower animals it

was an easy and obvious transition to man, and this step was soon taken. Since in his physical structure man shows so close a resemblance to the higher animals it was a natural conclusion that the laws governing the development of the one should apply also to the other, in spite of preconceived opinions derived from authority. Unfortunately the times were then hardly ripe for a calm and logical treatment of this question: prejudice in many cases took the place of argument, and the result was too often an undignified squabble instead of a scientific discussion. However, the dogmatism was not by any means all on one side. The disciples as usual went farther than the master, and their teaching when pushed to extremities resulted in a peculiarly dreary kind of materialism, a mental attitude which still survives to a certain extent among scientific and pseudo-scientific men of the old school. In more Recent times this dogmatic agnosticism of the middle Victorian period has been gradually replaced by speculations of a more positive type, such as those of the Mendelian school in biology and the doctrines of Bergson on the philosophical side. With these later developments we are not here concerned.

In dealing with the evolution and history of man as with that of any other animal, the first step is undoubtedly to collect the facts, and this is precisely what Lyell set out to do in the "Antiquity of Man." The first nineteen chapters of the book are purely an empirical statement of the evidence then available as to the existence of man in pre-historic times: the rest of the book is devoted to a consideration of the connection between the facts previously stated and Darwin's theory of the origin of species by variation and natural selection. The keynote of Lyell's work, throughout his life, was observation. Lyell was no cabinet geologist; he went to nature and studied phenomena at first hand. Possessed of abundant leisure and ample means he travelled far and wide, patiently collecting material and building up the modern science of physical geology, whose foundations had been laid by Hutton and Playfair. From the facts thus collected he drew his inferences, and if later researches showed these inferences to be wrong, unlike some of his contemporaries, he never hesitated to say so. Thus and thus only is true progress in science attained.

Lyell is universally recognised as the leader of the Uniformitarian school of geologists, and it will be well to consider briefly what is implied in this term. The principles of Uniformitarianism may be summed up thus: THE PRESENT IS THE KEY TO THE PAST. That is to say, the processes which have gone on in the past were the same in general character as those now seen in operation, though probably differing in degree. This theory is in direct opposition to the ideas of the CATASTROPHIC school, which were dominant at the beginning of the nineteenth century. The catastrophists attributed all past changes to sudden and violent convulsions of nature, by which all living beings were destroyed, to be replaced by a fresh creation. At least such were the tenets of the extremists. In opposition to these views the school of Hutton and Lyell introduced the principle of continuity and development. There is no discrepancy between Uniformitarianism and evolution. The idea of Uniformitarianism does not imply that things have always been the same; only that they were similar, and between these two terms there is a wide distinction. Evolution of any kind whatever naturally implies continuity, and this is the fundamental idea of Lyellian geology.

In spite, however, of this clear and definite conception of natural and organic evolution, in all those parts of his works dealing with earth-history, with the stratified rocks and with the organisms entombed in them, Lyell adopted a plan which has now been universally abandoned. He began with the most Recent formations and worked backwards from the known to the unknown. To modern readers this is perhaps the greatest drawback to his work, since it renders difficult the study of events in their actual sequence. However, it must be admitted that, taking into account the state of geological knowledge before his time, this course was almost inevitable. The succession of the later rocks was fairly well known, thanks to the labours of William Smith and others, but in the lower part of the sequence of stratified rocks there were many gaps, and more important still, there was no definite base. Although this want of a starting point has been largely supplied by the labours of Sedgwick, Murchison, De la Beche, Ramsay, and a host of followers, still considerable doubt prevails as to which constitutes the oldest truly stratified series, and the difficulty has only been partially circumvented by the adoption of an arbitrary base-line, from which the succession is worked out both upwards and downwards. So the problem is only removed a stage further back. In the study of human origins a similar difficulty is felt with special acuteness; the beginnings must of necessity be vague and uncertain, and the farther back we go the fainter will naturally be the traces of human handiwork and the more primitive and doubtful those traces when discovered.

The reprinting of the "Antiquity of Man" is particularly appropriate at the present time, owing to the increased attention drawn to the subject by recent discoveries. Ever since the publication of the "Origin of Species" and the discussions that resulted from that publication, the popular imagination has been much exercised by the possible existence of forms intermediate between the apes and man; the so-called "Missing Link." Much has been written on this subject, some of it well-founded and some very much the reverse. The discovery of the Neanderthal skull is fully described in this volume, and this skull is certainly of a low type, but it is more human than ape-like. The same remark applies still more strongly to the Engis skull, the man of Spy, the recently discovered Sussex skull, and other well-known examples of early human remains. The Pithecanthropus of Java alone shows perhaps more affinity to the apes. The whole subject has been most ably discussed by Professor Sollas in his recent book entitled "Ancient Hunters."

The study of Palaeolithic flint implements has been raised to a fine art. Both in England and France a regular succession of primitive types has been established and correlated with the gravel terraces of existing rivers, and even with the deposits of rivers no longer existing and with certain glacial deposits. But with all of these the actual bodily remains of man are comparatively scanty. From this it may be concluded that primitive methods of burial were such as to be unfavourable to the actual preservation of human remains. Attempts have also been made to prove the existence of man in pre-glacial times, but hitherto none of these have met with general acceptance, since in no case is the evidence beyond doubt.

One of the most important results of recent research in the subject

has been the establishment of the existence of man in interglacial times. When Lyell wrote, it was not fully recognised that the glaciation of Europe was not one continuous process, but that it could be divided into several episodes, glaciations, or advances of the ice, separated by a warm interglacial period. The monumental researches of Penck and Bruckner in the Alps have there established four glaciations with mild interglacial periods, but all of these cannot be clearly traced in Britain. One very important point also is the recognition of the affinities of certain types of Palaeolithic man to the Eskimo, the Australians, and the Bushmen of South Africa. However, it is impossible to give here a review of the whole subject. Full details of recent researches will be found in the works mentioned in the notes at the end of the book.

Another point of great interest and importance, arising directly from the study of early man is the nature of the events constituting the glacial period in Britain and elsewhere. This has been for many years a fertile subject of controversy, and is likely to continue such. Lyell, in common with most of the geologists of his day, assumes that during the glacial period the British Isles were submerged under the sea to a depth of many hundreds of feet, at any rate as regards the region north of a line drawn from London to Bristol. Later authors, however, explained the observed phenomena on the hypothesis of a vast ice-sheet of the Greenland type, descending from the mountains of Scotland and Scandinavia, filling up the North Sea and spreading over eastern England. This explanation is now accepted by the majority, but it must be recognised that it involves enormous mechanical difficulties. It is impossible to pursue the subject here; for a full discussion reference may be made to Professor Bonney's presidential address to the British Association at Sheffield in 1910.

It will be seen, therefore, that the "Antiquity of Man" opens up a wide field of speculation into a variety of difficult and obscure though interesting subjects. In the light of modern research it would be an easy task to pile up a mountain of criticism on points of detail. But, though easy, it would be a thankless task. It is scarcely too much to say that the dominant impression of most readers after perusing this book will be one of astonishment and admiration at the insight and breadth of view displayed by the author. When it was written the subject was a particularly thorny one to handle, and it undoubtedly required much courage to tackle the origin and development of the human race from a purely critical and scientific standpoint. It must be admitted on all hands that the result was eminently successful, taking into account the paucity of the available material, and the "Antiquity of Man" must ever remain one of the classics of prehistoric archaeology.

This edition of the "Antiquity of Man" has been undertaken in order to place before the public in an easily accessible form one of the best known works of the great geologist Sir Charles Lyell; the book had an immense influence in its own day, and it still remains one of the best general accounts of an increasingly important branch of knowledge.

In order to avoid a multiplicity of notes and thus to save space, the nomenclature has been to a certain extent modernised: a new general table of strata has been inserted in the first chapter, in place of the one originally there printed, which was cumbrous and

included many minor subdivisions of unnecessary minuteness.

The notes have been kept as short as possible, and they frequently contain little more than references to recent literature elucidating the points under discussion in the text.

R.H. RASTALL.
1914.

BIBLIOGRAPHY.

The passage of the Beresina (in verse), 1815.

Principles of Geology, being an attempt to explain the former changes of the earth's surface, by reference to causes now in operation, 1830-33
(third edition, 1834;
fourth, 1835;
fifth, 1837;
sixth, 1840;
seventh, 1847;
ninth, entirely revised edition, 1853;
tenth, entirely revised edition, 1867, 1868;
eleventh, entirely revised edition, 1872;
twelfth, edited by L. Lyell, 1875).

Elements of Geology, 1838
(second edition, 1841).

A Manual of Elementary Geology
(third and entirely revised edition of the former work, 1851;
fourth and entirely revised edition, 1852;
fifth, enlarged edition, 1855;
Supplement to the fifth edition, 1857;
second edition of the Supplement, revised, 1857).

Elements of Geology,
sixth edition, greatly enlarged, 1865.

Travels in North America, with geological observations on the United States, Canada, and Nova Scotia, 1845.

A Second Visit to the United States of North America, 1849.

The Students' Elements of Geology, 1871
(second edition, revised and corrected, 1874;
third, revised, with a table of British fossils [by R. Etheridge], 1878;
fourth, revised by P.M. Duncan, with a table of British fossils [by R. Etheridge], 1884).

The Geological Evidences of the Antiquity of Man, with remarks on theories of the origin of species by variation, 1863;
(second edition, revised, 1863;
third edition, revised, 1863;
fourth edition, revised, 1873).

There has also been published The Student's Lyell: a Manual of Elementary Geology, edited by J.W. Judd, 1896 (second edition revised and enlarged, 1911).

LECTURES, ADDRESSES, AND ARTICLES:

On a Recent Formation of Freshwater Limestone in Forfarshire ("Transactions of the Geological Society" 2nd series, volume 2, 1826, part 1).

On a Dike of Serpentine in the County of Forfar ("Edinburgh Journal of Science" 1825).

English Scientific Societies ("Quarterly Review" volume 34; three papers with Sir Roderick and Mrs. Murchison ("Edinburgh Philosophical Journal," 1829; abstract in "Proceedings of the Geological Society" 1; "Annales des Sciences Naturelles" 1829; abstract in "Proceedings of the Geological Society" 1).

Address delivered at the Geological Society of London, 1836.

Lectures on Geology--Eight Lectures on Geology, delivered at the Broadway Tabernacle, New York ("New York Tribune" 1842).

A Paper on Madeira ("Quarterly Journal of the Geological Society" 10, 1853).

On the Structure of Lavas which have Consolidated on Steep Slopes ("Philosophical Transactions" 1858).

Address (to the British Association) 1864.

TRANSLATIONS:

Antiquity of Man, translated into French by M. Chaper, 1864; and into German by L. Buchner, 1874.

Elements of Geology (sixth edition), translated into French by M. J. Gineston, 1867.

Report, extracted from the "Aberdeen Free Press" and translated into French, of Sir C. Lyell's address before the British Association, 1859, under the title of Antiquities antediluviennes: L'homme fossile.

LIFE:

Life, Letters and Journals of Sir Charles Lyell, edited by his sister-in-law, Mrs. Lyell, 1881.

See also:

Life and Letters of Charles Darwin, 1887.

Life and Letters of Sedgwick, by Clark and Hughes, 1890.

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GEOLOGICAL EVIDENCE OF THE ANTIQUITY OF MAN.

CHAPTER 1.

INTRODUCTORY.

Preliminary Remarks on the Subjects treated of in this Work.
Definition of the Terms Recent and Pleistocene.
Tabular View of the entire Series of Fossiliferous Strata.

No subject has lately excited more curiosity and general interest among geologists and the public than the question of the Antiquity of the Human Race--whether or no we have sufficient evidence in caves, or in the superficial deposits commonly called drift or "diluvium," to prove the former co-existence of man with certain extinct mammalia. For the last half-century the occasional occurrence in various parts of Europe of the bones of Man or the works of his hands in cave-breccias and stalagmites, associated with the remains of the extinct hyaena, bear, elephant, or rhinoceros, has given rise to a suspicion that the date of Man must be carried farther back than we had heretofore imagined. On the other hand extreme reluctance was naturally felt on the part of scientific reasoners to admit the validity of such evidence, seeing that so many caves have been inhabited by a succession of tenants and have been selected by Man as a place not only of domicile, but of sepulture, while some caves have also served as the channels through which the waters of occasional land-floods or engulfed rivers have flowed, so that the remains of living beings which have peopled the district at more than one era may have subsequently been mingled in such caverns and confounded together in one and the same deposit. But the facts brought to light in 1858, during the systematic investigation of the Brixham cave, near Torquay in

Devonshire, which will be described in the sequel, excited anew the curiosity of the British public and prepared the way for a general admission that scepticism in regard to the bearing of cave evidence in favour of the antiquity of Man had previously been pushed to an extreme.

Since that period many of the facts formerly adduced in favour of the co-existence in ancient times of Man with certain species of mammalia long since extinct have been re-examined in England and on the Continent, and new cases bearing on the same question, whether relating to caves or to alluvial strata in valleys, have been brought to light. To qualify myself for the appreciation and discussion of these cases, I have visited in the course of the last three years many parts of England, France, and Belgium, and have communicated personally or by letter with not a few of the geologists, English and foreign, who have taken part in these researches. Besides explaining in the present volume the results of this inquiry, I shall give a description of the glacial formations of Europe and North America, that I may allude to the theories entertained respecting their origin, and consider their probable relations in a chronological point of view to the human epoch, and why throughout a great part of the northern hemisphere they so often interpose an abrupt barrier to all attempts to trace farther back into the past the signs of the existence of Man upon the earth.

In the concluding chapters I shall offer a few remarks on the recent modifications of the Lamarckian theory of progressive development and transmutation, which are suggested by Mr. Darwin's work on the "Origin of Species by Variation and Natural Selection," and the bearing of this hypothesis on the different races of mankind and their connection with other parts of the animal kingdom.

NOMENCLATURE.

Some preliminary explanation of the nomenclature adopted in the following pages will be indispensable, that the meaning attached to the terms Recent, Pleistocene, and Post-Tertiary may be correctly understood. [Note 1.]

Previously to the year 1833, when I published the third volume of the "Principles of Geology," the strata called Tertiary had been divided by geologists into Lower, Middle, and Upper; the Lower comprising the oldest formations of the environs of Paris and London, with others of like age; the Middle, those of Bordeaux and Touraine; and the Upper, all that lay above or were newer than the last-mentioned group.

When engaged in 1828 in preparing for the press the treatise on geology above alluded to, I conceived the idea of classing the whole of this series of strata according to the different degrees of affinity which their fossil testacea bore to the living fauna. Having obtained information on this subject during my travels on the Continent, I learnt that M. Deshayes of Paris, already celebrated as a conchologist, had been led independently by the study of a large collection of Recent and fossil shells to very similar views respecting the possibility of arranging the Tertiary formations in chronological order, according to the proportional

number of species of shells identical with living ones, which characterised each of the successive groups above mentioned. After comparing 3000 fossil species with 5000 living ones, the result arrived at was, that in the lower Tertiary strata there were about 3 1/2 per cent identical with Recent; in the middle Tertiary (the faluns of the Loire and Gironde), about 17 per cent; and in the upper tertiary, from 35 to 50, and sometimes in the most modern beds as much as 90 to 95 per cent.

For the sake of clearness and brevity, I proposed to give short technical names to these sets of strata, or the periods to which they respectively belonged. I called the first or oldest of them Eocene, the second Miocene, and the third Pliocene. The first of the above terms, Eocene, is derived from Greek eos, dawn, and Greek kainos, recent; because an extremely small proportion of the fossil shells of this period could be referred to living species, so that this era seemed to indicate the dawn of the present testaceous fauna, no living species of shells having been detected in the antecedent or Secondary rocks.

Some conchologists are now unwilling to allow that any Eocene species of shell has really survived to our times so unaltered as to allow of its specific identification with a living species. I cannot enter in this place into this wide controversy. It is enough at present to remark that the character of the Eocene fauna, as contrasted with that of the antecedent Secondary formations, wears a very modern aspect, and that some able living conchologists still maintain that there are Eocene shells not specifically distinguishable from those now extant; though they may be fewer in number than was supposed in 1833.

The term Miocene (from Greek meion, less; and Greek kainos, recent) is intended to express a minor proportion of Recent species (of testacea); the term Pliocene (from Greek pleion, more; and Greek kainos, recent), a comparative plurality of the same.

It has sometimes been objected to this nomenclature that certain species of infusoria found in the chalk are still existing, and, on the other hand, the Miocene and Older Pliocene deposits often contain the remains of mammalia, reptiles, and fish, exclusively of extinct species. But the reader must bear in mind that the terms Eocene, Miocene, and Pliocene were originally invented with reference purely to conchological data, and in that sense have always been and are still used by me.

Since the first introduction of the terms above defined, the number of new living species of shells obtained from different parts of the globe has been exceedingly great, supplying fresh data for comparison, and enabling the palaeontologist to correct many erroneous identifications of fossil and Recent forms. New species also have been collected in abundance from Tertiary formations of every age, while newly discovered groups of strata have filled up gaps in the previously known series. Hence modifications and reforms have been called for in the classifications first proposed. The Eocene, Miocene, and Pliocene periods have been made to comprehend certain sets of strata of which the fossils do not always conform strictly in the proportion of Recent to extinct species with the definitions first given by me, or which are implied in the etymology of those terms. These innovations have

been treated of in my "Elements or Manual of Elementary Geology," and in the Supplement to the fifth edition of the same, published in 1859, where some modifications of my classification, as first proposed, are introduced; but I need not dwell on these on the present occasion, as the only formations with which we shall be concerned in the present volume are those of the most modern date, or the Post-Tertiary. It will be convenient to divide these into two groups, the Recent and the Pleistocene. In the Recent we may comprehend those deposits in which not only all the shells but all the fossil mammalia are of living species; in the Pleistocene those strata in which, the shells being Recent, a portion, and often a considerable one, of the accompanying fossil quadrupeds belongs to extinct species.

Cases will occur where it may be scarcely possible to draw the line of demarcation between the Newer Pliocene and Pleistocene, or between the latter and the recent deposits; and we must expect these difficulties to increase rather than diminish with every advance in our knowledge, and in proportion as gaps are filled up in the series of geological records.

The annexed tabular view (Table 1/1) of the whole series of fossiliferous strata will enable the reader to see at a glance the chronological relation of the Recent and Pleistocene to the antecedent periods. [Note 2.]

TABLE 1/1. STRATIFIED ROCKS.

KAINOZOIC OR TERTIARY:
- Pleistocene and Recent.
- Pliocene.
- Miocene.
- Oligocene.
- Eocene.

MESOZOIC OR SECONDARY:
- Cretaceous.
- Jurassic.
- Triassic.

PALAEOZOIC OR PRIMARY:
- Permian.
- Carboniferous.
- Devonian or old Red Sandstone.
- Silurian.
- Ordovician.
- Cambrian.

PRECAMBRIAN OR ARCHAEAN.

CHAPTER 2.

RECENT PERIOD--DANISH PEAT AND SHELL MOUNDS--SWISS LAKE-DWELLINGS.

(PLATE 1. A VILLAGE BUILT ON PILES IN A SWISS LAKE.
Restored by Dr. F. Keller, partly from Dumont D'Urville's Sketch of similar habitations in New Guinea.)

Works of Art in Danish Peat-Mosses.
Remains of three Periods of Vegetation in the Peat.
Ages of Stone, Bronze, and Iron.
Shell-Mounds or ancient Refuse-Heaps of the Danish Islands.
Change in geographical Distribution of Marine Mollusca
since their Origin.
Embedded Remains of Mammalia of Recent Species.
Human Skulls of the same Period.
Swiss Lake-Dwellings built on Piles.
Stone and Bronze Implements found in them.
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Chronological Computations of the Date of the Bronze and
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Lake-Dwellings, or artificial Islands called "Crannoges,"
in Ireland.

WORKS OF ART IN DANISH PEAT.

When treating in the "Principles of Geology" of the changes of the earth which have taken place in comparatively modern times, I have spoken of the embedding of organic bodies and human remains in peat, and explained under what conditions the growth of that vegetable substance is going on in northern and humid climates. Of late years, since I first alluded to the subject, more extensive investigations have been made into the history of the Danish peat-mosses. Of the results of these inquiries I shall give a brief abstract in the present chapter, that we may afterwards compare them with deposits of older date, which throw light on the antiquity of the human race.

The deposits of peat in Denmark,* varying in depth from 10 to 30 feet, have been formed in hollows or depressions in the northern drift or boulder formation hereafter to be described. (* An excellent account of these researches of Danish naturalists and antiquaries has been drawn up by an able Swiss geologist, M.A. Morlot, and will be found in the "Bulletin de la Societe Vaudoise des Sci. Nat." tome 6 Lausanne 1860.) The lowest stratum, 2 to 3 feet thick, consists of swamp-peat composed chiefly of moss or sphagnum, above which lies another growth of peat, not made up exclusively of aquatic or swamp plants. Around the borders of the bogs, and at various depths in them, lie trunks of trees, especially of the Scotch fir (Pinus sylvestris), often 3 feet in diameter, which must have grown on the margin of the peat-mosses, and have frequently fallen into them. This tree is not now, nor has ever been in historical times, a native of the Danish Islands, and when introduced there has not thriven; yet it was evidently indigenous in the human period, for Steenstrup has taken out with his own hands a flint instrument from below a buried trunk of one of these pines. It appears clear that the same Scotch fir was afterwards supplanted by the sessile variety of the common oak, of which many prostrate trunks occur in the peat at higher levels than the pines; and still higher the pedunculated variety of the same oak (Quercus robur, L.) occurs with the alder, birch (Betula verrucosa, Ehrh.), and hazel. The oak has now in its turn been almost superseded in Denmark by the common beech. Other trees, such as the white birch (Betula alba), characterise the lower part of

the bogs, and disappear from the higher; while others again, like the aspen (Populus tremula), occur at all levels, and still flourish in Denmark. All the land and freshwater shells, and all the mammalia as well as the plants, whose remains occur buried in the Danish peat, are of Recent species. [Note 3.]

It has been stated, that a stone implement was found under a buried Scotch fir at a great depth in the peat. By collecting and studying a vast variety of such implements, and other articles of human workmanship preserved in peat and in sand-dunes on the coast, as also in certain shell-mounds of the aborigines presently to be described, the Danish and Swedish antiquaries and naturalists, MM. Nilsson, Steenstrup, Forchhammer, Thomsen, Worsaae, and others, have succeeded in establishing a chronological succession of periods, which they have called the ages of stone, of bronze, and of iron, named from the materials which have each in their turn served for the fabrication of implements.

The age of stone in Denmark coincided with the period of the first vegetation, or that of the Scotch fir, and in part at least with the second vegetation, or that of the oak. But a considerable portion of the oak epoch coincided with "the age of bronze," for swords and shields of that metal, now in the Museum of Copenhagen, have been taken out of peat in which oaks abound. The age of iron corresponded more nearly with that of the beech tree.* (* Morlot "Bulletin de la Societe Vaudoise des Sci. Nat." tome 6 page 292.) [Note 4.]

M. Morlot, to whom we are indebted for a masterly sketch of the recent progress of this new line of research, followed up with so much success in Scandinavia and Switzerland, observes that the introduction of the first tools made of bronze among a people previously ignorant of the use of metals, implies a great advance in the arts, for bronze is an alloy of about nine parts of copper and one of tin; and although the former metal, copper, is by no means rare, and is occasionally found pure or in a native state, tin is not only scarce but never occurs native. To detect the existence of this metal in its ore, then to disengage it from the matrix, and finally, after blending it in due proportion with copper, to cast the fused mixture in a mould, allowing time for it to acquire hardness by slow cooling, all this bespeaks no small sagacity and skilful manipulation. Accordingly, the pottery found associated with weapons of bronze is of a more ornamental and tasteful style than any which belongs to the age of stone. Some of the moulds in which the bronze instruments were cast, and "tags," as they are called, of bronze, which are formed in the hole through which the fused metal was poured, have been found. The number and variety of objects belonging to the age of bronze indicates its long duration, as does the progress in the arts implied by the rudeness of the earlier tools, often mere repetitions of those of the stone age, as contrasted with the more skilfully worked weapons of a later stage of the same period.

It has been suggested that an age of copper must always have intervened between that of stone and bronze; but if so, the interval seems to have been short in Europe, owing apparently to the territory occupied by the aboriginal inhabitants having been invaded and conquered by a people coming from the East, to whom the use of swords, spears, and other weapons of bronze was familiar.

Hatchets, however, of copper have been found in the Danish peat.

The next stage of improvement, or that manifested by the substitution of iron for bronze, indicates another stride in the progress of the arts. Iron never presents itself, except in meteorites, in a native state, so that to recognise its ores, and then to separate the metal from its matrix, demands no inconsiderable exercise of the powers of observation and invention. To fuse the ore requires an intense heat, not to be obtained without artificial appliances, such as pipes inflated by the human breath, or bellows, or some other suitable machinery.

DANISH SHELL-MOUNDS, OR KJOKKENMODDING.*

(* Mr. John Lubbock published, after these sheets were written, an able paper on the Danish "Shell-mounds" in the October number of the "Natural History Review" 1861 page 489, in which he has described the results of a recent visit to Denmark, made by him in company with Mr. Busk.)

In addition to the peat-mosses, another class of memorials found in Denmark has thrown light on the pre-historical age. At certain points along the shores of nearly all the Danish islands, mounds may be seen, consisting chiefly of thousands of cast-away shells of the oyster, cockle, and other molluscs of the same species as those which are now eaten by Man. These shells are plentifully mixed up with the bones of various quadrupeds, birds, and fish, which served as the food of the rude hunters and fishers by whom the mounds were accumulated. I have seen similar large heaps of oysters, and other marine shells with interspersed stone implements, near the seashore, both in Massachusetts and in Georgia, U.S.A., left by the native North American Indians at points near to which they were in the habit of pitching their wigwams for centuries before the white man arrived.

Such accumulations are called by the Danes, Kjokkenmodding, or "kitchen-middens." Scattered all through them are flint knives, hatchets, and other instruments of stone, horn, wood, and bone, with fragments of coarse pottery, mixed with charcoal and cinders, but never any implements of bronze, still less of iron. The stone hatchets and knives had been sharpened by rubbing, and in this respect are one degree less rude than those of an older date, associated in France with the bones of extinct mammalia, of which more in the sequel. The mounds vary in height from 3 to 10 feet, and in area are some of them 1000 feet long, and from 150 to 200 wide. They are rarely placed more than 10 feet above the level of the sea, and are confined to its immediate neighbourhood, or if not (and there are cases where they are several miles from the shore), the distance is ascribable to the entrance of a small stream, which has deposited sediment, or to the growth of a peaty swamp, by which the land has been made to advance on the Baltic, as it is still doing in many places, aided, according to Puggaard, by a very slow upheaval of the whole country at the rate of 2 or 3 inches in a century.

There is also another geographical fact equally in favour of the antiquity of the mounds, namely, that they are wanting on those parts of the coast which border the Western Ocean, or exactly where the waves are now slowly eating away the land. There is every

reason to presume that originally there were stations along the coast of the North Sea as well as that of the Baltic, but by the gradual undermining of the cliffs they have all been swept away.

Another striking proof, perhaps the most conclusive of all, that the "kitchen-middens" are very old, is derived from the character of their embedded shells. These consist entirely of living species; but, in the first place, the common eatable oyster is among them, attaining its full size, whereas the same Ostrea edulis cannot live at present in the brackish waters of the Baltic except near its entrance, where, whenever a north-westerly gale prevails, a current setting in from the ocean pours in a great body of salt water. Yet it seems that during the whole time of the accumulation of the "kitchen-middens" the oyster flourished in places from which it is now excluded. In like manner the eatable cockle, mussel, and periwinkle (Cardium edule, Mytilus edulis, and Littorina littorea), which are met with in great numbers in the "middens," are of the ordinary dimensions which they acquire in the ocean, whereas the same species now living in the adjoining parts of the Baltic only attain a third of their natural size, being stunted and dwarfed in their growth by the quantity of fresh water poured by rivers into that inland sea.* (* See "Principles of Geology" chapter 30.) Hence we may confidently infer that in the days of the aboriginal hunters and fishers, the ocean had freer access than now to the Baltic, communicating probably through the peninsula of Jutland, Jutland having been at no remote period an archipelago. Even in the course of the nineteenth century, the salt waters have made one irruption into the Baltic by the Lymfiord, although they have been now again excluded. It is also affirmed that other channels were open in historical times which are now silted up.* (* See Morlot "Bulletin de la Societe Vaudoise des Sci. Nat." tome 6.)

If we next turn to the remains of vertebrata preserved in the mounds, we find that here also, as in the Danish peat-mosses, all the quadrupeds belong to species known to have inhabited Europe within the memory of Man. No remains of the mammoth, or rhinoceros, or of any extinct species appear, except those of the wild bull (Bos urus, Linn., or Bos primigenius, Bojanus), which are in such numbers as to prove that the species was a favourite food of the ancient people. But as this animal was seen by Julius Caesar, and survived long after his time, its presence alone would not go far to prove the mounds to be of high antiquity. The Lithuanian aurochs or bison (Bos bison, L., Bos priscus, Boj.), which has escaped extirpation only because protected by the Russian Czars, surviving in one forest in Lithuania) has not yet been met with, but will no doubt be detected hereafter, as it has been already found in the Danish peat. The beaver, long since destroyed in Denmark, occurs frequently, as does the seal (Phoca Gryppus, Fab.), now very rare on the Danish coast. With these are mingled bones of the red deer and roe, but the reindeer has not yet been found. There are also the bones of many carnivora, such as the lynx, fox, and wolf, but no signs of any domesticated animals except the dog. The long bones of the larger mammalia have been all broken as if by some instrument, in such a manner as to allow of the extraction of the marrow, and the gristly parts have been gnawed off, as if by dogs, to whose agency is also attributed the almost entire absence of the bones of young birds and of the smaller bones and softer parts of the skeletons of birds in general, even of those of large size. In reference to the latter, it has been proved experimentally by

Professor Steenstrup, that if the same species of birds are now given to dogs, they will devour those parts of the skeleton which are missing, and leave just those which are preserved in the old "kitchen-middens."

The dogs of the mounds, the only domesticated animals, are of a smaller race than those of the bronze period, as shown by the peat-mosses, and the dogs of the bronze age are inferior in size and strength to those of the iron age. The domestic ox, horse, and sheep, which are wanting in the mounds, are confined to that part of the Danish peat which was formed in the ages of bronze and iron.

Among the bones of birds, scarcely any are more frequent in the mounds than those of the auk (Alca impennis), now extinct. The Capercailzie (Tetrao urogallus) is also met with, and may, it is suggested, have fed on the buds of the Scotch fir in times when that tree flourished around the peat-bogs. The different stages of growth of the roedeer's horns, and the presence of the wild swan, now only a winter visitor, have been appealed to as proving that the aborigines resided in the same settlements all the year round. That they also ventured out to sea in canoes such as are now found in the peat-mosses, hollowed out of the trunk of a single tree, to catch fish far from land, is testified by the bony relics of several deep-sea species, such as the herring, cod, and flounder. The ancient people were not cannibals, for no human bones are mingled with the spoils of the chase. Skulls, however, have been obtained not only from peat, but from tumuli of the stone period believed to be contemporaneous with the mounds. These skulls are small and round, and have a prominent ridge over the orbits of the eyes, showing that the ancient race was of small stature, with round heads and overhanging eyebrows--in short, they bore a considerable resemblance to the modern Laplanders. The human skulls of the bronze age found in the Danish peat, and those of the iron period, are of an elongated form and larger size. There appear to be very few well-authenticated examples of crania referable to the bronze period--a circumstance no doubt attributable to the custom prevalent among the people of that era of burning their dead and collecting their bones in funeral urns.

No traces of grain of any sort have hitherto been discovered, nor any other indication that the ancient people had any knowledge of agriculture. The only vegetable remains in the mounds are burnt pieces of wood and some charred substance referred by Dr. Forchhammer to the Zostera marina, a sea plant which was perhaps used in the production of salt.

What may be the antiquity of the earliest human remains preserved in the Danish peat cannot be estimated in centuries with any approach to accuracy. In the first place, in going back to the bronze age, we already find ourselves beyond the reach of history or even of tradition. In the time of the Romans the Danish Isles were covered, as now, with magnificent beech forests. Nowhere in the world does this tree flourish more luxuriantly than in Denmark, and eighteen centuries seem to have done little or nothing towards modifying the character of the forest vegetation. Yet in the antecedent bronze period there were no beech trees, or at most but a few stragglers, the country being then covered with oak. In the age of stone again, the Scotch fir prevailed, and already there were human inhabitants in those old pine forests. How many

generations of each species of tree flourished in succession before the pine was supplanted by the oak, and the oak by the beech, can be but vaguely conjectured, but the minimum of time required for the formation of so much peat must, according to the estimate of Steenstrup and other good authorities, have amounted to at least 4000 years; and there is nothing in the observed rate of the growth of peat opposed to the conclusion that the number of centuries may not have been four times as great, even though the signs of Man's existence have not yet been traced down to the lowest or amorphous stratum. As to the "kitchen-middens," they correspond in date to the older portion of the peaty record, or to the earliest part of the age of stone as known in Denmark.

ANCIENT SWISS LAKE-DWELLINGS, BUILT ON PILES.

In the shallow parts of many Swiss lakes, where there is a depth of no more than from 5 to 15 feet of water, ancient wooden piles are observed at the bottom sometimes worn down to the surface of the mud, sometimes projecting slightly above it. These have evidently once supported villages, nearly all of them of unknown date, but the most ancient of which certainly belonged to the age of stone, for hundreds of implements resembling those of the Danish shell-mounds and peat-mosses have been dredged up from the mud into which the piles were driven.

The earliest historical account of such habitations is that given by Herodotus of a Thracian tribe, who dwelt, in the year 520 B.C., in Prasias, a small mountain-lake of Paeonia, now part of modern Roumelia.* (* Herodotus lib. 5 cap. 16. Rediscovered by M. de Ville "Natural History Review" volume 2 1862 page 486.)

Their habitations were constructed on platforms raised above the lake, and resting on piles. They were connected with the shore by a narrow causeway of similar formation. Such platforms must have been of considerable extent, for the Paeonians lived there with their families and horses. Their food consisted largely of the fish which the lake produced in abundance.

In rude and unsettled times, such insular sites afforded safe retreats, all communication with the mainland being cut off, except by boats, or by such wooden bridges as could be easily removed.

The Swiss lake-dwellings seem first to have attracted attention during the dry winter of 1853-54, when the lakes and rivers sank lower than had ever been previously known, and when the inhabitants of Meilen, on the Lake of Zurich, resolved to raise the level of some ground and turn it into land, by throwing mud upon it obtained by dredging in the adjoining shallow water. During these dredging operations they discovered a number of wooden piles deeply driven into the bed of the lake, and among them a great many hammers, axes, celts, and other instruments. All these belonged to the stone period with two exceptions, namely, an armlet of thin brass wire, and a small bronze hatchet.

Fragments of rude pottery fashioned by the hand were abundant, also masses of charred wood, supposed to have formed parts of the platform on which the wooden cabins were built. Of this burnt timber, on this and other sites, subsequently explored, there was such an abundance as to lead to the conclusion that many of the

settlements must have perished by fire. Herodotus has recorded that the Paeonians, above alluded to, preserved their independence during the Persian invasion, and defied the attacks of Darius by aid of the peculiar position of their dwellings. "But their safety," observes Mr. Wylie,* (* W.M. Wylie "Archaeologia" volume 38 1859, a valuable paper on the Swiss and Irish lake-habitations.) "was probably owing to their living in the middle of the lake, (Greek) en mese te limne, whereas the ancient Swiss settlers were compelled by the rapidly increasing depth of the water near the margins of their lakes to construct their habitations at a short distance from the shore, within easy bowshot of the land, and therefore not out of reach of fiery projectiles, against which thatched roofs and wooden walls could present but a poor defence." To these circumstances and to accidental fires we are probably indebted for the frequent preservation, in the mud around the site of the old settlements, of the most precious tools and works of art, such as would never have been thrown into the Danish "kitchen-middens," which have been aptly compared to a modern dusthole.

Dr. Ferdinand Keller of Zurich has drawn up a series of most instructive memoirs, illustrated with well-executed plates, of the treasures in stone, bronze, and bone brought to light in these subaqueous repositories, and has given an ideal restoration of part of one of the old villages (see Plate 1 above),* such as he conceives may have existed on the lakes of Zurich and Bienne. (* Keller "Pfahlbauten, Antiquarische Gesellschaft in Zurich" Bd. 12 and 13 1858-1861. In the fifth number of the "Natural History Review" January 9, 1862, Mr. Lubbock has published an excellent account of the works of the Swiss writers on their lake-habitations.) In this view, however, he has not simply trusted to his imagination, but has availed himself of a sketch published by M. Dumont d'Urville, of similar habitations of the Papuans in New Guinea in the Bay of Dorei. It is also stated by Dr. Keller, that on the River Limmat, near Zurich, so late as the last century, there were several fishing-huts constructed on this same plan.* (* Keller "Pfahlbauten, Antiquarische Gesellschaft in Zurich" Bd. 9 page 81 note.) It will be remarked that one of the cabins is represented as circular. That such was the form of many in Switzerland is inferred from the shape of pieces of clay which lined the interior, and which owe their preservation apparently to their having been hardened by fire when the village was burnt. In the sketch (Plate 1), some fishing-nets are seen spread out to dry on the wooden platform. The Swiss archaeologist has found abundant evidence of fishing-gear, consisting of pieces of cord, hooks, and stones used as weights. A canoe also is introduced, such as are occasionally met with. One of these, made of the trunk of a single tree, fifty feet long and three and a half feet wide, was found capsized at the bottom of the Lake of Bienne. It appears to have been laden with stones, such as were used to raise the foundation of some of the artificial islands.

It is believed that as many as 300 wooden huts were sometimes comprised in one settlement, and that they may have contained about 1000 inhabitants. At Wangen, M. Lohle has calculated that 40,000 piles were used, probably not all planted at one time nor by one generation. Among the works of great merit devoted specially to a description of the Swiss lake-habitations is that of M. Troyon, published in 1860.* (* "Sur les Habitations lacustres.") The number

of sites which he and other authors have already enumerated in Switzerland is truly wonderful. They occur on the large lakes of Constance, Zurich, Geneva, and Neufchatel, and on most of the smaller ones. Some are exclusively of the stone age, others of the bronze period. Of these last more than twenty are spoken of on the Lake of Geneva alone, more than forty on that of Neufchatel, and twenty on the small Lake of Bienne.

One of the sites first studied by the Swiss antiquaries was the small lake of Moosseedorf, near Berne, where implements of stone, horn, and bone, but none of metal, were obtained. Although the flint here employed must have come from a distance (probably from the south of France), the chippings of the material are in such profusion as to imply that there was a manufactory of implements on the spot. Here also, as in several other settlements, hatchets and wedges of jade have been observed of a kind said not to occur in Switzerland or the adjoining parts of Europe, and which some mineralogists would fain derive from the East; amber also, which, it is supposed, was imported from the shores of the Baltic.

At Wangen near Stein, on the Lake of Constance, another of the most ancient of the lake-dwellings, hatchets of serpentine and greenstone, and arrow-heads of quartz have been met with. Here also remains of a kind of cloth, supposed to be of flax, not woven but plaited, have been detected. Professor Heer has recognised lumps of carbonised wheat, Triticum vulgare, and grains of another kind, T. dicoccum, and barley, Hordeum distichum, and flat round cakes of bread; and at Robbenhausen and elsewhere Hordeum hexastichum in fine ears, the same kind of barley which is found associated with Egyptian mummies, showing clearly that in the stone period the lake-dwellers cultivated all these cereals, besides having domesticated the dog, the ox, the sheep, and the goat.

Carbonised apples and pears of small size, such as still grow in the Swiss forests, stones of the wild plum, seeds of the raspberry and blackberry, and beech-nuts, also occur in the mud, and hazel-nuts in great plenty.

Near Morges, on the Lake of Geneva, a settlement of the bronze period, no less than forty hatchets of that metal have been dredged up, and in many other localities the number and variety of weapons and utensils discovered, in a fine state of preservation, is truly astonishing.

It is remarkable that as yet all the settlements of the bronze period are confined to Western and Central Switzerland. In the more eastern lakes those of the stone period alone have as yet been discovered.

The tools, ornaments, and pottery of the bronze period in Switzerland bear a close resemblance to those of corresponding age in Denmark, attesting the wide spread of a uniform civilisation over Central Europe at that era. In some few of the Swiss aquatic stations a mixture of bronze and iron implements has been observed, but no coins. At Tiefenau, near Berne, in ground supposed to have been a battle-field, coins and medals of bronze and silver, struck at Marseilles, and of Greek manufacture, and iron swords, have been found, all belonging to the first and pre-Roman division of the age of iron.

In the settlements of the bronze era the wooden piles are not so much decayed as those of the stone period; the latter having wasted down quite to the level of the mud, whereas the piles of the bronze age (as in the Lake of Bienne, for example) still project above it.

Professor Rutimeyer of Basle, well-known to palaeontologists as the author of several important memoirs on fossil vertebrata, has recently published a scientific description of great interest of the animal remains dredged up at various stations where they had been embedded for ages in the mud into which the piles were driven. * (* "Die Fauna der Pfahlbauten in der Schweiz" Basel 1861.)

These bones bear the same relation to the primitive inhabitants of Switzerland and some of their immediate successors as do the contents of the Danish "kitchen-middens" to the ancient fishing and hunting tribes who lived on the shores of the Baltic.

The list of wild mammalia enumerated in this excellent treatise contains no less than twenty-four species, exclusive of several domesticated ones: besides which there are eighteen species of birds, the wild swan, goose, and two species of ducks being among them; also three reptiles, including the eatable frog and freshwater tortoise; and lastly, nine species of freshwater fish. All these (amounting to fifty-four species) are with one exception still living in Europe. The exception is the wild bull (Bos primigenius), which, as before stated, survived in historical times. The following are the mammalia alluded to:--The bear (Ursus arctos), the badger, the common marten, the polecat, the ermine, the weasel, the otter, wolf, fox, wild cat, hedgehog, squirrel, field-mouse (Mus sylvaticus), hare, beaver, hog (comprising two races, namely, the wild boar and swamp-hog), the stag (Cervus elaphus), the roe-deer, the fallow-deer, the elk, the steinbock (Capra ibex), the chamois, the Lithuanian bison, and the wild bull. The domesticated species comprise the dog, horse, ass, pig, goat, sheep, and several bovine races.

The greater number, if not all, of these animals served for food, and all the bones which contained marrow have been split open in the same way as the corresponding ones found in the shell-mounds of Denmark before mentioned. The bones both of the wild bull and the bison are invariably split in this manner. As a rule, the lower jaws with teeth occur in greater abundance than any other parts of the skeleton--a circumstance which, geologists know, holds good in regard to fossil mammalia of all periods. As yet the reindeer is missing in the Swiss lake-settlements as in the Danish "kitchen-middens," although this animal in more ancient times ranged over France, together with the mammoth, as far south as the Pyrenees.

A careful comparison of the bones from different sites has shown that in settlements such as Wangen and Moosseedorf, belonging to the earliest age of stone, when the habits of the hunter state predominated over those of the pastoral, venison, or the flesh of the stag and roe, was more eaten than the flesh of the domestic cattle and sheep. This was afterwards reversed in the later stone period and in the age of bronze. At that later period also the tame pig, which is wanting in some of the oldest stations, had replaced the wild boar as a common article of food. In the beginning of the

age of stone, in Switzerland, the goats outnumbered the sheep, but towards the close of the same period the sheep were more abundant than the goats.

The fox in the first era was very common, but it nearly disappears in the bronze age, during which period a large hunting-dog, supposed to have been imported into Switzerland from some foreign country, becomes the chief representative of the canine genus.

A single fragment of the bone of a hare (Lepus timidus) has been found at Moosseedorf. The almost universal absence of this quadruped is supposed to imply that the Swiss lake-dwellers were prevented from eating that animal by the same superstition which now prevails among the Laplanders, and which Julius Caesar found in full force amongst the ancient Britons.* (* "Commentaries" lib 5 chapter 12.)

That the lake-dwellers should have fed so largely on the fox, while they abstained from touching the hare, establishes, says Rutimeyer, a singular contrast between their tastes and ours.

Even in the earliest settlements, as already hinted, several domesticated animals occur, namely, the ox, sheep, goat, and dog. Of the three last, each was represented by one race only; but there were two races of cattle, the most common being of small size, and called by Rutimeyer Bos brachyceros (Bos longifrons, Owen), or the marsh cow, the other derived from the wild bull; though, as no skull has yet been discovered, this identification is not so certain as could be wished. It is, however, beyond question that at a later era, namely, towards the close of the stone and beginning of the bronze period, the lake-dwellers had succeeded in taming that formidable brute the Bos primigenius, the Urus of Caesar, which he described as very fierce, swift, and strong, and scarcely inferior to the elephant in size. In a tame state its bones were somewhat less massive and heavy, and its horns were somewhat smaller than in wild individuals. Still in its domesticated form, it rivalled in dimensions the largest living cattle, those of Friesland, in North Holland, for example. When most abundant, as at Concise on the Lake of Neufchatel, it had nearly superseded the smaller race, Bos brachyceros, and was accompanied there for a short time by a third bovine variety, called Bos trochoceros, an Italian race, supposed to have been imported from the southern side of the Alps. (Caesar "Commentaries" lib 5 chapter 12.) This last-mentioned race, however, seems only to have lasted for a short time in Switzerland.

The wild bull (Bos primigenius) is supposed to have flourished for a while in a wild and tame state, just as now in Europe the domestic pig co-exists with the wild boar; and Rutimeyer agrees with Cuvier and Bell,* (* "British Quadrupeds" page 415.) in considering our larger domestic cattle of northern Europe as the descendants of this wild bull, an opinion which Owen disputes.* (* "British Fossil Mammal." page 500.)

In the later division of the stone period, there were two tame races of the pig, according to Rutimeyer; one large, and derived from the wild boar, the other smaller, called the "marsh-hog," or Sus scrofa palustris. It may be asked how the osteologist can distinguish the tame from the wild races of the same species by

their skeletons alone. Among other characters, the diminished thickness of the bones and the comparative smallness of the ridges, which afford attachment to the muscles, are relied on; also the smaller dimensions of the tusks in the boar, and of the whole jaw and skull; and, in like manner, the diminished size of the horns of the bull and other modifications, which are the effects of a regular supply of food, and the absence of all necessity of exerting their activity and strength to obtain subsistence and defend themselves against their enemies.

A middle-sized race of dogs continued unaltered throughout the whole of the stone period; but the people of the bronze age possessed a larger hunting-dog, and with it a small horse, of which genus very few traces have been detected in the earlier settlements--a single tooth, for example, at Wangen, and only one or two bones at two or three other places.

In passing from the oldest to the most modern sites, the extirpation of the elk and beaver, and the gradual reduction in numbers of the bear, stag, roe, and freshwater tortoise are distinctly perceptible. The aurochs, or Lithuanian bison, appears to have died out in Switzerland about the time when weapons of bronze came into use. It is only in a few of the most modern lake-dwellings, such as Noville and Chavannes in the Canton de Vaud (which the antiquaries refer to the sixth century), that some traces are observable of the domestic cat, as well as of a sheep with crooked horns and with them bones of the domestic fowl.

After the sixth century, no extinction of any wild quadruped nor introduction of any tame one appears to have taken place, but the fauna was still modified by the wild species continuing to diminish in number and the tame ones to become more diversified by breeding and crossing, especially in the case of the dog, horse, and sheep. On the whole, however, the divergence of the domestic races from their aboriginal wild types, as exemplified at Wangen and Moosseedorf, is confined, according to Professor Rutimeyer, within narrow limits. As to the goat, it has remained nearly constant and true to its pristine form, and the small race of goat-horned sheep still lingers in some alpine valleys in the Upper Rhine; and in the same region a race of pigs, corresponding to the domesticated variety of Sus scrofa palustris, may still be seen.

Amidst all this profusion of animal remains extremely few bones of Man have been discovered; and only one skull, dredged up from Meilen, on the Lake of Zurich, of the early stone period, seems as yet to have been carefully examined. Respecting this specimen, Professor His observes that it exhibits, instead of the small and rounded form proper to the Danish peat-mosses, a type much more like that now prevailing in Switzerland, which is intermediate between the long-headed and short-headed form. (Rutimeyer "Die Fauna der Pfahlbauten in der Schweiz" page 181.)

So far, therefore, as we can draw safe conclusions from a single specimen, there has been no marked change of race in the human population of Switzerland during the periods above considered.

It is still a question whether any of these subaqueous repositories of ancient relics in Switzerland go back so far in time as the kitchen-middens of Denmark, for in these last there are no

domesticated animals except the dog, and no signs of the cultivation of wheat or barley; whereas we have seen that, in one of the oldest of the Swiss settlements, at Wangen, no less than three cereals make their appearance, with four kinds of domestic animals. Yet there is no small risk of error in speculating on the relative claims to antiquity of such ancient tribes, for some of them may have remained isolated for ages and stationary in their habits, while others advanced and improved.

We know that nations, both before and after the introduction of metals, may continue in very different stages of civilisation, even after commercial intercourse has been established between them, and where they are separated by a less distance than that which divides the Alps from the Baltic.

The attempts of the Swiss geologists and archaeologists to estimate definitely in years the antiquity of the bronze and stone periods, although as yet confessedly imperfect, deserve notice, and appear to me to be full of promise. The most elaborate calculation is that made by M. Morlot, respecting the delta of the Tiniere, a torrent which flows into the Lake of Geneva near Villeneuve. This small delta, to which the stream is annually making additions, is composed of gravel and sand. Its shape is that of a flattened cone, and its internal structure has of late been laid open to view in a railway cutting 1000 feet long and 32 feet deep. The regularity of its structure throughout implies that it has been formed very gradually, and by the uniform action of the same causes. Three layers of vegetable soil, each of which must at one time have formed the surface of the cone, have been cut through at different depths. The first of these was traced over a surface of 15,000 square feet, having an average thickness of 5 inches, and being about 4 feet below the present surface of the cone. This upper layer belonged to the Roman period, and contained Roman tiles and a coin. The second layer, followed over a surface of 25,000 square feet, was 6 inches thick, and lay at a depth of 10 feet. In it were found fragments of unvarnished pottery and a pair of tweezers in bronze, indicating the bronze epoch. The third layer, followed for 35,000 square feet, was 6 or 7 inches thick and 19 feet deep. In it were fragments of rude pottery, pieces of charcoal, broken bones, and a human skeleton having a small, round and very thick skull. M. Morlot, assuming the Roman period to represent an antiquity of from sixteen to eighteen centuries, assigns to the bronze age a date of between 3000 and 4000 years, and to the oldest layer, that of the stone period, an age of from 5000 to 7000 years.

Another calculation has been made by M. Troyon to obtain the approximate date of the remains of an ancient settlement built on piles and preserved in a peat-bog at Chamblon, near Yverdun, on the Lake of Neufchatel. The site of the ancient Roman town of Eburodunum (Yverdun), once on the borders of the lake, and between which and the shore there now intervenes a zone of newly-gained dry land, 2500 feet in breadth, shows the rate at which the bed of the lake has been filled up with river sediment in fifteen centuries. Assuming the lake to have retreated at the same rate before the Roman period, the pile-works of Chamblon, which are of the bronze period, must be at the least 3300 years old.

For the third calculation, communicated to me by M. Morlot, we are indebted to M. Victor Gillieron, of Neuveville, on the Lake of

Bienne. It relates to the age of a pile-dwelling, the mammalian bones of which are considered by M. Rutimeyer to indicate the earliest portion of the stone period of Switzerland, and to correspond in age with the settlement of Moosseedorf.

The piles in question occur at the Pont de Thiele, between the lakes of Bienne and Neufchatel. The old convent of St. Jean, founded 750 years ago, and built originally on the margin of the Lake of Bienne, is now at a considerable distance from the shore, and affords a measure of the rate of the gain of land in seven centuries and a half. Assuming that a similar rate of the conversion of water into marshy land prevailed antecedently, we should require an addition of sixty centuries for the growth of the morass intervening between the convent and the aquatic dwelling of Pont de Thiele, in all 6750 years. M. Morlot, after examining the ground, thinks it highly probable that the shape of the bottom on which the morass rests is uniform; but this important point has not yet been tested by boring. The result, if confirmed, would agree exceedingly well with the chronological computation before mentioned of the age of the stone period of Tiniere. As I have not myself visited Switzerland since these chronological speculations were first hazarded, I am unable to enter critically into a discussion of the objections which have been raised to the two first of them, or to decide on the merits of the explanations offered in reply.

IRISH LAKE-DWELLINGS OR CRANNOGES.

The lake-dwellings of the British isles, although not explored as yet with scientific zeal, as those of Switzerland have been in the last ten years, are yet known to be very numerous, and when carefully examined will not fail to throw great light on the history of the bronze and stone periods.

In the lakes of Ireland alone, no less than forty-six examples of artificial islands, called crannoges, have been discovered. They occur in Leitrim, Roscommon, Cavan, Down, Monaghan, Limerick, Meath, King's County, and Tyrone.* (* W.M. Wylie "Archaeologia" volume 38 1859 page 8.) One class of these "stockaded islands," as they have been sometimes called, was formed, according to Mr. Digby Wyatt, by placing horizontal oak beams at the bottom of the lake, into which oak posts, from 6 to 8 feet high, were mortised, and held together by cross beams, till a circular enclosure was obtained.

A space of 520 feet diameter, thus enclosed at Lagore, was divided into sundry timbered compartments, which were found filled up with mud or earth, from which were taken "vast quantities of the bones of oxen, swine, deer, goats, sheep, dogs, foxes, horses, and asses." All these were discovered beneath 16 feet of bog, and were used for manure; but specimens of them are said to be preserved in the museum of the Royal Irish Academy. From the same spot were obtained a great collection of antiquities, which, according to Lord Talbot de Malahide and Mr. Wylie, were referable to the ages of stone, bronze, and iron.* (* W.M. Wylie "Archaeologia" volume 38 1859 page 8, who cites "Archaeological Journal" volume 6 page 101.)

In Ardekillin Lake, in Roscommon, an islet of an oval form was observed, made of a layer of stones resting on logs of timber.

Round this artificial islet or crannoge thus formed was a stone wall raised on oak piles. A careful description has been put on record by Captain Mudge, R.N., of a curious log-cabin discovered by him in 1833 in Drumkellin bog, in Donegal, at a depth of 14 feet from the surface. It was 12 feet square and 9 feet high, being divided into two stories each 4 feet high. The planking was of oak split with wedges of stone, one of which was found in the building. The roof was flat. A staked enclosure had been raised round the cabin, and remains of other similar huts adjoining were seen but not explored. A stone celt, found in the interior of the hut, and a piece of leather sandal, also an arrow-head of flint, and in the bog close at hand a wooden sword, give evidence of the remote antiquity of this building, which may be taken as a type of the early dwellings on the Crannoge islands.

"The whole structure," says Captain Mudge, "was wrought with the rudest kind of implements, and the labour bestowed on it must have been immense. The wood of the mortises was more bruised than cut, as if by a blunt stone chisel."* (* Mudge "Archaeologia" volume 26.) Such a chisel lay on the floor of the hut, and by comparing it with the marks of the tool used in forming the mortises, they were found "to correspond exactly, even to the slight curved exterior of the chisel; but the logs had been hewn by a larger instrument, in the shape of an axe. On the floor of the dwelling lay a slab of freestone, 3 feet long and 14 inches thick, in the centre of which was a small pit three quarters of an inch deep, which had been chiselled out. This is presumed to have been used for holding nuts to be cracked by means of one of the round shingle stones, also found there, which had served as a hammer. Some entire hazel-nuts and a great quantity of broken shells were strewed about the floor."

The foundations of the house were made of fine sand, such as is found with shingle on the seashore about 2 miles distant. Below the layer of sand the bog or peat was ascertained, on probing it with an instrument, to be at least 15 feet thick. Although the interior of the building when discovered was full of "bog" or peaty matter, it seems when inhabited to have been surrounded by growing trees, some of the trunks and roots of which are still preserved in their natural position. The depth of overlying peat affords no safe criterion for calculating the age of the cabin or village, for I have shown in the "Principles of Geology" that both in England and Ireland, within historical times, bogs have burst and sent forth great volumes of black mud, which has been known to creep over the country at a slow pace, flowing somewhat at the rate of ordinary lava-currents, and sometimes overwhelming woods and cottages, and leaving a deposit upon them of bog-earth 15 feet thick.

None of these Irish lake-dwellings were built, like those of Helvetia, on platforms supported by piles deeply driven into the mud. "The Crannoge system of Ireland seems," says Mr. Wylie, "well nigh without a parallel in Swiss waters."

CHAPTER 3.

FOSSIL HUMAN REMAINS AND WORKS OF ART OF THE RECENT PERIOD--CONTINUED.

Delta and Alluvial Plain of the Nile.

Burnt Bricks in Egypt before the Roman Era.
Borings in 1851-54.
Ancient Mounds of the Valley of the Ohio.
Their Antiquity.
Sepulchral Mound at Santos in Brazil.
Delta of the Mississippi.
Ancient Human Remains in Coral Reefs of Florida.
Changes in Physical Geography in the Human Period.
Buried Canoes in Marine Strata near Glasgow.
Upheaval since the Roman Occupation of the Shores of the Firth of Forth.
Fossil Whales near Stirling.
Upraised Marine Strata of Sweden on Shores of the Baltic and the Ocean.
Attempts to compute their Age.

DELTA AND ALLUVIAL PLAIN OF THE NILE.

Some new facts of high interest illustrating the geology of the alluvial land of Egypt were brought to light between the years 1851 and 1854, in consequence of investigations suggested to the Royal Society by Mr. Leonard Horner, and which were partly carried out at the expense of the Society. The practical part of the undertaking was entrusted by Mr. Horner to an Armenian officer of engineers, Hekekyan Bey, who had for many years pursued his scientific studies in England, and was in every way highly qualified for the task.

It was soon found that to obtain the required information respecting the nature, depth, and contents of the Nile mud in various parts of the valley, a larger outlay was called for than had been originally contemplated. This expense the late viceroy, Abbas Pasha, munificently undertook to defray out of his treasury, and his successor, after his death, continued the operations with the same princely liberality.

Several engineers and a body of sixty workmen were employed under the superintendence of Hekekyan Bey, men inured to the climate and able to carry on the sinking of shafts and borings during the hot months, after the waters of the Nile had subsided, and in a season which would have been fatal to Europeans.

The results of chief importance arising out of this inquiry were obtained from two sets of shafts and borings sunk at intervals in lines crossing the great valley from east to west. One of these consisted of no fewer than fifty-one pits and artesian borings, made where the valley is 16 miles wide from side to side between the Arabian and Libyan deserts, in the latitude of Heliopolis, about 8 miles above the apex of the delta. The other line of borings and pits, twenty-seven in number, was in the parallel of Memphis, where the valley is only five miles broad.

Everywhere in these sections the sediment passed through was similar in composition to the ordinary Nile mud of the present day, except near the margin of the valley, where thin layers of quartzose sand, such as is sometimes blown from the adjacent desert by violent winds, were observed to alternate with the loam.

A remarkable absence of lamination and stratification was observed almost universally in the sediment brought up from all points except where the sandy layers above alluded to occurred. Mr. Horner attributes this want of all indication of successive deposition to

the extreme thinness of the film of matter which is thrown down annually on the great alluvial plain during the season of inundation. The tenuity of this layer must indeed be extreme, if the French engineers are tolerably correct in their estimate of the amount of sediment formed in a century, which they suppose not to exceed on the average 5 inches. When the waters subside, this thin layer of new soil, exposed to a hot sun, dries rapidly, and clouds of dust are raised by the winds. The superficial deposit, moreover, is disturbed almost everywhere by agricultural labours, and even were this not the case, the action of worms, insects, and the roots of plants would suffice to confound together the deposits of two successive years.

All the remains of organic bodies, such as land-shells, and the bones of quadrupeds, found during the excavations belonged to living species. Bones of the ox, hog, dog, dromedary and ass were not uncommon, but no vestiges of extinct mammalia. No marine shells were anywhere detected; but this was to be expected, as the borings, though they sometimes reached as low as the level of the Mediterranean, were never carried down below it--a circumstance much to be regretted, since where artesian borings have been made in deltas, as in those of the Po and Ganges, to the depth of several hundred feet below the sea level it has been found, contrary to expectation, that the deposits passed through were fluviatile throughout, implying, probably, that a general subsidence of those deltas and alluvial formations has taken place. Whether there has been in like manner a sinking of the land in Egypt, we have as yet no means of proving; but Sir Gardner Wilkinson infers it from the position in the delta on the shore near Alexandria of the tombs commonly called Cleopatra's Baths, which cannot, he says, have been originally built so as to be exposed to the sea which now fills them, but must have stood on land above the level of the Mediterranean. The same author adduces, as additional signs of subsidence, some ruined towns, now half under water, in the Lake Menzaleh, and channels of ancient arms of the Nile submerged with their banks beneath the waters of that same lagoon.

In some instances, the excavations made under the superintendence of Hekekyan Bey were on a large scale for the first 16 or 24 feet, in which cases jars, vases, pots and a small human figure in burnt clay, a copper knife, and other entire articles were dug up; but when water soaking through from the Nile was reached the boring instrument used was too small to allow of more than fragments of works of art being brought up. Pieces of burnt brick and pottery were extracted almost everywhere, and from all depths, even where they sank 60 feet below the surface towards the central parts of the valley. In none of these cases did they get to the bottom of the alluvial soil. It has been objected, among other criticisms, that the Arabs can always find whatever their employers desire to obtain. Even those who are too well acquainted with the sagacity and energy of Hekekyan Bey to suspect him of having been deceived, have suggested that the artificial objects might have fallen into old wells which had been filled up. This notion is inadmissible for many reasons. Of the ninety-five shafts and borings, seventy or more were made far from the sites of towns or villages; and allowing that every field may once have had its well, there would be but small chance of the borings striking upon the site even of a small number of them in seventy experiments.

Others have suggested that the Nile may have wandered over the whole valley, undermining its banks on one side and filling up old channels on the other. It has also been asked whether the delta with the numerous shifting arms of the river may not once have been at every point where the auger pierced.* (* For a detailed account of these sections, see Mr. Horner's paper in the "Philosophical Transactions" for 1855 to 1858.) To all these objections there are two obvious answers:--First, in historical times the Nile has on the whole been very stationary, and has not shifted its position in the valley; secondly, if the mud pierced through had been thrown down by the river in ancient channels, it would have been stratified, and would not have corresponded so closely with inundation mud, we learn from Captain Newbold that he observed in some excavations in the great plain alternations of sand and clay, such as are seen in the modern banks of the Nile; but in the borings made by Hekekyan Bey, such stratification seems scarcely in any case to have been detected.

The great aim of the criticisms above enumerated has been to get rid of the supposed anomaly of finding burnt brick and pottery at depths and places which would give them claim to an antiquity far exceeding that of the Roman domination in Egypt. For until the time of the Romans, it is said, no clay was burnt into bricks in the valley of the Nile. But a distinguished antiquary, Mr. S. Birch, assures me that this notion is altogether erroneous, and that he has under his charge in the British Museum, first, a small rectangular baked brick, which came from a Theban tomb which bears the name of Thothmes, a superintendent of the granaries of the god Amen Ra, the style of art, inscription, and name, showing that it is as old as the 18th dynasty (about 1450 B.C.); secondly, a brick bearing an inscription, partly obliterated, but ending with the words "of the temple of Amen Ra." This brick, decidedly long anterior to the Roman dominion, is referred conjecturally, by Mr. Birch, to the 19th dynasty, or 1300 B.C. Sir Gardner Wilkinson has also in his possession pieces of mortar, which he took from each of the three great pyramids, in which bits of broken pottery and of burnt clay or brick are embedded.

M. Girard, of the French expedition to Egypt, supposed the average rate of the increase of Nile mud on the plain between Assouan and Cairo to be five English inches in a century. This conclusion, according to Mr. Horner, is very vague, and founded on insufficient data; the amount of matter thrown down by the waters in different parts of the plain varying so much that to strike an average with any approach to accuracy must be most difficult. Were we to assume six inches in a century, the burnt brick met with at a depth of 60 feet would be 12,000 years old.

Another fragment of red brick was found by Linant Bey, in a boring 72 feet deep, being 2 or 3 feet below the level of the Mediterranean, in the parallel of the apex of the delta, 200 metres distant from the river, on the Libyan side of the Rosetta branch.* (* Horner "Philosophical Transactions" 1858.) M. Rosiere, in the great French work on Egypt, has estimated the mean rate of deposit of sediment in the delta at 2 1/4 inches in a century;* (* Description de l'Egypte "Histoire Naturelle" tome 2 page 494.) were we to take 2 1/2 inches, a work of art 72 feet deep must have been buried more than 30,000 years ago. But if the boring of Linant Bey

was made where an arm of the river had been silted up at a time when the apex of the delta was somewhat farther south, or more distant from the sea than now, the brick in question might be comparatively very modern.

The experiments instituted by Mr. Horner at the pedestal of the fallen statue of King Rameses at Memphis, in the hope of obtaining an accurate chronometric scale for testing the age of a given thickness of Nile sediment, are held by some experienced Egyptologists not to be satisfactory, on the ground of the uncertainty of the rate of deposit accumulated at that locality. The point sought to be determined was the exact amount of Nile mud which had accumulated there since the time when that statue is supposed by some antiquaries to have been erected. Could we have obtained possession of such a measure, the rate of deposition might be judged of, approximately at least, whenever similar mud was observed in other places, or below the foundations of those same monuments. But the ancient Egyptians are known to have been in the habit of enclosing with embankments the areas on which they erected temples, statues, and obelisks, so as to exclude the waters of the Nile; and the point of time to be ascertained, in every case where we find a monument buried to a certain depth in mud, as at Memphis and Heliopolis, is the era when the city fell into such decay that the ancient embankments were neglected, and the river allowed to inundate the site of the temple, obelisk, or statue.

Even if we knew the date of the abandonment of such embankments, the enclosed areas would not afford a favourable opportunity for ascertaining the average rate of deposit in the alluvial plain; for Herodotus tells us that in his time those spots from which the Nile waters had been shut out for centuries appeared sunk, and could be looked down into from the surrounding grounds, which had been raised by the gradual accumulation over them of sediment annually thrown down. If the waters at length should break into such depressions, they must at first carry with them into the enclosure much mud washed from the steep surrounding banks, so that a greater quantity would be deposited in a few years than perhaps in as many centuries on the great plain outside the depressed area, where no such disturbing causes intervened.

ANCIENT MOUNDS OF THE VALLEY OF THE OHIO.

As I have already given several European examples of monuments of prehistoric date belonging to the Recent period, I will now turn to the American continent. Before the scientific investigation by Messrs. Squier and Davis of the "Ancient Monuments of the Mississippi Valley",* (* "Smithsonian Contributions" volume 1 1847.) no one suspected that the plains of that river had been occupied, for ages before the French and British colonists settled there, by a nation of older date and more advanced in the arts than the Red Indians whom the Europeans found there. There are hundreds of large mounds in the basin of the Mississippi, and especially in the valleys of the Ohio and its tributaries, which have served, some of them for temples, others for outlook or defence, and others for sepulture. The unknown people by whom they were constructed, judging by the form of several skulls dug out of the burial-places, were of the Mexican or Toltec race. Some of the earthworks are on so grand a scale as to embrace areas of 50 or 100 acres within a simple enclosure, and the solid contents of one mould are estimated

at 20 million of cubic feet, so that four of them would be more than equal in bulk to the Great Pyramid of Egypt, which comprises 75 million. From several of these repositories pottery and ornamental sculpture have been taken, and various articles in silver and copper, also stone weapons, some composed of hornstone unpolished, and much resembling in shape some ancient flint implements found near Amiens and other places in Europe, to be alluded to in the sequel.

It is clear that the Ohio mound-builders had commercial intercourse with the natives of distant regions, for among the buried articles some are made of native copper from Lake Superior, and there are also found mica from the Alleghenies, sea-shells from the Gulf of Mexico, and obsidian from the Mexican mountains.

The extraordinary number of the mounds implies a long period, during which a settled agricultural population had made considerable progress in civilisation, so as to require large temples for their religious rites, and extensive fortifications to protect them from their enemies. The mounds were almost all confined to fertile valleys or alluvial plains, and some at least are so ancient that rivers have had time since their construction to encroach on the lower terraces which support them, and again to recede for the distance of nearly a mile, after having undermined and destroyed a part of the works. When the first European settlers entered the valley of the Ohio, they found the whole region covered with an uninterrupted forest, and tenanted by the Red Indian hunter, who roamed over it without any fixed abode, or any traditionary connection with his more civilised predecessors. The only positive data as yet obtained for calculating the minimum of time which must have elapsed since the mounds were abandoned, have been derived from the age and nature of the trees found growing on some of these earthworks. When I visited Marietta in 1842, Dr. Hildreth took me to one of the mounds, and showed me where he had seen a tree growing on it, the trunk of which when cut down displayed eight hundred rings of annual growth.* (* Lyell's "Travels in North America" volume 2 page 29.) But the late General Harrison, President in 1841 of the United States, who was well skilled in woodcraft, has remarked, in a memoir on this subject, that several generations of trees must have lived and died before the mounds could have been overspread with that variety of species which they supported when the white man first beheld them, for the number and kinds of trees were precisely the same as those which distinguished the surrounding forest. "We may be sure," observed Harrison, "that no trees were allowed to grow so long as the earthworks were in use; and when they were forsaken, the ground, like all newly cleared land in Ohio, would for a time be monopolised by one or two species of tree, such as the yellow locust and the black or white walnut. When the individuals which were the first to get possession of the ground had died out one after the other, they would in many cases, instead of being replaced by the same species, be succeeded (by virtue of the law which makes a rotation of crops profitable in agriculture) by other kinds, till at last, after a great number of centuries (several thousand years, perhaps), that remarkable diversity of species characteristic of North America, and far exceeding what is seen in European forests, would be established."

MOUNDS OF SANTOS IN BRAZIL.

I will next say a few words respecting certain human bones embedded in a solid rock at Santos in Brazil, to which I called attention in my "Travels in North America" in 1842.* (* Volume 1 page 200.) I then imagined the deposit containing them to be of submarine origin--an opinion which I have long ceased to entertain. We learn from a memoir of Dr. Meigs that the River Santos has undermined a large mound, 14 feet in height, and about 3 acres in area, covered with trees, near the town of St. Paul, and has exposed to view many skeletons, all inclined at angles between 20 and 25 degrees, and all placed in a similar east and west position.* (* Meigs "Transactions of the American Philosophical Society" 1828 page 285.) Seeing, in the Museum of Philadelphia, fragments of the calcareous stone or tufa from this spot, containing a human skull with teeth, and in the same matrix, oysters with serpulae attached, I at first concluded that the whole deposit had been formed beneath the waters of the sea, or at least, that it had been submerged after its origin, and again upheaved; also, that there had been time since its emergence for the growth on it of a forest of large trees. But after reading again, with more care, the original memoir of Dr. Meigs, I cannot doubt that the shells, like those of eatable kinds, so often accumulated in the mounds of the North American Indians not far from the sea, may have been brought to the place and heaped up with other materials at the time when the bodies were buried. Subsequently, the whole artificial earthwork, with its shells and skeletons, may have been bound together into a solid stone by the infiltration of carbonate of lime, and the mound may therefore be of no higher antiquity than some of those above alluded to on the Ohio, which, as we have seen, have in like manner been exposed in the course of ages to the encroachments and undermining action of rivers.

DELTA OF THE MISSISSIPPI.

I have shown in my "Travels in North America" that the deposits forming the delta and alluvial plain of the Mississippi consist of sedimentary matter, extending over an area of 30,000 square miles, and known in some parts to be several hundred feet deep. Although we cannot estimate correctly how many years it may have required for the river to bring down from the upper country so large a quantity of earthy matter--the data for such a computation being as yet incomplete--we may still approximate to a minimum of the time which such an operation must have taken, by ascertaining experimentally the annual discharge of water by the Mississippi, and the mean annual amount of solid matter contained in its waters. The lowest estimate of the time required would lead us to assign a high antiquity, amounting to many tens of thousands of years (probably more than 100,000) to the existing delta.

Whether all or how much of this formation may belong to the recent period, as above defined, I cannot pretend to decide, but in one part of the modern delta near New Orleans, a large excavation has been made for gas-works, where a succession of beds, almost wholly made up of vegetable matter, has been passed through, such as we now see forming in the cypress swamps of the neighbourhood, where the deciduous cypress (Taxodium distichum), with its strong and spreading roots, plays a conspicuous part. In this excavation, at the depth of sixteen feet from the surface, beneath four buried forests superimposed one upon the other, the workmen are stated by

Dr. B. Dowler to have found some charcoal and a human skeleton, the cranium of which is said to belong to the aboriginal type of the Red Indian race. As the discovery in question had not been made when I saw the excavation in progress at the gas-works in 1846, I cannot form an opinion as to the value of the chronological calculations which have led Dr. Dowler to ascribe to this skeleton an antiquity of 50,000 years. In several sections, both natural in the banks of the Mississippi and its numerous arms, and where artificial canals had been cut, I observed erect stumps of trees, with their roots attached, buried in strata at different heights, one over the other. I also remarked, that many cypresses which had been cut through, exhibited many hundreds of rings of annual growth, and it then struck me that nowhere in the world could the geologist enjoy a more favourable opportunity for estimating in years the duration of certain portions of the Recent epoch.* (* Dowler cited by Dr. W. Usher in Nott and Gliddon's "Types of Mankind" page 352.)

CORAL REEFS OF FLORIDA.

Professor Agassiz has described a low portion of the peninsula of Florida as consisting of numerous reefs of coral, which have grown in succession so as to give rise to a continual annexation of land, gained gradually from the sea in a southerly direction. This growth is still in full activity, and assuming the rate of advance of the land to be one foot in a century, the reefs being built up from a depth of 75 feet, and that each reef has in its turn added ten miles to the coast, Professor Agassiz calculates that it has taken 135,000 years to form the southern half of this peninsula. Yet the whole is of Post-Tertiary origin, the fossil zoophytes and shells being all of the same species as those now inhabiting the neighbouring sea.* (* Agassiz in Nott and Gliddon ibid. page 352.) In a calcareous conglomerate forming part of the above-mentioned series of reefs, and supposed by Agassiz, in accordance with his mode of estimating the rate of growth of those reefs, to be about 10,000 years old, some fossil human remains were found by Count Pourtales. They consisted of jaws and teeth, with some bones of the foot.

RECENT DEPOSITS OF SEAS AND LAKES.

I have shown, in the "Principles of Geology," where the recent changes of the earth illustrative of geology are described at length, that the deposits accumulated at the bottom of lakes and seas within the last 4000 or 5000 years can neither be insignificant in volume or extent. They lie hidden, for the most part, from our sight; but we have opportunities of examining them at certain points where newly-gained land in the deltas of rivers has been cut through during floods, or where coral reefs are growing rapidly, or where the bed of a sea or lake has been heaved up by subterranean movements and laid dry.

As examples of such changes of level by which marine deposits of the Recent period have become accessible to human observation, I have adduced the strata near Naples in which the Temple of Serapis at Pozzuoli was entombed.* (* "Principles of Geology" Index "Serapis.") These upraised strata, the highest of which are about 25 feet above the level of the sea, form a terrace skirting the eastern shore of the Bay of Baiae. They consist partly of clay,

partly of volcanic matter, and contain fragments of sculpture, pottery, and the remains of buildings, together with great numbers of shells, retaining in part their colour, and of the same species as those now inhabiting the neighbouring sea. Their emergence can be proved to have taken place since the beginning of the sixteenth century. [Note 5.]

In the same work, as an example of a freshwater deposit of the Recent period, I have described certain strata in Cashmere, a country where violent earthquakes, attended by alterations in the level of the ground, are frequent, in which freshwater shells of species now inhabiting the lakes and rivers of that region are embedded, together with the remains of pottery, often at the depth of fifty feet, and in which a splendid Hindoo temple has lately been discovered, and laid open to view by the removal of the lacustrine silt which had enveloped it for four or five centuries.

In the same treatise it is stated that the west coast of South America, between the Andes and the Pacific, is a great theatre of earthquake movements, and that permanent upheavals of the land of several feet at a time have been experienced since the discovery of America. In various parts of the littoral region of Chile and Peru, strata have been observed enclosing shells in abundance, all agreeing specifically with those now swarming in the Pacific. In one bed of this kind, in the island of San Lorenzo, near Lima, Mr. Darwin found, at the altitude of 85 feet above the sea, pieces of cotton-thread, plaited rush, and the head of a stalk of Indian corn, the whole of which had evidently been embedded with the shells. At the same height, on the neighbouring mainland, he found other signs corroborating the opinion that the ancient bed of the sea had there also been uplifted 85 feet since the region was first peopled by the Peruvian race. But similar shelly masses are also met with at much higher elevations, at innumerable points between the Chilean and Peruvian Andes and the sea-coast, in which no human remains have as yet been observed. The preservation for an indefinite period of such perishable substances as thread is explained by the entire absence of rain in Peru. The same articles, had they been enclosed in the permeable sands of an European raised beach, or in any country where rain falls even for a small part of the year, would probably have disappeared entirely [Note 6.]

In the literature of the eighteenth century, we find frequent allusion to the "era of existing continents," a period supposed to have coincided in date with the first appearance of Man upon the earth, since which event it was imagined that the relative level of the sea and land had remained stationary, no important geographical changes having occurred, except some slight additions to the deltas of rivers, or the loss of narrow strips of land where the sea had encroached upon its shores. But modern observations have tended continually to dispel this delusion, and the geologist is now convinced that at no given era of the past have the boundaries of land and sea, or the height of the one and depth of the other, or the geographical range of the species inhabiting them, whether of animals or plants, become fixed and unchangeable. Of the extent to which fluctuations have been going on since the globe had already become the dwelling-place of Man, some idea may be formed from the examples which I shall give in this and the next nine chapters.

UPHEAVAL SINCE THE HUMAN PERIOD OF THE CENTRAL DISTRICT OF

SCOTLAND. [NOTE 7.]

It has long been a fact familiar to geologists, that, both on the east and west coasts of the central part of Scotland, there are lines of raised beaches, containing marine shells of the same species as those now inhabiting the neighbouring sea.* (* R. Chambers "Sea Margins" 1848 and papers by Mr. Smith of Jordan Hill "Memoirs of the Wernerian Society" volume 8 and by Mr. C. Maclaren.) The two most marked of these littoral deposits occur at heights of about 50 and 25 feet above high-water mark, that of 50 feet being considered as the more ancient, and owing its superior elevation to a continuance of the upheaving movement. They are seen in some places to rest on the boulder clay of the glacial period, which will be described in future chapters.

In those districts where large rivers, such as the Clyde, Forth, and Tay, enter the sea, the lower of the two deposits, or that of 25 feet, expands into a terrace fringing the estuaries, and varying in breadth from a few yards to several miles. Of this nature are the flat lands which occur along the margin of the Clyde at Glasgow, which consist of finely laminated sand, silt, and clay. Mr. John Buchanan, a zealous antiquary, writing in 1855, informs us that in the course of the eighty years preceding that date, no less than seventeen canoes had been dug out of this estuarine silt, and that he had personally inspected a large number of them before they were exhumed. Five of them lay buried in silt under the streets of Glasgow, one in a vertical position with the prow uppermost as if it had sunk in a storm. In the inside of it were a number of marine shells. Twelve other canoes were found about 100 yards back from the river, at the average depth of about 19 feet from the surface of the soil, or 7 feet above high-water mark; but a few of them were only 4 or 5 feet deep, and consequently more than 20 feet above the sea-level. One was sticking in the sand at an angle of 45 degrees, another had been capsized and lay bottom uppermost; all the rest were in a horizontal position, as if they had sunk in smooth water.* (* J. Buchanan "Report of the British Association" 1855 page 80; also "Glasgow, Past and Present" 1856.)

Almost every one of these ancient boats was formed out of a single oak-stem, hollowed out by blunt tools, probably stone axes, aided by the action of fire; a few were cut beautifully smooth, evidently with metallic tools. Hence a gradation could be traced from a pattern of extreme rudeness to one showing great mechanical ingenuity. Two of them were built of planks, one of the two, dug up on the property of Bankton in 1853, being 18 feet in length, and very elaborately constructed. Its prow was not unlike the beak of an antique galley; its stern, formed of a triangular-shaped piece of oak, fitted in exactly like those of our day. The planks were fastened to the ribs, partly by singularly shaped oaken pins, and partly by what must have been square nails of some kind of metal; these had entirely disappeared, but some of the oaken pins remained. This boat had been upset, and was lying keel uppermost, with the prow pointing straight up the river. In one of the canoes, a beautifully polished celt or axe of greenstone was found, in the bottom of another a plug of cork, which, as Mr. Geikie remarks, "could only have come from the latitudes of Spain, Southern France, or Italy."* (* Geikie, "Quarterly Journal of the Geological Society" volume 18 1862 page 224.)

There can be no doubt that some of these buried vessels are of far more ancient date than others. Those most roughly hewn, may be relics of the stone period; those more smoothly cut, of the bronze age; and the regularly built boat of Bankton may perhaps come within the age of iron. The occurrence of all of them in one and the same upraised marine formation by no means implies that they belong to the same era, for in the beds of all great rivers and estuaries, there are changes continually in progress brought about by the deposition, removal, and redeposition of gravel, sand, and fine sediment, and by the shifting of the channel of the main currents from year to year, and from century to century. All these it behoves the geologist and antiquary to bear in mind, so as to be always on their guard, when they are endeavouring to settle the relative date, whether of objects of art or of organic remains embedded in any set of alluvial strata. Some judicious observations on this head occur in Mr. Geikie's memoir above cited, which are so much in point that I shall give them in full, and in his own words.

"The relative position in the silt, from which the canoes were exhumed, could help us little in any attempt to ascertain their relative ages, unless they had been found vertically above each other. The varying depths of an estuary, its banks of silt and sand, the set of its currents, and the influence of its tides in scouring out alluvium from some parts of its bottom and redepositing it in others, are circumstances which require to be taken into account in all such calculations. Mere coincidence of depth from the present surface of the ground, which is tolerably uniform in level, by no means necessarily proves contemporaneous deposition. Nor would such an inference follow even from the occurrence of the remains in distant parts of the very same stratum. A canoe might be capsized and sent to the bottom just beneath low-water mark; another might experience a similar fate on the following day, but in the middle of the channel. Both would become silted up on the floor of the estuary; but as that floor would be perhaps 20 feet deeper in the centre than towards the margin of the river, the one canoe might actually be twenty feet deeper in the alluvium than the other; and on the upheaval of the alluvial deposits, if we were to argue merely from the depth at which the remains were embedded, we should pronounce the canoe found at the one locality to be immensely older than the other, seeing that the fine mud of the estuary is deposited very slowly and that it must therefore have taken a long period to form so great a thickness as 20 feet. Again, the tides and currents of the estuary, by changing their direction, might sweep away a considerable mass of alluvium from the bottom, laying bare a canoe that may have foundered many centuries before. After the lapse of so long an interval, another vessel might go to the bottom in the same locality and be there covered up with the older one on the same general plane. These two vessels, found in such a position, would naturally be classed together as of the same age, and yet it is demonstrable that a very long period may have elapsed between the date of the one and that of the other. Such an association of these canoes, therefore, cannot be regarded as proving synchronous deposition; nor, on the other hand, can we affirm any difference of age from mere relative position, unless we see one canoe actually buried beneath another."* (* Geikie, "Quarterly Journal of the Geological Society" volume 18 1862, page 222.)

At the time when the ancient vessels, above described, were

navigating the waters where the city of Glasgow now stands, the whole of the low lands which bordered the present estuary of the Clyde formed the bed of a shallow sea. The emergence appears to have taken place gradually and by intermittent movements, for Mr. Buchanan describes several narrow terraces one above the other on the site of the city itself, with steep intervening slopes composed of the laminated estuary formation. Each terrace and steep slope probably mark pauses in the process of upheaval, during which low cliffs were formed, with beaches at their base. Five of the canoes were found within the precincts of the city at different heights on or near such terraces.

As to the date of the upheaval, the greater part of it cannot be assigned to the stone period, but must have taken place after tools of metal had come into use.

Until lately, when attempts were made to estimate the probable antiquity of such changes of level, it was confidently assumed, as a safe starting-point, that no alteration had occurred in the relative level of land and sea, in the central district of Scotland, since the construction of the Roman or Pictish wall (the "Wall of Antonine"), which reached from the Firth of Forth to that of the Clyde. The two extremities, it was said, of this ancient structure, bear such a relation to the present level of the two estuaries, that neither subsidence nor elevation of the land could have occurred for seventeen centuries at least.

But Mr. Geikie has lately shown that a depression of 25 feet on the Forth would not lay the eastern extremity of the Roman wall at Carriden under water, and he was therefore desirous of knowing whether the western end of the same would be submerged by a similar amount of subsidence. It has always been acknowledged that the wall terminated upon an eminence called the Chapel Hill, near the village of West Kilpatrick, on the Clyde. The foot of this hill, Mr. Geikie estimates to be about 25 or 27 feet above high-water mark, so that a subsidence of 25 feet could not lay it under water. Antiquaries have sometimes wondered that the Romans did not carry the wall farther west than this Chapel Hill; but Mr. Geikie now suggests, in explanation, that all the low land at present intervening between that point and the mouth of the Clyde, was sixteen or seventeen centuries ago, washed by the tides at high water.

The wall of Antonine, therefore, yields no evidence in favour of the land having remained stationary since the time of the Romans, but on the contrary, appears to indicate that since its erection the land has actually risen. Recent explorations by Mr. Geikie and Dr. Young, of the sites of the old Roman harbours along the southern margin of the Firth of Forth, lead to similar inferences. In the first place, it has long been known that there is a raised beach containing marine shells of living littoral species, at a height of about 25 feet, at Leith, as well as at other places along the coast above and below Edinburgh. Inveresk, a few miles below that city, is the site of an ancient Roman port, and if we suppose the sea at high water to have washed the foot of the heights on which the town stood, the tide would have ascended far up the valley of the Esk, and would have made the mouth of that river a safe and commodious harbour; whereas, had it been a shoaling estuary, as at present, it is difficult to see how the Romans

should have made choice of it as a port.

At Cramond, at the mouth of the river Almond, above Edinburgh, was Alaterva, the chief Roman harbour on the southern coast of the Forth, where numerous coins, urns, sculptured stones and the remnant of a harbour have been detected. The old Roman quays built along what must then have been the sea margin, have been found on what is now dry land, and although some silt carried down in suspension by the waters of the Forth may account for a part of the gain of low land, we yet require an upward movement of about 20 feet to explain the growth of the dreary expanse of mud now stretching along the shore and extending outwards, where it attains its greatest breadth, well-nigh two miles, across which vessels, even of light burden, can now only venture at full tide. Had these shoals existed eighteen centuries ago, they would have prevented the Romans from selecting this as their chief port; whereas, if the land were now to sink 20 feet, Cramond would unquestionably be the best natural harbour along the whole of the south side of the Forth.* (* Geikie, "Edinburgh New Philosophical Journal" for July 1861.)

Corresponding in level with the raised beach at Leith, above mentioned (or about 25 feet above high-water mark), is the Carse of Stirling, a low tract of land consisting of loamy and peaty beds, in which several skeletons of whales of large size have been found. One of these was dug up at Airthrie,* (* Bald, "Edinburgh Philosophical Journal" 1 page 393 and "Memoirs of the Wernerian Society" 3 page 327.) near Stirling, about a mile from the river, and 7 miles from the sea. Mr. Bald mentions that near it were found two pieces of stag's horn, artificially cut, through one of which a hole, about an inch in diameter, had been perforated. Another whale, 85 feet long, was found at Dunmore, a few miles below Stirling,* (* "Edinburgh Philosophical Journal" 11 pages 220, 415.) which, like that of Airthrie, lay about 20 feet above high-water mark. Three other skeletons of whales were found at Blair Drummond, between the years 1819 and 1824, 7 miles up the estuary above Stirling,* (* "Memoirs of the Wernerian Society" volume 5 page 440.) also at an elevation of between 20 and 30 feet above the sea. Near two of these whales, pointed instruments of deer's horn were found, one of which retained part of a wooden handle, probably preserved by having been enclosed in peat. This weapon is now in the museum at Edinburgh.

The position of these fossil whales and bone implements, and still more of an iron anchor found in the Carse of Falkirk, below Stirling, shows that the upheaval by which the raised beach of Leith was laid dry extended far westward probably as far as the Clyde, where, as we have seen, marine strata containing buried canoes rise to a similar height above the sea.

The same upward movement which reached simultaneously east and west from sea to sea was also felt as far north as the estuary of the Tay. This may be inferred from the Celtic name of Inch being attached to many hillocks, which rise above the general level of the alluvial plains, implying that these eminences were once surrounded by water or marshy ground. At various localities also in the silt of the Carse of Gowrie iron implements have been found.

The raised beach, also containing a great number of marine shells

of recent species, traced up to a height of 14 feet above the sea by Mr. W.J. Hamilton at Elie, on the southern coast of Fife, is doubtless another effect of the same extensive upheaval.* (* "Proceedings of the Geological Society" volume 2 1833 page 280.) A similar movement would also account for some changes which antiquaries have recorded much farther south, on the borders of the Solway Firth; though in this case, as in that of the estuary of the Forth, the conversion of sea into land has always been referred to the silting up of estuaries, and not to upheaval. Thus Horsley insists on the difficulty of explaining the position of certain Roman stations, on the Solway, the Forth, and the Clyde, without assuming that the sea has been excluded from certain areas which it formerly occupied.* (* "Britannia" page 157 1860.)

On a review of the whole evidence, geological and archaeological, afforded by the Scottish coast-line, we may conclude that the last upheaval of 25 feet took place not only since the first human population settled in the island; but long after metallic implements had come into use, and there seems even a strong presumption in favour of the opinion that the date of the elevation may have been subsequent to the Roman occupation.

But the 25 feet rise is only the last stage of a long antecedent process of elevation, for examples of Recent marine shells have been observed 40 feet and upwards above the sea in Ayrshire. At one of these localities, Mr. Smith of Jordanhill informs me that a rude ornament made of cannel coal has been found on the coast in the parish of Dundonald, lying 50 feet above the sea-level, on the surface of the boulder-clay or till, and covered with gravel containing marine shells. If we suppose the upward movement to have been uniform in central Scotland before and after the Roman era, and assume that as 25 feet indicate seventeen centuries, so 50 feet imply a lapse of twice that number, or 3400 years, we should then carry back the date of the ornament in question to fifteen centuries before our era, or to the days of Pharaoh, and the period usually assigned to the exodus of the Israelites from Egypt. [Note 8.]

But all such estimates must be considered, in the present state of science, as tentative and conjectural, since the rate of movement of the land may not have been uniform, and its direction not always upwards, and there may have been long stationary periods, one of which of more than usual duration seems indicated by the 50-foot raised beach, which has been traced for vast distances along the western coast of Scotland.

COAST OF CORNWALL.

Sir H. De la Beche has adduced several proofs of changes of level, in the course of the human period, in his "Report on the Geology of Cornwall and Devon," 1839. He mentions (page 406) that several human skulls and works of art, buried in an estuary deposit, were found in mining gravel for tin at Pentuan, near St. Austell, the skulls lying at the depth of 40 feet from the surface, and others at Carnon at the depth of 53 feet. The overlying strata were marine, containing sea-shells of living species, and bones of whales, besides the remains of several living species of mammalia.

Other examples of works of art, such as stone hatchets, canoes, and

ships, buried in ancient river-beds in England, and in peat and shell-marl, I have mentioned in my work before cited.

SWEDEN AND NORWAY.

In the same work I have shown that near Stockholm, in Sweden, there occur, at slight elevations above the sea-level, horizontal beds of sand, loam, and marl, containing the same peculiar assemblage of testacea which now live in the brackish waters of the Baltic. Mingled with these, at different depths, have been detected various works of art implying a rude state of civilization, and some vessels built before the introduction of iron, and even the remains of an ancient hut, the marine strata containing it, which had been formed during a previous depression, having been upraised, so that the upper beds are now 60 feet higher than the surface of the Baltic. In the neighbourhood of these recent strata, both to the north-west and south of Stockholm, other deposits similar in mineral composition occur, which ascend to greater heights, in which precisely the same assemblage of fossil shells is met with, but without any intermixture, so far as is yet known, of human bones or fabricated articles.

On the opposite or western coast of Sweden, at Uddevalla, Post-Tertiary strata, containing recent shells, not of that brackish water character peculiar to the Baltic, but such as now live in the Northern Ocean, ascend to the height of 200 feet; and beds of clay and sand of the same age attain elevations of 300 and even 600 feet in Norway, where they have been usually described as "raised beaches." They are, however, thick deposits of submarine origin, spreading far and wide, and filling valleys in the granite and gneiss, just as the Tertiary formations, in different parts of Europe, cover or fill depressions in the older rocks.

Although the fossil fauna characterising these upraised sands and clays consists exclusively of existing northern species of testacea, it is more than probable that they may not all belong to that division of the Pleistocene strata which we are now considering. If the contemporary mammalia were known, they would, in all likelihood, be found to be referable, at least in part, to extinct species; for, according to Loven (an able living naturalist of Norway), the species do not constitute such an assemblage as now inhabits corresponding latitudes in the North Sea. On the contrary, they decidedly represent a more arctic fauna. In order to find the same species flourishing in equal abundance, or in many cases to find them at all, we must go northwards to higher latitudes than Uddevalla in Sweden, or even nearer the pole than Central Norway.

Judging by the uniformity of climate now prevailing from century to century, and the insensible rate of variation in the geographical distribution of organic beings in our own times, we may presume that an extremely lengthened period was required even for so slight a modification in the range of the molluscous fauna, as that of which the evidence is here brought to light. There are also other independent reasons for suspecting that the antiquity of these deposits may be indefinitely great as compared to the historical period. I allude to their present elevation above the sea, some of them rising, in Norway, to the height of 600 feet or more. The upward movement now in progress in parts of Norway and Sweden extends, as I have elsewhere shown,* (* "Principles" 9th edition

chapter 30.) throughout an area about 1000 miles north and south, and for an unknown distance east and west, the amount of elevation always increasing as we proceed towards the North Cape, where it is said to equal 5 feet in a century. If we could assume that there had been an average of 2 1/2 feet in each hundred years for the last fifty centuries, this would give an elevation of 125 feet in that period. In other words, it would follow that the shores, and a considerable area of the former bed of the North Sea, had been uplifted vertically to that amount, and converted into land in the course of the last 5000 years. A mean rate of continuous vertical elevation of 2 1/2 feet in a century would, I conceive, be a high average; yet, even if this be assumed, it would require 24,000 years for parts of the sea-coast of Norway, where the Pleistocene marine strata occur, to attain the height of 600 feet. [Note 9.]

CHAPTER 4.

PLEISTOCENE PERIOD--BONES OF MAN AND EXTINCT MAMMALIA IN BELGIAN CAVERNS.

Earliest Discoveries in Caves of Languedoc of Human Remains with Bones of extinct Mammalia.
Researches in 1833 of Dr. Schmerling in the Liege Caverns.
Scattered Portions of Human Skeletons associated with Bones of Elephant and Rhinoceros.
Distribution and probable Mode of Introduction of the Bones.
Implements of Flint and Bone.
Schmerling's Conclusions as to the Antiquity of Man ignored.
Present State of the Belgian Caves.
Human Bones recently found in Cave of Engihoul.
Engulfed Rivers.
Stalagmitic Crust.
Antiquity of the Human Remains in Belgium how proved.

Having hitherto considered those formations in which both the fossil shells and the mammalia are of living species, we may now turn our attention to those of older date, in which the shells being all recent, some of the accompanying mammalia are extinct, or belong to species not known to have lived within the times of history or tradition.

DISCOVERIES OF MM. TOURNAL AND CHRISTOL IN 1828 IN THE SOUTH OF FRANCE.

In the "Principles of Geology," when treating of the fossil remains found in alluvium and the mud of caverns, I gave an account in 1832 of the investigations made by MM. Tournal and Christol in the South of France.* (* 1st edition volume 2 chapter 14 1832, and 9th edition page 738, 1853.)

M. Tournal stated in his memoir that in the cavern of Bize, in the department of the Aude, he had found human bones and teeth, together with fragments of rude pottery, in the same mud and breccia cemented by stalagmite in which land-shells of living species were embedded, and the bones of mammalia, some of extinct, others of recent species. The human bones were declared by his fellow-labourer, M. Marcel de Serres, to be in the same chemical

condition as those of the accompanying quadrupeds.* (* "Annales des Sciences Naturelles" tome 15 1828 page 348.)

Speaking of these fossils of the Bize cavern five years later, M. Tournal observed that they could not be referred, as some suggested, to a "diluvial catastrophe," for they evidently had not been washed in suddenly by a transient flood, but must have been introduced gradually, together with the enveloping mud and pebbles, at successive periods.* (* "Annales de Chimie et de Physique" 1833 page 161.)

M. Christol, who was engaged at the same time in similar researches in another part of Languedoc, published an account of them a year later, in which he described some human bones, as occurring in the cavern of Pondres, near Nimes, in the same mud with the bones of an extinct hyaena and rhinoceros.* (* Christol, "Notice sur les Ossements humains des Cavernes du Gard" Montpellier 1829.) The cavern was in this instance filled up to the roof with mud and gravel, in which fragments of two kinds of pottery were detected, the lowest and rudest near the bottom of the cave, below the level of the extinct mammalia.

It has never been questioned that the hyaena and rhinoceros found by M. Christol were of extinct species; but whether the animals enumerated by M. Tournal might not all of them be referred to quadrupeds which are known to have been living in Europe in the historical period seems doubtful. They were said to consist of a stag, an antelope, and a goat, all named by M. Marcel de Serres as new; but the majority of palaeontologists do not agree with this opinion. Still it is true, as M. Lartet remarks, that the fauna of the cavern of Bize must be of very high antiquity, as shown by the presence, not only of the Lithuanian aurochs (Bison europaeus), but also of the reindeer, which has not been an inhabitant of the South of France in historical times, and which, in that country, is almost everywhere associated, whether in ancient alluvium or in the mud of caverns, with the mammoth.

In my work before cited,* (* "Principles" 9th edition page 739.) I stated that M. Desnoyers, an observer equally well versed in geology and archaeology, had disputed the conclusion arrived at by MM. Tournal and Christol, that the fossil rhinoceros, hyaena, bear, and other lost species had once been inhabitants of France contemporaneously with Man. "The flint hatchets and arrow-heads," he said, "and the pointed bones and coarse pottery of many French and English caves, agree precisely in character with those found in the tumuli, and under the dolmens (rude altars of unhewn stone) of the primitive inhabitants of Gaul, Britain, and Germany. The human bones, therefore, in the caves which are associated with such fabricated objects, must belong not to antediluvian periods, but to a people in the same stage of civilization as those who constructed the tumuli and altars."

"In the Gaulish monuments," he added, "we find, together with the objects of industry above mentioned, the bones of wild and domestic animals of species now inhabiting Europe, particularly of deer, sheep, wild boars, dogs, horses, and oxen. This fact has been ascertained in Quercy and other provinces; and it is supposed by antiquaries that the animals in question were placed beneath the Celtic altars in memory of sacrifices offered to the Gaulish

divinity Hesus, and in the tombs to commemorate funeral repasts, and also from a superstition prevalent among savage nations, which induces them to lay up provisions for the manes of the dead in a future life. But in none of these ancient monuments have any bones been found of the elephant, rhinoceros, hyaena, tiger, and other quadrupeds, such as are found in caves, which might certainly have been expected had these species continued to flourish at the time that this part of Gaul was inhabited by Man."* (* Desnoyers, "Bulletin de la Societe Geologique de France" tome 2 page 252; and article on Caverns, "Dictionnaire Universelle d'Histoire Naturelle" Paris 1845.)

After giving no small weight to the arguments of M. Desnoyers, and the writings of Dr. Buckland on the same subject, and myself visiting several caves in Germany, I came to the opinion that the human bones mixed with those of extinct animals, in osseous breccias and cavern mud, in different parts of Europe, were probably not coeval. The caverns having been at one period the dens of wild beasts, and having served at other times as places of human habitation, worship, sepulture, concealment, or defence, one might easily conceive that the bones of Man and those of animals, which were strewed over the floors of subterranean cavities, or which had fallen into tortuous rents connecting them with the surface, might, when swept away by floods, be mingled in one promiscuous heap in the same ossiferous mud or breccia.* (* "Principles" 9th edition page 740.)

That such intermixtures have really taken place in some caverns, and that geologists have occasionally been deceived, and have assigned to one and the same period fossils which had really been introduced at successive times, will readily be conceded. But of late years we have obtained convincing proofs, as we shall see in the sequel, that the mammoth, and many other extinct mammalian species very common in caves, occur also in undisturbed alluvium, embedded in such a manner with works of art, as to leave no room for doubt that Man and the mammoth coexisted; Such discoveries have led me, and other geologists, to reconsider the evidence previously derived from caves brought forward in proof of the high antiquity of Man. With a view of re-examining this evidence, I have lately explored several caverns in Belgium and other countries, and re-read the principal memoirs and treatises treating of the fossil remains preserved in them, the results of which inquiries I shall now proceed to lay before the reader.

RESEARCHES, IN 1833-1834, OF DR. SCHMERLING IN THE CAVERNS NEAR LIEGE.

The late Dr. Schmerling of Liege, a skilful anatomist and palaeontologist, after devoting several years to the exploring of the numerous ossiferous caverns which border the valleys of the Meuse and its tributaries, published two volumes descriptive of the contents of more than forty caverns. One of these volumes consisted of an atlas of plates, illustrative of the fossil bones.* (* "Recherches sur les Ossements fossiles decouverts dans les Cavernes de la Province de Liege", Liege 1833-1834.)

Many of the caverns had never before been entered by scientific observers, and their floors were encrusted with unbroken stalagmite. At a very early stage of his investigations, Dr.

Schmerling found the bones of Man so rolled and scattered as to preclude all idea of their having been intentionally buried on the spot. He also remarked that they were of the same colour, and in the same condition as to the amount of animal matter contained in them, as those of the accompanying animals, some of which, like the cave-bear, hyaena, elephant, and rhinoceros, were extinct; others, like the wild cat, beaver, wild boar, roe-deer, wolf, and hedgehog, still extant. The fossils were lighter than fresh bones, except such as had their pores filled with carbonate of lime, in which case they were often much heavier. The human remains of most frequent occurrence were teeth detached from the jaw, and the carpal, metacarpal, tarsal, metatarsal, and phalangeal bones separated from the rest of the skeleton. The corresponding bones of the cave-bear, the most abundant of the accompanying mammalia, were also found in the Liege caverns more commonly than any others, and in the same scattered condition. Occasionally, some of the long

bones of mammalia were observed to have been first broken across, and then reunited or cemented again by stalagmite, as they lay on the floor of the cave.

No gnawed bones nor any coprolites were found by Schmerling. He therefore inferred that the caverns of the province of Liege had not been the dens of wild beasts, but that their organic and inorganic contents had been swept into them by streams communicating with the surface of the country. The bones, he suggested, may often have been rolled in the beds of such streams before they reached their underground destination. To the same agency the introduction of many land-shells dispersed through the cave-mud was ascribed, such as Helix nemoralis, H. lapicida, H. pomatia, and others of living species. Mingled with such shells, in some rare instances, the bones of freshwater fish, and of a snake (Coluber), as well as of several birds, were detected.

The occurrence here and there of bones in a very perfect state, or of several bones belonging to the same skeleton in natural juxtaposition, and having all their most delicate apophyses uninjured, while many accompanying bones in the same breccia were rolled, broken, or decayed, was accounted for by supposing that portions of carcasses were sometimes floated in during floods while still clothed with their flesh. No example was discovered of an entire skeleton, not even of one of the smaller mammalia, the bones of which are usually the least injured.

The incompleteness of each skeleton was especially ascertained in regard to the human subjects, Dr. Schmerling being careful, whenever a fragment of such presented itself, to explore the cavern himself, and see whether any other bones of the same skeleton could be found. In the Engis cavern, distant about eight miles to the south-west of Liege, on the left bank of the Meuse, the remains of at least three human individuals were disinterred. The skull of one of these, that of a young person, was embedded by the side of a mammoth's tooth. It was entire but so fragile, that nearly all of it fell to pieces during its extraction. Another skull, that of an adult individual, and the only one preserved by Dr. Schmerling in a sufficient state of integrity to enable the anatomist to speculate on the race to which it belonged, was buried 5 feet deep in a breccia, in which the tooth of a rhinoceros, several bones of a horse, and some of the reindeer, together with some ruminants,

occurred. This skull, now in the museum of the University of Liege, is figured in Chapter 5 (Figure 2), where further observations will be offered on its anatomical character, after a fuller account of the contents of the Liege caverns has been laid before the reader.

On the right bank of the Meuse, on the opposite side of the river to Engis, is the cavern of Engihoul. Bones of extinct animals mingled with those of Man were observed to abound in both caverns; but with this difference, that whereas in the Engis cave there were several human crania and very few other bones, in Engihoul there occurred numerous bones of the extremities belonging to at least three human individuals, and only two small fragments of a cranium. The like capricious distribution held good in other caverns, especially with reference to the cave-bear, the most frequent of the extinct mammalia. Thus, for example in the cave of Chokier, skulls of the bear were few, and other parts of the skeleton abundant, whereas in several other caverns these proportions were exactly reversed, while at Goffontaine skulls of the bear and other parts of the skeleton were found in their natural numerical proportions. Speaking generally, it may be said that human bones, where any were met with, occurred at all depths in the cave-mud and gravel, sometimes above and sometimes below those of the bear, elephant, rhinoceros, hyaena, etc.

Some rude flint implements of the kind commonly called flint knives or flakes, of a triangular form in the cross section (as in Figure 14), were found by Schmerling dispersed generally through the cave-mud, but he was too much engrossed with his osteological inquiries to collect them diligently. He preserved some few of them, however, which I have seen in the museum at Liege. He also discovered in the cave of Chokier, 2 1/2 miles south-west from Liege, a polished and jointed needle-shaped bone, with a hole pierced obliquely through it at the base; such a cavity, he observed, as had never given passage to an artery. This instrument was embedded in the same matrix with the remains of a rhinoceros.* (* Schmerling part 2 page 177.)

Another cut bone and several artificially-shaped flints were found in the Engis cave, near the human skulls before alluded to. Schmerling observed, and we shall have to refer to the fact in the sequel (Chapter 8), that although in some forty fossiliferous caves explored by him human bones were the exception, yet these flint implements were universal, and he added that "none of them could have been subsequently introduced, being precisely in the same position as the remains of the accompanying animals." "I therefore," he continues, "attach great importance to their presence; for even if I had not found the human bones under conditions entirely favourable to their being considered as belonging to the antediluvian epoch, proofs of Man's existence would still have been supplied by the cut bones and worked flints"* (* Schmerling, part 2 page 179.)

Dr. Schmerling, therefore, had no hesitation in concluding from the various facts ascertained by him, that Man once lived in the Liege district contemporaneously with the cave-bear and several other extinct species of quadrupeds. But he was much at a loss when he attempted to invent a theory to explain the former state of the fauna of the region now drained by the Meuse; for he shared the notion, then very prevalent among naturalists, that the mammoth and

the hyaena* (* Ibid. part 2 pages 70 and 96.) were beasts of a warmer climate than that now proper to Western Europe. In order to account for the presence of such "tropical species," he was half-inclined to imagine that they had been transported by a flood from some distant region; then again he raised the question whether they might not have been washed out of an older alluvium, which may have pre-existed in the neighbourhood. This last hypothesis was directly at variance with his own statements, that the remains of the mammoth and hyaena were identical in appearance, colour, and chemical condition with those of the bear and other associated fossil animals, none of which exhibited signs of having been previously enveloped in any dissimilar matrix. Another enigma which led Schmerling astray in some of his geological speculations was the supposed presence of the agouti, a South American rodent, "proper to the torrid zone." My friend M. Lartet, guided by Schmerling's figures of the teeth of this species, suggests, and I have little doubt with good reason, that they appertain to the porcupine, a genus found fossil in Pleistocene deposits of certain caverns in the south of France.

In the year 1833, I passed through Liege, on my way to the Rhine, and conversed with Dr. Schmerling, who showed me his splendid collection, and when I expressed some incredulity respecting the alleged antiquity of the fossil human bones, he pointedly remarked that if I doubted their having been contemporaneous with the bear or rhinoceros, on the ground of Man being a species of more modern date, I ought equally to doubt the co-existence of all the other living species, such as the red deer, roe, wild cat, wild boar, wolf, fox, weasel, beaver, hare, rabbit, hedgehog, mole, dormouse, field-mouse, water-rat, shrew, and others, the bones of which he had found scattered everywhere indiscriminately through the same mud with the extinct quadrupeds. The year after this conversation I cited Schmerling's opinions, and the facts bearing on the antiquity of Man, in the 3rd edition of my "Principles of Geology" (page 161, 1834), and in succeeding editions, without pretending to call in question their trustworthiness, but at the same time without giving them the weight which I now consider they were entitled to. He had accumulated ample evidence to prove that Man had been introduced into the earth at an earlier period than geologists were then willing to believe.

One positive fact, it will be said, attested by so competent a witness, ought to have outweighed any amount of negative testimony, previously accumulated, respecting the non-occurrence elsewhere of human remains in formations of the like antiquity. In reply, I can only plead that a discovery which seems to contradict the general tenor of previous investigations is naturally received with much hesitation. To have undertaken in 1832, with a view of testing its truth, to follow the Belgian philosopher through every stage of his observations and proofs, would have been no easy task even for one well-skilled in geology and osteology. To be let down, as Schmerling was, day after day, by a rope tied to a tree, so as to slide to the foot of the first opening of the Engis cave,* (* Schmerling part 1 page 30.) where the best-preserved human skulls were found; and, after thus gaining access to the first subterranean gallery, to creep on all fours through a contracted passage leading to larger chambers, there to superintend by torchlight, week after week and year after year, the workmen who were breaking through the stalagmitic crust as hard as marble, in

order to remove piece by piece the underlying bone-breccia nearly as hard; to stand for hours with one's feet in the mud, and with water dripping from the roof on one's head, in order to mark the position and guard against the loss of each single bone of a skeleton; and at length, after finding leisure, strength, and courage for all these operations, to look forward, as the fruits of one's labour, to the publication of unwelcome intelligence, opposed to the prepossessions of the scientific as well as of the unscientific public--when these circumstances are taken into account, we need scarcely wonder, not only that a passing traveller failed to stop and scrutinise the evidence, but that a quarter of a century should have elapsed before even the neighbouring professors of the University of Liege came forth to vindicate the truthfulness of their indefatigable and clear-sighted countryman.

In 1860, when I revisited Liege, twenty-six years after my interview with Schmerling, I found that several of the caverns described by him had in the interval been annihilated. Not a vestige, for example, of the caves of Engis, Chokier, and Goffontaine remained. The calcareous stone, in the heart of which the cavities once existed, had been quarried away, and removed bodily for building and lime-making. Fortunately, a great part of the Engihoul cavern, situated on the right bank of the Meuse, was still in the same state as when Schmerling delved into it in 1831, and drew from it the bones of three human skeletons. I determined, therefore, to examine it, and was so fortunate as to obtain the assistance of a zealous naturalist of Liege, Professor Malaise, who accompanied me to the cavern, where we engaged some workmen to break through the crust of stalagmite, so that we could search for bones in the undisturbed earth beneath. Bones and teeth of the cave-bear were soon found, and several other extinct quadrupeds which Schmerling has enumerated. My companion, continuing the work perseveringly for weeks after my departure, succeeded at length in extracting from the same deposit, at the depth of 2 feet below the crust of stalagmite, three fragments of a human skull, and two perfect lower jaws with teeth, all associated in such a manner with the bones of bears, large pachyderms, and ruminants, and so precisely resembling these in colour and state of preservation, as to leave no doubt in his mind that Man was contemporary with the extinct animals. Professor Malaise has given figures of the human remains in the "Bulletin" of the Royal Academy of Belgium for 1860. * (* Volume 10 page 546.)

The rock in which the Liege caverns occur belongs generally to the Carboniferous or Mountain Limestone, in some few cases only to the older Devonian formation. Whenever the work of destruction has not gone too far, magnificent sections, sometimes 200 and 300 feet in height, are exposed to view. They confirm Schmerling's doctrine, that most of the materials, organic and inorganic, now filling the caverns, have been washed into them through narrow vertical or oblique fissures, the upper extremities of which are choked up with soil and gravel, and would scarcely ever be discoverable at the surface, especially in so wooded a country. Among the sections obtained by quarrying, one of the finest which I saw was in the beautiful valley of Fond du Foret, above Chaudefontaine, not far from the village of Magnee, where one of the rents communicating with the surface has been filled up to the brim with rounded and half-rounded stones, angular pieces of limestone and shale, besides sand and mud, together with bones, chiefly of the cave-bear.

Connected with this main duct, which is from 1 to 2 feet in width, are several minor ones, each from 1 to 3 inches wide, also extending to the upper country or table-land, and choked up with similar materials. They are inclined at angles of 30 and 40 degrees, their walls being generally coated with stalactite, pieces of which have here and there been broken off and mingled with the contents of the rents, thus helping to explain why we so often meet with detached pieces of that substance in the mud and breccia of the Belgian caves. It is not easy to conceive that a solid horizontal floor of hard stalagmite should, after its formation, be broken up by running water; but when the walls of steep and tortuous rents, serving as feeders to the principal fissures and to inferior vaults and galleries are encrusted with stalagmite, some of the incrustation may readily be torn up when heavy fragments of rock are hurried by a flood through passages inclined at angles of 30 or 40 degrees.

The decay and decomposition of the fossil bones seem to have been arrested in most of the caves by a constant supply of water charged with carbonate of lime, which dripped from the roofs while the caves were becoming gradually filled up. By similar agency the mud, sand, and pebbles were usually consolidated.

The following explanation of this phenomenon has been suggested by the eminent chemist Liebig. On the surface of Franconia, where the limestone abounds in caverns, is a fertile soil in which vegetable matter is continually decaying. This mould or humus, being acted on by moisture and air, evolves carbonic acid, which is dissolved by rain. The rain water, thus impregnated, permeates the porous limestone, dissolves a portion of it, and afterwards, when the excess of carbonic acid evaporates in the caverns, parts with the calcareous matter and forms stalactite. So long as water flows, even occasionally, through a suite of caverns, no layer of pure stalagmite can be produced; hence the formation of such a layer is generally an event posterior in date to the cessation of the old system of drainage, an event which might be brought about by an earthquake causing new fissures, or by the river wearing its way down to a lower level, and thenceforth running in a new channel.

In all the subterranean cavities, more than forty in number, explored by Schmerling, he only observed one cave, namely that of Chokier, where there were two regular layers of stalagmite, divided by fossiliferous cave-mud. In this instance, we may suppose that the stream, after flowing for a long period at one level, cut its way down to an inferior suite of caverns, and, flowing through them for centuries, choked them up with debris; after which it rose once more to its original higher level: just as in the Mountain Limestone district of Yorkshire some rivers, habitually absorbed by a "swallow hole," are occasionally unable to discharge all their water through it; in which case they rise and rush through a higher subterranean passage, which was at some former period in the regular line of drainage, as is often attested by the fluviatile gravel still contained in it.

There are now in the basin of the Meuse, not far from Liege, several examples of engulfed brooks and rivers: some of them, like that of St. Hadelin, east of Chaudefontaine, which reappears after an underground course of a mile or two; others, like the Vesdre, which is lost near Goffontaine, and after a time re-emerges; some,

again, like the torrent near Magnee, which, after entering a cave, never again comes to the day. In the season of floods such streams are turbid at their entrance, but clear as a mountain-spring where they issue again; so that they must be slowly filling up cavities in the interior with mud, sand, pebbles, snail-shells, and the bones of animals which may be carried away during floods.

The manner in which some of the large thigh and shank bones of the rhinoceros and other pachyderms are rounded, while some of the smaller bones of the same creatures, and of the hyaena, bear, and horse, are reduced to pebbles, shows that they were often transported for some distance in the channels of torrents, before they found a resting-place.

When we desire to reason or speculate on the probable antiquity of human bones found fossil in such situations as the caverns near Liege, there are two classes of evidence to which we may appeal for our guidance. First, considerations of the time required to allow of many species of carnivorous and herbivorous animals, which flourished in the cave period, becoming first scarce, and then so entirely extinct as we have seen that they had become before the era of the Danish peat and Swiss lake dwellings; secondly, the great number of centuries necessary for the conversion of the physical geography of the Liege district from its ancient to its present configuration; so many old underground channels, through which brooks and rivers flowed in the cave period, being now laid dry and choked up.

The great alterations which have taken place in the shape of the valley of the Meuse and some of its tributaries are often demonstrated by the abrupt manner in which the mouths of fossiliferous caverns open in the face of perpendicular precipices 200 feet or more in height above the present streams. There appears also, in many cases, to be such a correspondence in the openings of caverns on opposite sides of some of the valleys, both large and small, as to incline one to suspect that they originally belonged to a series of tunnels and galleries which were continuous before the present system of drainage came into play, or before the existing valleys were scooped out. Other signs of subsequent fluctuations are afforded by gravel containing elephant's bones at slight elevations above the Meuse and several of its tributaries. It may be objected that, according to the present rate of change, no lapse of ages would suffice to bring about such revolutions in physical geography as we are here contemplating. This may be true. It is more than probable that the rate of change was once far more active than it is now in the basin of the Meuse. Some of the nearest volcanoes, namely, those of the Lower Eifel about 60 miles to the eastward, seem to have been in eruption in Pleistocene times, and may perhaps have been connected and coeval with repeated risings or sinkings of the land in the Liege district. It might be said, with equal truth, that according to the present course of events, no series of ages would suffice to reproduce such an assemblage of cones and craters as those of the Eifel (near Andernach, for example); and yet some of them may be of sufficiently modern date to belong to the era when Man was contemporary with the mammoth and rhinoceros in the basin of the Meuse.

But, although we may be unable to estimate the minimum of time

required for the changes in physical geography above alluded to, we cannot fail to perceive that the duration of the period must have been very protracted, and that other ages of comparative inaction may have followed, separating the Pleistocene from the historical periods, and constituting an interval no less indefinite in its duration.

CHAPTER 5.

PLEISTOCENE PERIOD--FOSSIL HUMAN SKULLS OF THE NEANDERTHAL AND ENGIS CAVES.

Human Skeleton found in Cave near Dusseldorf.
Its geological Position and probable Age.
Its abnormal and ape-like Characters.
Fossil Human Skull of the Engis Cave near Liege.
Professor Huxley's Description of these Skulls.
Comparison of each, with extreme Varieties of the native Australian Race.
Range of Capacity in the Human and Simian Brains.
Skull from Borreby in Denmark.
Conclusions of Professor Huxley.
Bearing of the peculiar Characters of the Neanderthal Skull on the Hypothesis of Transmutation.

FOSSIL HUMAN SKELETON OF THE NEANDERTHAL CAVE NEAR DUSSELDORF.

Before I speak more particularly of the opinions which anatomists have expressed respecting the osteological characters of the human skull from Engis, near Liege, mentioned in the last chapter and described by Dr. Schmerling, it will be desirable to say something of the geological position of another skull, or rather skeleton, which, on account of its peculiar conformation, has excited no small sensation in the last few years. I allude to the skull found in 1857 in a cave situated in that part of the valley of the Dussel, near Dusseldorf, which is called the Neanderthal. The spot is a deep and narrow ravine about 70 English miles north-east of the region of the Liege caverns treated of in the last chapter, and close to the village and railway station of Hochdal between Dusseldorf and Elberfeld. The cave occurs in the precipitous southern or left side of the winding ravine, about sixty feet above the stream, and a hundred feet below the top of the cliff. The accompanying section (Figure 1.) will give the reader an idea of its position.

When Dr. Fuhlrott of Elberfeld first examined the cave, he found it to be high enough to allow a man to enter. The width was 7 or 8 feet, and the length or depth 15. I visited the spot in 1860, in company with Dr. Fuhlrott, who had the kindness to come expressly from Elberfeld to be my guide, and who brought with him the original fossil skull, and a cast of the same, which he presented to me. In the interval of three years, between 1857 and 1860, the ledge of rock, f, on which the cave opened, and which was originally 20 feet wide, had been almost entirely quarried away, and, at the rate at which the work of dilapidation was proceeding, its complete destruction seemed near at hand.

(FIGURE 1. SECTION OF THE NEANDERTHAL CAVE NEAR DUSSELDORF.

a. Cavern 60 feet above the Dussel, and 100 feet below the surface of the country at c.
b. Loam covering the floor of the cave near the bottom of which the human skeleton was found.
b, c. Rent connecting the cave with the upper surface of the country.
d. Superficial sandy loam.
e. Devonian limestone.
f. Terrace, or ledge of rock.)

In the limestone are many fissures, one of which, still partially filled with mud and stones, is represented in the section at a c as continuous from the cave to the upper surface of the country. Through this passage the loam, and possibly the human body to which the bones belonged, may have been washed into the cave below. The loam, which covered the uneven bottom of the cave, was sparingly mixed with rounded fragments of chert, and was very similar in composition to that covering the general surface of that region.

There was no crust of stalagmite overlying the mud in which the human skeleton was found, and no bones of other animals in the mud with the skeleton; but just before our visit in 1860 the tusk of a bear had been met with in some mud in a lateral embranchment of the cave, in a situation precisely similar to b, Figure 1, and on a level corresponding with that of the human skeleton. This tusk, shown us by the proprietor of the cave, was 2 1/2 inches long and quite perfect; but whether it was referable to a recent or extinct species of bear, I could not determine.

From a printed letter of Dr. Fuhlrott we learn that on removing the loam, which was five feet thick, from the cave, the human skull was first noticed near the entrance, and, further in, the other bones lying in the same horizontal plane. It is supposed that the skeleton was complete, but the workmen, ignorant of its value, scattered and lost most of the bones, preserving only the larger ones.* (* Fuhlrott, Letter to Professor Schaaffhausen, cited "Natural History Review" Number 2 page 156. See also "Naturhistorischer Verein" Bonn 1859.)

The cranium, which Dr. Fuhlrott showed me, was covered both on its outer and inner surface, and especially on the latter, with a profusion of dendritical crystallisations, and some other bones of the skeleton were ornamented in the same way. These markings, as Dr. Hermann von Meyer observes, afford no sure criterion of antiquity, for they have been observed on Roman bones. Nevertheless, they are more common in bones that have been long embedded in the earth. The skull and bones, moreover, of the Neanderthal skeleton had lost so much of their animal matter as to adhere strongly to the tongue, agreeing in this respect with the ordinary condition of fossil remains of the Pleistocene period. On the whole, I think it probable that this fossil may be of about the same age as those found by Schmerling in the Liege caverns; but, as no other animal remains were found with it, there is no proof that it may not be newer. Its position lends no countenance whatever to the supposition of its being more ancient.

When the skull and other parts of the skeleton were first exhibited at a German scientific meeting at Bonn, in 1857, some doubts were

expressed by several naturalists, whether it was truly human. Professor Schaaffhausen, who, with the other experienced zoologists, did not share these doubts, observed that the cranium, which included the frontal bone, both parietals, part of the squamous, and the upper third of the occipital, was of unusual size and thickness, the forehead narrow and very low, and the projection of the supra-orbital ridges enormously great. He also stated that the absolute and relative length of the thigh bone, humerus, radius, and ulna, agreed well with the dimensions of a European individual of like stature at the present day; but that the thickness of the bones was very extraordinary, and the elevations and depressions for the attachment of muscles were developed in an unusual degree. Some of the ribs, also, were of a singularly rounded shape and abrupt curvature, which was supposed to indicate great power in the thoracic muscles.* (* Professor Schaaffhausen's "Memoir" translated "Natural History Review" April 1861.)

In the same memoir, the Prussian anatomist remarks that the depression of the forehead (See Figure 3.), is not due to any artificial flattening, such as is practised in various modes by barbarous nations in the Old and New World, the skull being quite symmetrical, and showing no indication of counter-pressure at the occiput; whereas, according to Morton, in the Flat-heads of the Columbia, the frontal and parietal bones are always unsymmetrical.* (* "Natural History Review" Number 2 page 160.) On the whole, Professor Schaaffhausen concluded that the individual to whom the Neanderthal skull belonged must have been distinguished by small cerebral development, and uncommon strength of corporeal frame.

When on my return to England I showed the cast of the cranium to Professor Huxley, he remarked at once that it was the most ape-like skull he had ever beheld. Mr. Busk, after giving a translation of Professor Schaaffhausen's memoir in the "Natural History Review," added some valuable comments of his own on the characters in which this skull approached that of the gorilla and chimpanzee.

Professor Huxley afterwards studied the cast with the object of assisting me to give illustrations of it in this work, and in doing so discovered what had not previously been observed, that it was quite as abnormal in the shape of its occipital as in that of its frontal or superciliary region. Before citing his words on the subject, I will offer a few remarks on the Engis skull which the same anatomist has compared with that of the Neanderthal. [Note 10.]

FOSSIL SKULL OF THE ENGIS CAVE NEAR LIEGE.

Among six or seven human skeletons, portions of which were collected by Dr. Schmerling from three or four caverns near Liege, embedded in the same matrix with the remains of the elephant, rhinoceros, bear, hyaena, and other extinct quadrupeds, the most perfect skull, as I have before stated, was that of an adult individual found in the cavern of Engis. This skull, Dr. Schmerling figured in his work, observing that it was too imperfect to enable the anatomist to determine the facial angle, but that one might infer, from the narrowness of the frontal portion, that it belonged to an individual of small intellectual development. He speculated on its Ethiopian affinities, but not confidently, observing truly that it would require many more specimens to enable an anatomist to

arrive at sound conclusions on such a point. M. Geoffroy St. Hilaire and other osteologists, who examined the specimen, denied that it resembled a negro's skull. When I saw the original in the museum at Liege, I invited Dr. Spring, one of the professors of the university, to whom we are indebted for a valuable memoir on the human bones found in the cavern of Chauvaux, near Namur, to have a cast made of this Engis skull. He not only had the kindness to comply with my request, but rendered a service to the scientific world by adding to the original cranium several detached fragments which Dr. Schmerling had obtained from Engis, and which were found to fit in exactly, so that the cast represented at Figure 2 is more complete than that given in the first plate of Schmerling's work. It exhibits on the right side the position of the auditory foramen (see Figure 6), which was not included in Schmerling's figure. Mr. Busk, when he saw this cast, remarked to me that, although the forehead was, as Schmerling had truly stated, somewhat narrow, it might nevertheless be matched by the skulls of individuals of European race, an observation since fully borne out by measurements, as will be seen in the sequel.

OBSERVATIONS BY PROFESSOR HUXLEY ON THE HUMAN SKULLS OF ENGIS AND THE NEANDERTHAL.

"The Engis skull, as originally figured by Professor Schmerling, was in a very imperfect state; but other fragments have since been added to it by the care of Dr. Spring, and the cast upon which my observations are based (Figure 2) exhibits the frontal, parietal, and occipital regions, as far as the middle of the occipital foramen, with the squamous and mastoid portions of the right temporal bone entire, or nearly so, while the left temporal bone is wanting. From the middle of the occipital foramen to the middle of the roof of each orbit, the base of the skull is destroyed, and the facial bones are entirely absent.

"The extreme length of the skull is 7.7 inches, and as its extreme breadth is not more than 5.25, its form is decidedly dolichocephalic. At the same time its height (4 3/4 inches from the plane of the glabello-occipital line (a d) to the vertex) is good, and the forehead is well arched; so that while the horizontal circumference of the skull is about 20 1/2 inches, the longitudinal arc from the nasal spine of the frontal bone to the occipital protuberance (d) measures about 13 3/4 inches. The transverse arc from one auditory foramen to the other across the middle of the sagittal suture measures about 13 inches. The sagittal suture (b c) is 5 1/2 inches in length. The superciliary prominences are well, but not excessively, developed, and are separated by a median depression in the region of the glabella. They indicate large frontal sinuses. If a line joining the glabella and the occipital protuberance (a d) be made horizontal, no part of the occiput projects more than 1/10th of an inch behind the posterior extremity of that line; and the upper edge of the auditory foramen is almost in contact with the same line, or rather with one drawn parallel to it on the outer surface of the skull.

(FIGURE 2. SIDE VIEW OF THE CAST OF PART OF A HUMAN SKULL FOUND BY DR. SCHMERLING EMBEDDED AMONGST THE REMAINS OF EXTINCT MAMMALIA IN THE CAVE OF ENGIS, NEAR LIEGE.

a. Superciliary ridge and glabella.

b. Coronal suture.
c. The apex of the lamboidal suture.
d. The occipital protuberance.)

"The Neanderthal skull, with which also I am acquainted only by means of Professor Schaaffhausen's drawings of an excellent cast and of photographs, is so extremely different in appearance from the Engis cranium, that it might well be supposed to belong to a distinct race of mankind. It is 8 inches in extreme length and 5.75 inches in extreme breadth, but only measures 3.4 inches from the glabello-occipital line to the vertex. The longitudinal arc, measured as above, is 12 inches; the transverse arc cannot be exactly ascertained, in consequence of the absence of the temporal bones, but was probably about the same, and certainly exceeded 10 1/4 inches. The horizontal circumference is 23 inches. This great circumference arises largely from the vast development of the superciliary ridges, which are occupied by great frontal sinuses whose inferior apertures are displayed exceedingly well in one of Dr. Fuhlrott's photographs, and form a continuous transverse prominence, somewhat excavated in the middle line, across the lower part of the brows. In consequence of this structure, the forehead appears still lower and more retreating than it really is. To an anatomical eye the posterior part of the skull is even more striking than the anterior. The occipital protuberance occupies the extreme posterior end of the skull when the glabello-occipital line is made horizontal, and so far from any part of the occipital region extending beyond it, this region of the skull slopes obliquely upward and forward, so that the lambdoidal suture is situated well upon the upper surface of the cranium. At the same time, notwithstanding the great length of the skull, the sagittal suture is remarkably short (4 1/2 inches), and the squamosal suture is very straight.

(FIGURE 3. SIDE VIEW OF THE CAST OF A PART OF A HUMAN SKULL FROM A CAVE IN THE NEANDERTHAL, NEAR DUSSELDORF.

a. Superciliary ridge and glabella.
b. The coronal suture.
c. The apex of the lamboidal suture.
d. The occipital protuberance.)

"In human skulls, the superior curved ridge of the occipital bone and the occipital protuberance correspond, approximatively, with the level of the tentorium and with the lateral sinuses, and consequently with the inferior limit of the posterior lobes of the brain. At first, I found some difficulty in believing that a human brain could have its posterior lobes so flattened and diminished as must have been the case in the Neanderthal man, supposing the ordinary relation to obtain between the superior occipital ridges and the tentorium; but on my application, through Sir Charles Lyell, Dr. Fuhlrott, the possessor of the skull, was good enough not only to ascertain the existence of the lateral sinuses in their ordinary position, but to send convincing proofs of the fact, in excellent photographic views of the interior of the skull, exhibiting clear indications of these sinuses.

"There can be no doubt that, as Professor Schaaffhausen and Mr. Busk have stated, this skull is the most brutal of all known human skulls, resembling those of the apes not only in the prodigious

development of the superciliary prominences and the forward extension of the orbits, but still more in the depressed form of the brain-case, in the straightness of the squamosal suture, and in the complete retreat of the occiput forwards and upward, from the superior occipital ridges.

(FIGURE 4. OUTLINE OF THE SKULL OF AN ADULT CHIMPANZEE, OF THAT FROM THE NEANDERTHAL, AND OF THAT OF A EUROPEAN, DRAWN TO THE SAME ABSOLUTE SIZE, IN ORDER BETTER TO EXHIBIT THEIR RELATIVE DIFFERENCES.

The superciliary region of the Neanderthal skull appears less prominent than in Figure 3, as the contours are all taken along the middle line where the superciliary projection of the Neanderthal skull is least marked. a. The glabella. b. The occipital protuberance, or the point on the exterior of each skull which corresponds roughly with the attachment of the tentorium, or with the inferior boundary of the posterior cerebral lobes.)

"But the cranium, in its present condition, is stated by Professor Schaaffhausen to contain 1033.24 cubic centimetres of water, or, in other words, about 63 English cubic inches. As the entire skull could hardly have held less than 12 cubic inches more, its minimum capacity may be estimated at 75 cubic inches. The most capacious healthy European skull yet measured had a capacity of 114 cubic inches, the smallest (as estimated by weight of brain) about 55 cubic inches, while, according to Professor Schaaffhausen, some Hindoo skulls have as small a capacity as about 46 cubic inches (27 ounces of water). The largest cranium of any Gorilla yet measured contained 34.5 cubic inches. The Neanderthal cranium stands, therefore, in capacity, very nearly on a level with the mean of the two human extremes, and very far above the pithecoid maximum.

(FIGURE 5. SKULL ASSOCIATED WITH GROUND FLINT IMPLEMENTS, FROM A TUMULUS AT BORREBY IN DENMARK, AFTER A CAMERA LUCIDA DRAWING BY MR. G. BUSK, F.R.S.
The thick dark line indicates so much of the skull as corresponds with the fragment from the Neanderthal.

a. Superciliary ridge.
b. Coronal suture.
c. The apex of the lamboidal suture.
d. The occipital protuberance.
e. The auditory foramen.)

"Hence, even in the absence of the bones of the arm and thigh, which, according to Professor Schaaffhausen, had the precise proportions found in Man, although they were stouter than ordinary human bones, there could be no reason for ascribing this cranium to anything but a man; while the strength and development of the muscular ridges of the limb-bones are characters in perfect accordance with those exhibited, in a minor degree, by the bones of such hardy savages, exposed to a rigorous climate, as the Patagonians.

"The Neanderthal cranium has certainly not undergone compression, and, in reply to the suggestion that the skull is that of an idiot, it may be urged that the onus probandi lies with those who adopt the hypothesis. Idiotcy is compatible with very various forms and

capacities of the cranium, but I know of none which present the least resemblance to the Neanderthal skull; and, furthermore, I shall proceed to show that the latter manifests but an extreme degree of a stage of degradation exhibited, as a natural condition, by the crania of certain races of mankind.

"Mr. Busk drew my attention, some time ago, to the resemblance between some of the skulls taken from tumuli of the stone period at Borreby in Denmark, of which Mr. Busk possesses numerous accurate figures, and the Neanderthal cranium. One of the Borreby skulls in particular (Figure 5) has remarkably projecting superciliary ridges, a retreating forehead, a low flattened vertex, and an occiput which shelves upward and forward. But the skull is relatively higher and broader, or more brachycephalic, the sagittal suture longer, and the superciliary ridges less projecting, than in the Neanderthal skull. Nevertheless, there is, without doubt, much resemblance in character between the two skulls--a circumstance which is the more interesting, since the other Borreby skulls have better foreheads and less prominent superciliary ridges, and exhibit altogether a higher conformation.

"The Borreby skulls belong to the stone period of Denmark, and the people to whom they appertained were probably either contemporaneous with, or later than, the makers of the 'refuse-heaps' of that country. In other words, they were subsequent to the last great physical changes of Europe, and were contemporaries of the urus and bison, not of the Elephas primigenius, Rhinoceros tichorhinus, and Hyaena spelaea.

"Supposing for a moment, what is not proven, that the Neanderthal skull belonged to a race allied to the Borreby people and was as modern as they, it would be separated by as great a distance of time as of anatomical character from the Engis skull, and the possibility of its belonging to a distinct race from the latter might reasonably appear to be greatly heightened.

"To prevent the possibility of reasoning in a vicious circle, however, I thought it would be well to endeavour to ascertain what amount of cranial variation is to be found in a pure race at the present day; and as the natives of Southern and Western Australia are probably as pure and homogeneous in blood, customs, and language, as any race of savages in existence, I turned to them, the more readily as the Hunterian museum contains a very fine collection of such skulls.

"I soon found it possible to select from among these crania two (connected by all sorts of intermediate gradations), the one of which should very nearly resemble the Engis skull, while the other should somewhat less closely approximate the Neanderthal cranium in form, size, and proportions. And at the same time others of these skulls presented no less remarkable affinities with the low type of Borreby skull.

"That the resemblances to which I allude are by no means of a merely superficial character, is shown by the accompanying diagram (Figure 6), which gives the contours of the two ancient and of one of the Australian skulls, and by the following table of measurements.

TABLE 5/1.

COLUMN 1: TYPE OF SKULL.

COLUMN 2 (A): The horizontal circumference in the plane of a line joining the glabella with the occipital protuberance.

COLUMN 3 (B): The longitudinal arc from the nasal depression along the middle line of the skull to the occipital tuberosity.

COLUMN 4 (C): From the level of the glabello-occipital line on each side, across the middle of the sagittal suture to the same point on the opposite side.

COLUMN 5 (D): The vertical height from the glabello-occipital line.

COLUMN 6 (E): The extreme longitudinal measurement.

COLUMN 7 (F): The extreme transverse measurement.* (* I have taken the glabello-occipital line as a base in these measurements, simply because it enables me to compare all the skulls, whether fragments or entire, together. The greatest circumference of the English skull lies in a plane considerably above that of the glabello-occipital line, and amounts to 22 inches.)

Engis : 20 1/2 : 13 3/4 : 12 1/2 : 4 3/4 : 7 3/4 : 5 1/4.
Australian,
Number 1 : 20 1/2 : 13 : 12 : 4 3/4 : 7 1/2 : 5 4/10.
Australian,
Number 2 : 22 : 12 1/2 : 10 3/4 : 3 8/10 : 7.9 : 5 3/4.
Neanderthal : 23 : 12 : 10 : 3 3/4 : 8 : 5 3/4.

"The question whether the Engis skull has rather the character of one of the high races or of one of the lower has been much disputed, but the following measurements of an English skull, noted in the catalogue of the Hunterian museum as typically Caucasian (see Figure 4) will serve to show that both sides may be right, and that cranial measurements alone afford no safe indication of race.

English : 21 : 13 3/4 : 12 1/2 : 4 4/10 : 7 7/8 : 5 1/3.

"In making the preceding statement, it must be clearly understood that I neither desire to affirm that the Engis and Neanderthal skulls belong to the Australian race, nor to assert even that the ancient skulls belong to one and the same race, so far as race is measured by language, colour of skin, or character of hair. Against the conclusion that they are of the same race as the Australians various minor anatomical differences of the ancient skulls, such as the great development of the frontal sinuses, might be urged; while against the supposition of either the identity, or the diversity, of race of the two arises the known independence of the variation of cranium on the one hand, and of hair, colour, and language on the other.

"But the amount of variation of the Borreby skulls, and the fact that the skulls of one of the purest and most homogeneous of existing races of men can be proved to differ from one another in the same characters, though perhaps not quite to the same extent, as the Engis and Neanderthal skulls, seem to me to prohibit any

cautious reasoner from affirming the latter to have been necessarily of distinct races.

(FIGURE 6. OUTLINES OF THE SKULL FROM THE NEANDERTHAL, OF AN AUSTRALIAN SKULL FROM PORT ADELAIDE, AND OF THE SKULL FROM THE CAVE OF ENGIS, DRAWN TO THE SAME ABSOLUTE LENGTH, IN ORDER THE BETTER TO CONTRAST THEIR PROPORTIONS.

a. The glabella.
b. The occipital protuberance, or the point on the exterior of each skull which corresponds roughly with the attachment of the tentorium, or with the inferior boundary of the posterior cerebral lobes.
e. The position of the auditory foramen of the Engis skull.)

"The marked resemblances between the ancient skulls and their modern Australian analogues, however, have a profound interest, when it is recollected that the stone axe is as much the weapon and the implement of the modern as of the ancient savage; that the former turns the bones of the kangaroo and of the emu to the same account as the latter did the bones of the deer and the urus; that the Australian heaps up the shells of devoured shellfish in mounds which represent the "refuse-heaps" or "Kjokkenmodding," of Denmark; and, finally, that, on the other side of Torres Straits, a race akin to the Australians are among the few people who now build their houses on pile-works, like those of the ancient Swiss lakes.

"That this amount of resemblance in habit and in the conditions of existence is accompanied by as close a resemblance in cranial configuration, illustrates on a great scale that what Cuvier demonstrated of the animals of the Nile valley is no less true of men; circumstances remaining similar, the savage varies little more, it would seem, than the ibis or the crocodile, especially if we take into account the enormous extent of the time over which our knowledge of man now extends, as compared with that measured by the duration of the sepulchres of Egypt.

"Finally, the comparatively large cranial capacity of the Neanderthal skull, overlaid though it may be by pithecoid bony walls, and the completely human proportions of the accompanying limb-bones, together with the very fair development of the Engis skull, clearly indicate that the first traces of the primordial stock whence Man has proceeded need no longer be sought, by those who entertain any form of the doctrine of progressive development, in the newest Tertiaries; but that they may be looked for in an epoch more distant from the age of the Elephas primigenius than that is from us."

The two skulls which form the subject of the preceding comments and illustrations have given rise to nearly an equal amount of surprise for opposite reasons; that of Engis because being so unequivocally ancient, it approached so near to the highest or Caucasian type; that of the Neanderthal, because, having no such decided claims to antiquity, it departs so widely from the normal standard of humanity. Professor Huxley's observation regarding the wide range of variation, both as to shape and capacity, in the skulls of so pure a race as the native Australian, removes to no small extent this supposed anomaly, assuming what though not proved is very probable, that both varieties co-existed in the Pleistocene period

in Western Europe.

As to the Engis skull, we must remember that although associated with the elephant, rhinoceros, bear, tiger, and hyaena, all of extinct species, it nevertheless is also accompanied by a bear, stag, wolf, fox, beaver, and many other quadrupeds of species still living. Indeed many eminent palaeontologists, and among them Professor Pictet, think that, numerically considered, the larger portion of the mammalian fauna agrees specifically with that of our own period, so that we are scarcely entitled to feel surprised if we find human races of the Pleistocene epoch undistinguishable from some living ones. It would merely tend to show that Man has been as constant in his osteological characters as many other mammalia now his contemporaries. The expectation of always meeting with a lower type of human skull, the older the formation in which it occurs, is based on the theory of progressive development, and it may prove to be sound; nevertheless we must remember that as yet we have no distinct geological evidence that the appearance of what are called the inferior races of mankind has always preceded in chronological order that of the higher races.

It is now admitted that the differences between the brain of the highest races of Man and that of the lowest,* (* "Natural History Review" 1861 page 8.) though less in degree, are of the same order as those which separate the human from the simian brain; and the same rule holds good in regard to the shape of the skull. The average Negro skull differs from that of the European in having a more receding forehead, more prominent superciliary ridges, and more largely developed prominences and furrows for the attachment of muscles; the face also, and its lines, are larger proportionally. The brain is somewhat less voluminous on the average in the lower races of mankind, its convolutions rather less complicated, and those of the two hemispheres more symmetrical, in all which points an approach is made to the simian type. It will also be seen, by reference to the late Dr. Morton's works, and by the foregoing statements of Professor Huxley, that the range of size or capacity between the highest and lowest human brain is greater than that between the highest simian and lowest human brain; but the Neanderthal skull, although in several respects it is more ape-like than any human skull previously discovered, is, in regard to volume, by no means contemptible.

Eminent anatomists have shown that in the average proportions of some of the bones the Negro differs from the European, and that in most of these characters, he makes a slightly nearer approach to the anthropoid quadrumana;* but Professor Schaaffhausen has pointed out that in these proportions the Neanderthal skeleton does not differ from the ordinary standard, so that the skeleton by no means indicates a transition between Homo and Pithecus. (* "The inferior races of mankind exhibit proportions which are in many respects intermediate between the higher, or European, orders, and the monkeys. In the Negro, for instance, the stature is less than in the European. The cranium, as is well known, bears a small proportion to the face. Of the extremities the upper are proportionately longer, and there is, in both upper and lower, a less marked preponderance of the proximal over the distal segments. For instance, in the Negro, the thigh and arm are rather shorter than in the European; the leg is actually of equal length in both races, and is therefore, relatively, a little longer in the Negro;

the fore-arm in the latter is actually, as well as relatively, a little longer; the foot is an eighth, and the hand a twelfth longer than in the European. It is well known that the foot is less well formed in the Negro than in the European. The arch of the instep, the perfect conformation of which is essential to steadiness and ease of gait, is less elevated in the former than in the latter. The foot is thereby rendered flatter as well as longer, more nearly resembling the monkey's, between which and the European there is a marked difference in this particular."--From "A Treatise on the Human Skeleton" by Dr. Humphry, Lecturer on Surgery and Anatomy in the Cambridge University Medical School, page 91.)

There is doubtless, as shown in the diagram Figure 4, a nearer resemblance in the outline of the Neanderthal skull to that of a chimpanzee than had ever been observed before in any human cranium; and Professor Huxley's description of the occipital region shows that the resemblance is not confined to the mere excessive prominence of the superciliary ridges.

The direct bearing of the ape-like character of the Neanderthal skull on Lamarck's doctrine of progressive development and transmutation, or on that modification of it which has of late been so ably advocated by Mr. Darwin, consists in this, that the newly observed deviation from a normal standard of human structure is not in a casual or random direction, but just what might have been anticipated if the laws of variation were such as the transmutationists require. For if we conceive the cranium to be very ancient, it exemplifies a less advanced stage of progressive development and improvement. If it be a comparatively modern race, owing its peculiarities of conformation to degeneracy, it is an illustration of what botanists call "atavism," or the tendency of varieties to revert to an ancestral type, which type, in proportion to its antiquity, would be of lower grade. To this hypothesis, of a genealogical connection between Man and the lower animals, I shall again allude in the concluding chapters. [Note 11.]

CHAPTER 6.

PLEISTOCENE ALLUVIUM AND CAVE DEPOSITS WITH FLINT IMPLEMENTS.

General Position of Drift with extinct Mammalia in Valleys.
Discoveries of M. Boucher de Perthes at Abbeville.
Flint Implements found also at St. Acheul, near Amiens.
Curiosity awakened by the systematic Exploration of the Brixham Cave.
Flint Knives in same, with Bones of extinct Mammalia.
Superposition of Deposits in the Cave.
Visits of English and French Geologists to Abbeville and Amiens.

PLEISTOCENE ALLUVIUM CONTAINING FLINT IMPLEMENTS IN THE VALLEY OF THE SOMME.

Throughout a large part of Europe we find at moderate elevations above the present river-channels, usually at a height of less than 40 feet, but sometimes much higher, beds of gravel, sand, and loam containing bones of the elephant, rhinoceros, horse, ox, and other quadrupeds, some of extinct, others of living, species, belonging for the most part to the fauna already alluded to in the fourth chapter as characteristic of the interior of caverns. The greater

part of these deposits contain fluviatile shells, and have undoubtedly been accumulated in ancient river-beds. These old channels have long since been dry, the streams which once flowed in them having shifted their position, deepening the valleys, and often widening them on one side.

It has naturally been asked, if Man co-existed with the extinct species of the caves, why were his remains and the works of his hands never embedded outside the caves in ancient river-gravel containing the same fossil fauna? Why should it be necessary for the geologist to resort for evidence of the antiquity of our race to the dark recesses of underground vaults and tunnels which may have served as places of refuge or sepulture to a succession of human beings and wild animals, and where floods may have confounded together in one breccia the memorials of the fauna of more than one epoch? Why do we not meet with a similar assemblage of the relics of Man, and of living and extinct quadrupeds, in places where the strata can be thoroughly scrutinised in the light of day?

Recent researches have at length demonstrated that such memorials, so long sought for in vain, do in fact exist, and their recognition is the chief cause of the more favourable reception now given to the conclusions which MM. Tournal, Christol, Schmerling, and others, arrived at thirty years ago respecting the fossil contents of caverns. [Note 12.]

A very important step in this new direction was made thirteen years after the publication of Schmerling's researches, by M. Boucher de Perthes, who found in ancient alluvium at Abbeville, in Picardy, some flint implements, the relative antiquity of which was attested by their geological position. The antiquarian knowledge of their discoverer enabled him to recognise in their rude and peculiar type a character distinct from that of the polished stone weapons of a later period, usually called "celts." In the first volume of his "Antiquites Celtiques," published in 1847, M. Boucher de Perthes styled these older tools "antediluvian," because they came from the lowest beds of a series of ancient alluvial strata bordering the valley of the Somme, which geologists had termed "diluvium." He had begun to collect these implements in 1841. From that time they had been annually dug out of the drift or deposits of gravel and sand, of which fine sections were laid open from 20 to 35 feet in depth, whenever excavations were made in repairing the fortifications of Abbeville; or as often as flints were wanted for the roads, or loam for making bricks. For years previously bones of quadrupeds of the genera elephant, rhinoceros, bear, hyaena, stag, ox, horse, and others, had been collected there, and sent from time to time to Paris to be examined and named by Cuvier, who had described them in his Ossements Fossiles. A correct account of the associated flint tools and of their position was given in 1847 by M. Boucher de Perthes in his work above cited, and they were stated to occur at various depths, often 20 or 30 feet from the surface, in sand and gravel, especially in those strata which were nearly in contact with the subjacent white Chalk. But the scientific world had no faith in the statement that works of art, however rude, had been met with in undisturbed beds of such antiquity. Few geologists visited Abbeville in winter, when the sand-pits were open, and when they might have opportunities of verifying the sections, and judging whether the instruments had really been embedded by natural causes in the same strata with the bones of the mammoth,

rhinoceros, and other extinct mammalia. Some of the tools figured in the "Antiquites Celtiques" were so rudely shaped, that many imagined them to have owed their peculiar forms to accidental fracture in a river's bed; others suspected frauds on the part of the workmen, who might have fabricated them for sale, or that the gravel had been disturbed, and that the worked flints had got mingled with the bones of the mammoth long after that animal and its associates had disappeared from the earth.

No one was more sceptical than the late eminent physician of Amiens, Dr. Rigollot, who had long before (in the year 1819) written a memoir on the fossil mammalia of the valley of the Somme. He was at length induced to visit Abbeville, and, having inspected the collection of M. Boucher de Perthes, returned home resolved to look for himself for flint tools in the gravel-pits near Amiens. There, accordingly, at a distance of about 30 miles from Abbeville, he immediately found abundance of similar flint implements, precisely the same in the rudeness of their make, and the same in their geological position; some of them in gravel nearly on a level with the Somme, others in similar deposits resting on Chalk at a height of about 90 feet above the river.

Dr. Rigollot having in the course of four years obtained several hundred specimens of these tools, most of them from St. Acheul in the south-east suburbs of Amiens, lost no time in communicating an account of them to the scientific world, in a memoir illustrated by good figures of the worked flints and careful sections of the beds. These sections were executed by M. Buteux, an engineer well qualified for the task, who had written a good description of the geology of Picardy. Dr. Rigollot, in this memoir, pointed out most clearly that it was not in the vegetable soil, nor in the brick-earth with land and freshwater shells next below, but in the lower beds of coarse flint-gravel, usually 12, 20, or 25 feet below the surface, that the implements were met with, just as they had been previously stated by M. Boucher de Perthes to occur at Abbeville. The conclusion, therefore, which was legitimately deduced from all the facts, was that the flint tools and their fabricators were coeval with the extinct mammalia embedded in the same strata.

BRIXHAM CAVE, NEAR TORQUAY, DEVONSHIRE.

Four years after the appearance of Dr. Rigollot's paper, a sudden change of opinion was brought about in England respecting the probable co-existence, at a former period, of Man and many extinct mammalia, in consequence of the results obtained from a careful exploration of a cave at Brixham, near Torquay, in Devonshire. As the new views very generally adopted by English geologists had no small influence on the subsequent progress of opinion in France, I shall interrupt my account of the researches made in the valley of the Somme, by a brief notice of those which were carried on in 1858 in Devonshire with more than usual care and scientific method. Dr. Buckland, in his celebrated work, entitled "Reliquiae Diluvianae," published in 1823, in which he treated of the organic remains contained in caves, fissures, and "diluvial gravel" in England, had given a clear statement of the results of his own original observations, and had declared that none of the human bones or stone implements met with by him in any of the caverns could be considered to be as old as the mammoth and other extinct

quadrupeds. Opinions in harmony with this conclusion continued until very lately to be generally in vogue in England; although about the time that Schmerling was exploring the Liege caves, the Reverend Mr. McEnery, a Catholic priest, residing near Torquay, had found in a cave one mile east of that town, called "Kent's Hole," in red loam covered with stalagmite, not only bones of the mammoth, tichorhine rhinoceros, hippopotamus, cave-bear, and other mammalia, but several remarkable flint tools, some of which he supposed to be of great antiquity, while there were also remains of Man in the same cave of a later date.* (* The manuscript and plates prepared for a joint memoir on Kent's Hole, by Mr. McEnery and Dr. Buckland, have recently been published by Mr. Vivian of Torquay, from which, as well as from some of the unprinted manuscript, I infer that Mr. McEnery only refrained out of deference to Dr. Buckland from declaring his belief in the contemporaneousness of certain flint implements of an antique type and the bones of extinct animals. Two of these implements from Kent's Hole, figured in Plate 12 of the posthumous work above alluded to, approach very closely in form and size to the common Abbeville implements.)

About ten years afterwards, in a "Memoir on the Geology of South Devon," published in 1842 by the Geological Society of London,* (* "Transactions of the Geological Society" 2nd series volume 6 page 444.) an able geologist, Mr. Godwin-Austen, declared that he had obtained in the same cave (Kent's Hole) works of Man from undisturbed loam or clay, under stalagmite, mingled with the remains of extinct animals, and that all these must have been introduced "before the stalagmite flooring had been formed." He maintained that such facts could not be explained away by the hypothesis of sepulture, as in Dr. Buckland's well-known case of the human skeleton of Paviland, because in the Devon cave the flint implements were widely distributed through the loam, and lay beneath the stalagmite.

As the osseous and other contents of Kent's Hole had, by repeated diggings, been thrown into much confusion, it was thought desirable in 1858, when a new and intact bone-cave was discovered at Brixham, about four miles south of Torquay, to have a thorough and systematic examination made of it. The Royal Society, chiefly at the instance of Dr. Falconer, made two grants towards defraying the expenses, and Miss Burdett-Coutts contributed liberally towards the same object. A committee of geologists was charged with the investigations, among whom Dr. Falconer and Mr. Prestwich took a prominent part, visiting Torquay while the excavations were in progress. Mr. Pengelly, another member of the committee, well qualified for the task by nearly twenty years' previous experience in cave explorations, zealously directed and superintended the work. By him, in 1859, I was conducted through the subterranean galleries after they had been cleared out; and Dr. Falconer, who was also at Torquay, showed me the numerous fossils which had been discovered, and which he was then studying, all numbered and labelled, with reference to a journal in which the geological position of each specimen was recorded with scrupulous care.

The discovery of the existence of this suite of caverns near the sea at Brixham was made accidentally by the roof of one of them being broken through in quarrying. None of the four external openings now exposed to view in steep cliffs or in the sloping side of a valley were visible before the breccia and earthy matter which

blocked them up were removed during the late exploration. According to a ground-plan drawn up by Professor Ramsay, it appears that some of the passages which run nearly north and south are fissures connected with the vertical dislocation of the rocks, while another set, running nearly east and west, are tunnels, which have the appearance of having been to a great extent hollowed out by the action of running water. The central or main entrance, leading to what is called the "reindeer gallery," because a perfect antler of that animal was found sticking in the stalagmitic floor, is 95 feet above the level of the sea, being also 78 above the bottom of the adjoining valley. The united length of the galleries which were cleared out amounted to several hundred feet. Their width never exceeded 8 feet. They were sometimes filled up to the roof with mud, but occasionally there was a considerable space between the roof and floor. The latter, in the case of the fissure-caves, was covered with stalagmite, but in the tunnels it was usually free from any such incrustation. The following was the general succession of the deposits forming the contents of the underground passages and channels:--

First. At the top, a layer of stalagmite varying in thickness from 1 to 15 inches, which sometimes contained bones, such as the reindeer's horn, already mentioned, and an entire humerus of the cave-bear.

Secondly. Next below, loam or bone-earth, of an ochreous red colour, with angular stones and some pebbles, from 2 to 13 feet in thickness.

Thirdly. At the bottom of all, gravel with many rounded pebbles in it. This was everywhere removed so long as the tunnels which narrowed downwards were wide enough to be worked. It proved to be almost entirely barren of fossils.

The mammalia obtained from the bone-earth consisted of Elephas primigenius, or mammoth; Rhinoceros tichorhinus; Ursus spelaeus; Hyaena spelaea; Felis spelaea, or the cave-lion; Cervus tarandus, or the reindeer; a species of horse, ox, and several rodents, and others not yet determined.

No human bones were obtained anywhere during these excavations, but many flint knives, chiefly from the lowest part of the bone-earth; and one of the most perfect lay at the depth of 13 feet from the surface, and was covered with bone-earth of that thickness. Neglecting the less perfect specimens, some of which were met with even in the lowest gravel, about fifteen knives, recognised as artificially formed by the most experienced antiquaries, were taken from the bone-earth, and usually from near the bottom. Such knives, considered apart from the associated mammalia, afford in themselves no safe criterion of antiquity, as they might belong to any part of the age of stone, similar tools being sometimes met with in tumuli posterior in date to the era of the introduction of bronze. But the contemporaneity of those at Brixham with the extinct animals is demonstrated not only by the occurrence at one point in overlying stalagmite of the bone of a cave-bear, but also by the discovery at the same level in the bone-earth, and in close proximity to a very perfect flint tool, of the entire left hind-leg of a cave-bear.
This specimen, which was shown me by Dr. Falconer and Mr. Pengelly, was exhumed from the earthy deposit in the reindeer gallery, near

its junction with the flint-knife gallery, at the distance of about sixty-five feet from the main entrance. The mass of earth containing it was removed entire, and the matrix cleared away carefully by Dr. Falconer in the presence of Mr. Pengelly. Every bone was in its natural place, the femur, tibia, fibula, ankle-bone, or astragalus, all in juxtaposition. Even the patella or detached bone of the knee-pan was searched for, and not in vain. Here, therefore, we have evidence of an entire limb not having been washed in a fossil state out of an older alluvium, and then swept afterwards into a cave, so as to be mingled with flint implements, but having been introduced when clothed with its flesh, or at least when it had the separate bones bound together by their natural ligaments, and in that state buried in mud.

If they were not all of contemporary date, it is clear from this case, and from the humerus of the Ursus spelaeus, before cited, as found in a floor of stalagmite, that the bear lived after the flint tools were manufactured, or in other words, that Man in this district preceded the cave-bear.

A glance at the position of Windmill Hill, in which the caverns are situated, and a brief survey of the valleys which bound it on three sides, are enough to satisfy a geologist that the drainage and geographical features of this region have undergone great changes since the gravel and bone-earth were carried by streams into the subterranean cavities above described. Some worn pebbles of haematite, in particular, can only have come from their nearest parent rock, at a period when the valleys immediately adjoining the caves were much shallower than they now are. The reddish loam in which the bones are embedded is such as may be seen on the surface of limestone in the neighbourhood, but the currents which were formerly charged with such mud must have run at a level 78 feet above that of the stream now flowing in the same valley. It was remarked by Mr. Pengelly that the stones and bones in the loam had their longest axes parallel to the direction of the tunnels and fissures, showing that they were deposited by the action of a stream.* (* Pengelly, "Geologist" volume 4 1861 page 153.)

It appears that so long as the flowing water had force enough to propel stony fragments, no layer of fine mud could accumulate, and so long as there was a regular current capable of carrying in fine mud and bones, no superficial crust of stalagmite. In some passages, as before stated, stalagmite was wanting, while in one place seven or eight alternations of stalagmite and loam were observed, seeming to indicate a prevalence of more rainy seasons, succeeded by others, when the water was for a time too low to flood the area where the calcareous incrustation accumulated.

If the regular sequence of the three deposits of pebbles, mud, and stalagmite was the result of the causes above explained, the order of superposition would be constant, yet we could not be sure that the gravel in one passage might not sometimes be coeval with the bone-earth or stalagmite in another.

If therefore the flint knives had not been very widely dispersed, and if one of them had not been at the bottom of the bone-earth, close to the leg of the bear above described, their antiquity relatively to the extinct mammalia might have been questioned. No coprolites were found in the Brixham excavations, and very few

gnawed bones. These few may have been brought from some distance before they reached their place of rest. Upon the whole, the same conclusion which Dr. Schmerling came to, respecting the filling up of the caverns near Liege, seems applicable to the caves of Brixham.

Dr. Falconer, after aiding in the investigations above alluded to near Torquay, stopped at Abbeville on his way to Sicily, in the autumn of 1858, and saw there the collection of M. Boucher de Perthes. Being at once satisfied that the flints called hatchets had really been fashioned by the hand of Man, he urged Mr. Prestwich, by letter, thoroughly to explore the geology of the valley of the Somme. This he accordingly accomplished, in company with Mr. John Evans [Note 13], of the Society of Antiquaries, and, before his return that same year, succeeded in dissipating all doubts from the minds of his geological friends by extracting, with his own hands, from a bed of undisturbed gravel, at St. Acheul, a well-shaped flint hatchet. This implement was buried in the gravel at a depth of 17 feet from the surface, and was lying on its flat side. There were no signs of vertical rents in the enveloping matrix, nor in the overlying beds of sand and loam, in which were many land and freshwater shells; so that it was impossible to imagine that the tool had gradually worked its way downwards, as some had suggested, through the incumbent soil, into an older formation.* (* Prestwich, "Proceedings of the Royal Society" 1859 and "Philosophical Transactions" 1860.)

There was no one in England whose authority deserved to have so much weight in overcoming incredulity in regard to the antiquity of the implements in question. For Mr. Prestwich, besides having published a series of important memoirs on the Tertiary formations of Europe, had devoted many years specially to the study of the drift and its organic remains. His report, therefore, to the Royal Society, accompanied by a photograph showing the position of the flint tool in situ before it was removed from its matrix, not only satisfied many inquirers, but induced others to visit Abbeville and Amiens; and one of these, Mr. Flower, who accompanied Mr. Prestwich on his second excursion to St. Acheul, in June 1859, succeeded, by digging into the bank of gravel, in disinterring, at the depth of 22 feet from the surface, a fine, symmetrically-shaped weapon of an oval form, lying in and beneath strata which were observed by many witnesses to be perfectly undisturbed.* (* "Quarterly Journal of the Geological Society" volume 16 1860 page 190.)

Shortly afterwards, in the year 1859, I visited the same pits, and obtained seventy flint tools, one of which was taken out while I was present, though I did not see it before it had fallen from the matrix. I expressed my opinion in favour of the antiquity of the flint tools to the meeting of the British Association at Aberdeen, in the same year.* (* See "Report of British Association" for 1859.) On my way through Rouen, I stated my convictions on this subject to M. George Pouchet, who immediately betook himself to St. Acheul, commissioned by the municipality of Rouen, and did not quit the pits till he had seen one of the hatchets extracted from gravel in its natural position.* (* "Actes du Musee d'Histoire Naturelle de Rouen" 1860 page 33.)

M. Gaudry also gave the following account of his researches in the same year to the Royal Academy of Sciences at Paris. "The great

point was not to leave the workmen for a single instant, and to satisfy oneself by actual inspection whether the hatchets were found in situ. I caused a deep excavation to be made, and found nine hatchets, most distinctly in situ in the diluvium, associated with teeth of Equus fossilis and a species of Bos, different from any now living, and similar to that of the diluvium and of caverns."* (* "Comptes rendus" September 26 and October 3, 1859.) In 1859, M. Hebert, an original observer of the highest authority, declared to the Geological Society of France that he had, in 1854, or four years before Mr. Prestwich's visit to St. Acheul, seen the sections at Abbeville and Amiens, and had come to the opinion that the hatchets were imbedded in the "lower diluvium," and that their origin was as ancient as that of the mammoth and the rhinoceros. M. Desnoyers also made excavations after M. Gaudry, at St. Acheul, in 1859, with the same results.* (* "Bulletin" volume 17 page 18.)

After a lively discussion on the subject in England and France, it was remembered, not only that there were numerous recorded cases leading to similar conclusions in regard to cavern deposits, but, also, that Mr. Frere had, so long ago as 1797, found flint weapons, of the same type as those of Amiens, in a freshwater formation in Suffolk, in conjunction with elephant remains; and nearly a hundred years earlier (1715), another tool of the same kind had been exhumed from the gravel of London, together with bones of an elephant; to all which examples I shall allude more fully in the sequel.

I may conclude this chapter by quoting a saying of Professor Agassiz, "that whenever a new and startling fact is brought to light in science, people first say, 'it is not true,' then that 'it is contrary to religion,' and lastly, 'that everybody knew it before.'"

If I were considering merely the cultivators of geology, I should

say that the doctrine of the former co-existence of Man with many extinct mammalia had already gone through these three phases in the progress of every scientific truth towards acceptance. But the grounds of this belief have not yet been fully laid before the general public, so as to enable them fairly to weigh and appreciate the evidence. I shall therefore do my best in the next three chapters to accomplish this task.

CHAPTER 7.

PEAT AND PLEISTOCENE ALLUVIUM OF THE VALLEY OF THE SOMME.

Geological Structure of the Valley of the Somme and of the surrounding Country.
Position of Alluvium of different Ages.
Peat near Abbeville.
Its animal and vegetable Contents.
Works of Art in Peat.
Probable Antiquity of the Peat, and Changes of Level since its Growth began.
Flint Implements of antique Type in older Alluvium.
Their various Forms and great Numbers.

GEOLOGICAL STRUCTURE OF THE SOMME VALLEY.

The valley of the Somme in Picardy, alluded to in the last chapter, is situated geologically in a region of white Chalk with flints, the strata of which are nearly horizontal. The Chalk hills which bound the valley are almost everywhere between 200 and 300 feet in height. On ascending to that elevation, we find ourselves on an extensive table-land, in which there are slight elevations and depressions. The white Chalk itself is scarcely ever exposed at the surface on this plateau, although seen on the slopes of the hills, as at b and c (Figure 7). The general surface of the upland region is covered continuously for miles in every direction by loam or brick-earth (Number 4), about 5 feet thick, devoid of fossils. To the wide extent of this loam the soil of Picardy chiefly owes its great fertility. Here and there we also observe, on the Chalk, outlying patches of Tertiary sand and clay (Number 5, Figure 7), with Eocene fossils, the remnants of a formation once more extensive, and which probably once spread in one continuous mass over the Chalk, before the present system of valleys had begun to be shaped out. It is necessary to allude to these relics of Tertiary strata, of which the larger part is missing, because their denudation has contributed largely to furnish the materials of gravels in which the flint implements and bones of extinct mammalia are entombed. From this source have been derived not only the regular-formed egg-shaped pebbles, so common in the old fluviatile alluvium at all levels, but those huge masses of hard sandstone, several feet in diameter, to which I shall allude in the sequel. The upland loam also (Number 4) has often, in no slight degree, been formed at the expense of the same Tertiary sands and clays, as is attested by its becoming more or less sandy or argillaceous, according to the nature of the nearest Eocene outlier in the neighbourhood.

The average width of the valley of the Somme between Amiens and Abbeville is one mile. The height, therefore, of the hills, in relation to the river-plain, could not be correctly represented in the annexed diagram (Figure 7), as they would have to be reduced in altitude; or if not, it would be necessary to make the space between c and b four times as great. The dimensions also of the masses, of drift or alluvium, 2 and 3, have been exaggerated, in order to render them sufficiently conspicuous; for, all important as we shall find them to be as geological monuments of the Pleistocene period, they form a truly insignificant feature in the general structure of the country, so much so, that they might easily be overlooked in a cursory survey of the district, and are usually unnoticed in geological maps not specially devoted to the superficial formations.

(FIGURE 7. SECTION ACROSS THE VALLEY OF THE SOMME IN PICARDY.

1. Peat, 20 to 30 feet thick, resting on gravel, a.
2. Lower level gravel with elephants' bones and flint tools, covered with fluviatile loam, 20 to 40 feet thick.
3. Higher level gravel with similar fossils, and with overlying loam, in all 30 feet thick.
4. Upland loam without shells (Limon des plateaux), 5 or 6 feet thick.
5. Eocene strata, resting on the Chalk in patches.)

It will be seen by the description given of the section (Figure 7) that Number 2 indicates the lower level gravels, and Number 3 the higher ones, or those rising to elevations of 80 or 100 feet above the river. Newer than these is the peat Number 1, which is from 10 to 30 feet in thickness, and which is not only of later date than the alluvium, 2 and 3, but is also posterior to the denudation of those gravels, or to the time when the valley was excavated through them. Underneath the peat is a bed of gravel, a, from 3 to 14 feet thick, which rests on undisturbed Chalk. This gravel was probably formed, in part at least, when the valley was scooped out to its present depth, since which time no geological change has taken place, except the growth of the peat, and certain oscillations in the general level of the country, to which we shall allude by and by. A thin layer of impervious clay separates the gravel a from the peat Number 1, and seems to have been a necessary preliminary to the growth of the peat.

PEAT OF THE VALLEY OF THE SOMME.

As hitherto, in our retrospective survey, we have been obliged, for the sake of proceeding from the known to the less known, to reverse the natural order of history, and to treat of the newer before the older formations, I shall begin my account of the geological monuments of the valley of the Somme by saying something of the most modern of all of them, the peat. This substance occupies the lower parts of the valley far above Amiens, and below Abbeville as far as the sea. It has already been stated to be in some places 30 feet thick, and is even occasionally more than 30 feet, corresponding in that respect to the Danish mosses before described (Chapter 2). Like them, it belongs to the Recent period; all the embedded mammalia, as well as the shells, being of the same species as those now inhabiting Europe. The bones of quadrupeds are very numerous, as I can bear witness, having seen them brought up from a considerable depth near Abbeville, almost as often as the dredging instrument was used. Besides remains of the beaver, I was shown, in the collection of M. Boucher de Perthes, two perfect lower jaws with teeth of the bear, Ursus arctos; and in the Paris Museum there is another specimen, also from the Abbeville peat.

The list of mammalia already comprises a large proportion of those proper to the Swiss lake-dwellings, and to the shell-mounds and peat of Denmark; but unfortunately as yet no special study has been made of the French fauna, like that by which the Danish and Swiss zoologists and botanists have enabled us to compare the wild and tame animals and the vegetation of the age of stone with that of the age of iron.

Notwithstanding the abundance of mammalian bones in the peat, and the frequency of stone implements of the Celtic and Gallo-Roman periods, M. Boucher de Perthes has only met with three or four fragments of human skeletons.

At some depth in certain places in the valley near Abbeville, the trunks of alders have been found standing erect as they grew, with their roots fixed in an ancient soil, afterwards covered with peat. Stems of the hazel, and nuts of the same, abound; trunks, also, of the oak and walnut. The peat extends to the coast, and is there seen passing under the sand-dunes and below the sea-level. At the mouth of the river Canche, which joins the sea near the embouchure

of the Somme, yew trees, firs, oaks, and hazels have been dug out of peat, which is there worked for fuel, and is about three feet thick.* (* D'Archiac, "Histoire des Progres" volume 2 page 154.) During great storms, large masses of compact peat, enclosing trunks of flattened trees, have been thrown up on the coast at the mouth of the Somme; seeming to indicate that there has been a subsidence of the land and a consequent submergence of what was once a westward continuation of the valley of the Somme into what is now a part of the English Channel.

Whether the vegetation of the lowest layers of peat differed as to the geographical distribution of some of the trees from the middle, and this from the uppermost peat, as in Denmark, has not yet been ascertained; nor have careful observations been made with a view of calculating the minimum of time which the accumulation of so dense a mass of vegetable matter must have taken. A foot in thickness of highly compressed peat, such as is sometimes reached in the bottom of the bogs, is obviously the equivalent in time of a much greater thickness of peat of spongy and loose texture, found near the surface. The workmen who cut peat, or dredge it up from the bottom of swamps and ponds, declare that in the course of their lives none of the hollows which they have found, or caused by extracting peat, have ever been refilled, even to a small extent. They deny, therefore, that the peat grows. This, as M. Boucher de Perthes observes, is a mistake; but it implies that the increase in one generation is not very appreciable by the unscientific.

The antiquary finds near the surface Gallo-Roman remains, and still deeper Celtic weapons of the stone period. [Note 14.] But the depth at which Roman works of art occur varies in different places, and is no sure test of age; because in some parts of the swamps, especially near the river, the peat is often so fluid that heavy substances may sink through it, carried down by their own gravity. In one case, however, M. Boucher de Perthes observed several large flat dishes of Roman pottery, lying in a horizontal position in the peat, the shape of which must have prevented them from sinking or penetrating through the underlying peat. Allowing about fourteen centuries for the growth of the superincumbent vegetable matter, he calculated that the thickness gained in a hundred years would be no more than three centimetres.* (* "Antiquites Celtiques" volume 2 page 134.) This rate of increase would demand so many thousands of years for the formation of the entire thickness of 30 feet that we must hesitate before adopting it as a chronometric scale. Yet, by multiplying observations of this kind, and bringing one to bear upon and check another, we may eventually succeed in obtaining data for estimating the age of the peaty deposit. [Note 15.]

The rate of increase in Denmark may not be applicable to France; because differences in the humidity of the climate, or in the intensity and duration of summer's heat and winter's cold, as well as diversity in the species of plants which most abound, would cause the peat to grow more or less rapidly, not only when we compare two distinct countries in Europe, but the same country at two successive periods.

I have already alluded to some facts which favour the idea that there has been a change of level on the coast since the peat began to grow. This conclusion seems confirmed by the mere thickness of peat at Abbeville, and the occurrence of alder and hazel-wood near

the bottom of it. If 30 feet of peat were now removed, the sea would flow up and fill the valley for miles above Abbeville. Yet this vegetable matter is all of supra-marine origin, for where shells occur in it they are all of terrestrial or fluviatile kinds, so that it must have grown above the sea-level when the land was more elevated than now. We have already seen what changes in the relative level of sea and land have occurred in Scotland subsequently to the time of the Romans, and are therefore prepared to meet with proofs of similar movements in Picardy. In that country they have probably not been confined simply to subsidence, but have comprised oscillations in the level of the land, by which marine shells of the Pleistocene period have been raised some 10 feet or more above the level of the sea.

Small as is the progress hitherto made in interpreting the pages of the peaty record, their importance in the valley of the Somme is enhanced by the reflection that, whatever be the number of centuries to which they relate, they belong to times posterior to the ancient implement-bearing beds, which we are next to consider, and are even separated from them, as we shall see, by an interval far greater than that which divides the earliest strata of the peat from the latest.

FLINT IMPLEMENTS OF THE PLEISTOCENE PERIOD IN THE VALLEY OF THE SOMME.

The alluvium of the valley of the Somme exhibits nothing extraordinary or exceptional in its position or external appearance, nor in the arrangement or composition of its materials, nor in its organic remains; in all these characters it might be matched by the drift of a hundred other valleys in France or England. Its claim to our peculiar attention is derived from the wonderful number of flint tools, of a very antique type, which, as stated in the last chapter, occur in undisturbed strata, associated with the bones of extinct quadrupeds.

As much doubt has been cast on the question, whether the so-called flint hatchets have really been shaped by the hands of Man, it will be desirable to begin by satisfying the reader's mind on that point, before inviting him to study the details of sections of successive beds of mud, sand, and gravel, which vary considerably even in contiguous localities.

Since the spring of 1859, I have paid three visits to the Valley of the Somme, and examined all the principal localities of these flint tools. In my excursions around Abbeville, I was accompanied by M. Boucher de Perthes, and during one of my explorations in the Amiens district, by Mr. Prestwitch. The first time I entered the pits at St. Acheul, I obtained seventy flint instruments, all of them collected from the drift in the course of the preceding five or six weeks. The two prevailing forms of these tools are represented in the annexed Figures 8 and 9, each of which are half the size of the originals; the first being the spear-headed form, varying in length from six to eight inches; the second, the oval form, which is not unlike some stone implements, used to this day as hatchets and tomahawks by natives of Australia, but with this difference, that the edge in the Australian weapons (as in the case of those called celts in Europe) has been produced by friction, whereas the cutting edge in the old tools of the valley of the Somme was always gained

by the simple fracture of the flint, and by the repetition of many dexterous blows.

The oval-shaped Australian weapons, however, differ in being sharpened at one end only. The other, though reduced by fracture to the same general form, is left rough, in which state it is fixed into a cleft stick, which serves as a handle. To this it is firmly bound by thin straps of opossum's hide. One of these tools, now in my possession, was given me by Mr. Farquharson of Haughton, who saw a native using it in 1854 on the Auburn river, in Burnet district, North Australia.

Out of more than a hundred flint implements which I obtained at St. Acheul, not a few had their edges more or less fractured or worn, either by use as instruments before they were buried in gravel, or by being rolled in the river's bed.

Some of these tools were probably used as weapons, both of war and of the chase, others to grub up roots, cut down trees, and scoop out canoes. Some of them may have served, as Mr. Prestwich has suggested, for cutting holes in the ice both for fishing and for obtaining water, as will be explained in the eighth chapter when we consider the arguments in favour of the higher level drift having belonged to a period when the rivers were frozen over for several months every winter.

(FIGURE 8. FLINT IMPLEMENT FROM ST. ACHEUL, NEAR AMIENS,
OF THE SPEAR-HEAD SHAPE
(half the size of the original, which is 7 1/2 inches long).

a. Side view.
b. Same seen edgewise.

These spear-headed implements have been found in greater number, proportionally to the oval ones, in the upper level gravel at St. Acheul, than in any of the lower gravels in the valley of the Somme. In these last the oval form predominates, especially at Abbeville.)

When the natural form of a Chalk-flint presented a suitable handle at one end, as in the specimen, Figure 10, that part was left as found. The portion, for example, between b and c has probably not been altered; the protuberances which are fractured having been broken off by river action before the flint was chipped artificially. The other extremity, a, has been worked till it acquired a proper shape and cutting edge.

(FIGURES 9 AND 10. FLINT IMPLEMENTS FROM THE PLEISTOCENE DRIFT OF ABBEVILLE AND AMIENS.

FIGURE 9. a. OVAL-SHAPED FLINT HATCHET FROM MAUTORT,
NEAR ABBEVILLE,

half size of original, which is 5 1/2 inches long, from a bed of gravel underlying the fluvio-marine stratum. b. Same seen edgewise. c. Shows a recent fracture of the edge of the same at the point a, or near the top. This portion of the tool, c, is drawn of the natural size, the black central part being the unaltered flint, the white outer coating, the layer which has been formed by

discoloration or bleaching since the tool was first made. The entire surface of Number 9 must have been black when first shaped, and the bleaching to such a depth must have been the work of time, whether produced by exposure to the sun and air before it was embedded, or afterwards when it lay deep in the soil.

FIGURE 10. FLINT TOOL FROM ST. ACHEUL, seen edgewise; original 6 1/2 inches long, and 3 inches wide.

b, c. Portion not artificially shaped.
a, b. Part chipped into shape, and having a cutting edge at a.)

Many of the hatchets are stained of an ochreous-yellow colour, when they have been buried in yellow gravel, others have acquired white or brown tints, according to the matrix in which they have been enclosed.

This accordance in the colouring of the flint tools with the character of the bed from which they have come, indicates, says Mr. Prestwich, not only a real derivation from such strata, but also a sojourn therein of equal duration to that of the naturally broken flints forming part of the same beds.* (* "Philosophical Transactions" 1861 page 297.)

(FIGURES 11, 12 AND 13. DENDRITES ON SURFACES OF FLINT HATCHETS IN THE DRIFT OF ST. ACHEUL, NEAR AMIENS.

FIGURE 11. a. Natural size.

FIGURE 12. b. Natural size. c. Magnified.

FIGURE 13. d. Natural size.
e. Magnified.)

The surface of many of the tools is encrusted with a film of carbonate of lime, while others are adorned by those ramifying crystallisations called dendrites (see Figures 11, 12 and 13), usually consisting of the mixed oxides of iron and manganese, forming extremely delicate blackish brown sprigs, resembling the smaller kinds of sea weed. They are a useful test of antiquity when suspicions are entertained of the workmen having forged the hatchets which they offer for sale. The most general test, however, of the genuineness of the implements obtained by purchase is their superficial varnish-like or vitreous gloss, as contrasted with the dull aspect of freshly fractured flints. I also remarked, during each of my three visits to Amiens, that there were some extensive gravel-pits, such as those of Montiers and St. Roch, agreeing in their geological character with those of St. Acheul, and only a mile or two distant, where the workmen, although familiar with the forms, and knowing the marketable value of the articles above described, assured me that they had never been able to find a single implement.

Respecting the authenticity of the tools as works of art, Professor Ramsay, than whom no one could be a more competent judge, observes: "For more than twenty years, like others of my craft, I have daily handled stones, whether fashioned by nature or art; and the flint hatchets of Amiens and Abbeville seem to me as clearly works of art as any Sheffield whittle."* (* "Athenaeum" July 16, 1859.)

Mr. Evans classifies the implements under three heads, two of which, the spear heads and the oval or almond-shaped kinds, have already been described. The third form (Figure 14) consists of flakes, apparently intended for knives or some of the smaller ones for arrow heads.

(FIGURE 14. FLINT KNIFE OR FLAKE FROM BELOW THE SAND CONTAINING CYRENA FLUMINALIS. MENCHECOURT, ABBEVILLE.
d. Transverse section along the line of fracture, b, c.
Size, two-thirds of the original.
)

In regard to their origin, Mr. Evans observes that there is a uniformity of shape, a correctness of outline, and a sharpness about the cutting edges and points, which cannot be due to anything but design.* (* "Archaeologia" volume 38.)

Of these knives and flakes, I obtained several specimens from a pit which I caused to be dug at Abbeville, in sand in contact with the Chalk, and below certain fluvio-marine beds, which will be alluded to in the next chapter.

Between the spear-head and oval shapes, there are various intermediate gradations, and there are also a vast variety of very rude implements, many of which may have been rejected as failures, and others struck off as chips in the course of manufacturing the more perfect ones. Some of these chips can only be recognised by an experienced eye as bearing marks of human workmanship.

It has often been asked, how, without the use of metallic hammers, so many of these oval and spear-headed tools could have been wrought into so uniform a shape. Mr. Evans, in order experimentally to illustrate the process, constructed a stone hammer, by mounting a pebble in a wooden handle, and with this tool struck off flakes from the edge on both sides of a Chalk flint, till it acquired precisely the same shape as the oval tool, Figure 9.

If I were invited to estimate the probable number of the more perfect tools found in the valley of the Somme since 1842, rejecting all the knives, and all that might be suspected of being spurious or forged, I should conjecture that they far exceeded a thousand. Yet it would be a great mistake to imagine that an antiquary or geologist, who should devote a few weeks to the exploration of such a valley as that of the Somme, would himself be able to detect a single specimen. But few tools were lying on the surface. The rest have been exposed to view by the removal of such a volume of sand, clay, and gravel, that the price of the discovery of one of them could only be estimated by knowing how many hundred labourers have toiled at the fortifications of Abbeville, or in the sand and gravel pits near that city, and around Amiens, for road materials and other economic purposes, during the last twenty years.

(FIGURE 15. FOSSILS OF THE WHITE CHALK.

a, b. Coscinopora globularis, D'Orbigny. Orbitolina concava, Parker and Jones. c. Part of same magnified.)

In the gravel pits of St. Acheul, and in some others near Amiens, small round bodies, having a tubular cavity in the centre, occur. They are well known as fossils of the White Chalk. Dr. Rigollot suggested that they might have been strung together as beads, and he supposed the hole in the middle to have been artificial. Some of these round bodies are found entire in the Chalk and in the gravel, others have naturally a hole passing through them, and sometimes one or two holes penetrating some way in from the surface, but not extending to the other side. Others, like b, Figure 15, have a large cavity, which has a very artificial aspect. It is impossible to decide whether they have or have not served as personal ornaments, recommended by their globular form, lightness, and by being less destructible than ordinary Chalk. Granting that there were natural cavities in the axis of some of them, it does not follow that these may not have been taken advantage of for stringing them as beads, while others may have been artificially bored through. Dr. Rigollot's argument in favour of their having been used as necklaces or bracelets, appears to me a sound one. He says he often found small heaps or groups of them in one place, all perforated, just as if, when swept into the river's bed by a flood, the bond which had united them together remained unbroken.* (* Rigollot, "Memoire sur des Instruments en Silex" etc., Amiens 1854 page 16.)

CHAPTER 8.

PLEISTOCENE ALLUVIUM WITH FLINT IMPLEMENTS OF THE VALLEY OF THE SOMME--CONCLUDED.

Fluvio-marine Strata, with Flint Implements, near Abbeville.
Marine Shells in same.
Cyrena fluminalis.
Mammalia.
Entire Skeleton of Rhinoceros.
Flint Implements, why found low down in Fluviatile Deposits.
Rivers shifting their Channels.
Relative Ages of higher and lower-level Gravels.
Section of Alluvium of St. Acheul.
Two Species of Elephant and Hippopotamus coexisting with Man in France.
Volume of Drift, proving Antiquity of Flint Implements.
Absence of Human Bones in tool-bearing Alluvium, how explained.
Value of certain Kinds of negative Evidence tested thereby.
Human Bones not found in drained Lake of Haarlem.

In the section of the valley of the Somme given in Figure 7, the successive formations newer than the Chalk are numbered in chronological order, beginning with the most modern, or the peat, which is marked Number 1, and which has been treated of in the last chapter. Next in the order of antiquity are the lower-level gravels, Number 2, which we have now to describe; after which the alluvium, Number 3, found at higher levels, or about 80 and 100 feet above the river-plain, will remain to be considered.

I have selected, as illustrating the old alluvium of the Somme occurring at levels slightly elevated above the present river, the sand and gravel-pits of Menchecourt, in the northwest suburbs of Abbeville, to which, as before stated, attention was first drawn by

M. Boucher de Perthes, in his work on Celtic antiquities. Here, although in every adjoining pit some minor variations in the nature and thickness of the superimposed deposits may be seen, there is yet a general approach to uniformity in the series. The only stratum of which the relative age is somewhat doubtful, is the gravel marked a, underlying the peat, and resting on the Chalk. It is only known by borings, and some of it may be of the same age as Number 3; but I believe it to be for the most part of more modern origin, consisting of the wreck of all the older gravel, including Number 3, and formed during the last hollowing out and deepening of the valley immediately before the commencement of the growth of peat.

The greater number of flint implements have been dug out of Number 3, often near the bottom, and twenty-five, thirty, or even more than thirty feet below the surface of Number 1.

A geologist will perceive by a glance at the section that the valley of the Somme must have been excavated nearly to its present depth and width when the strata of Number 3 were thrown down, and that after the deposits Numbers 3, 2, and 1 had been formed in succession, the present valley was scooped out, patches only of Numbers 3 and 2 being left. For these deposits cannot originally have ended abruptly as they now do, but must have once been continuous farther towards the centre of the valley.

(FIGURE 16. SECTION OF FLUVIO-MARINE STRATA, CONTAINING FLINT IMPLEMENTS AND BONES OF EXTINCT MAMMALIA, AT MENCHECOURT, ABBEVILLE.*

(* For detailed sections and maps of this district, see Prestwich, "Philosophical Transactions" 1860 page 277.)

1. Brown clay with angular flints, and occasionally Chalk rubble, unstratified, following the slope of the hill, probably of subaerial origin, of very varying thickness, from 2 to 5 feet and upwards.
2. Calcareous loam, buff-coloured, resembling loess, for the most part unstratified, in some places with slight traces of stratification, containing freshwater and land shells, with bones of elephants, etc.; thickness about 15 feet.
3. Alternations of beds of gravel, marl, and sand, with freshwater and land shells, and, in some of the lower sands, a mixture of marine shells; also bones of elephant, rhinoceros, etc., and flint implements; thickness about 12 feet.

a. Gravel underlying peat, age undetermined.
b. Layer of impervious clay, separating the gravel from the peat.)

To begin with the oldest, Number 3, it is made up of a succession of beds, chiefly of freshwater origin, but occasionally a mixture of marine and fluviatile shells is observed in it, proving that the sea sometimes gained upon the river, whether at high tides or when the fresh water was less in quantity during the dry season, and sometimes perhaps when the land was slightly depressed in level. All these accidents might occur again and again at the mouth of any river, and give rise to alternations of fluviatile and marine strata, such as are seen at Menchecourt.

In the lowest beds of gravel and sand in contact with the Chalk, flint hatchets, some perfect, others much rolled, have been found;

and in a sandy bed in this position some workmen, whom I employed to sink a pit, found four flint knives. Above this sand and gravel occur beds of white and siliceous sand, containing shells of the genera Planorbis, Limnea, Paludina, Valvata, Cyclas, Cyrena, Helix, and others, all now natives of the same part of France, except Cyrena fluminalis (Figure 17), which no longer lives in Europe, but inhabits the Nile, and many parts of Asia, including Cashmere, where it abounds. No species of Cyrena is now met with in a living state in Europe. Mr. Prestwich first observed it fossil at Menchecourt, and it has since been found in two or three contiguous sand-pits, always in the fluvio-marine bed. [Note 16.]

(FIGURE 17. Cyrena fluminalis, O.F. Muller, sp.*
(* For synonyms, see S. Woodward "Tibet Shells" "Proceedings of the Zoological Society" July 8, 1856.)

a. Interior of left valve, from Gray's Thurrock, Essex.
b. Hinge of the same magnified.
c. Interior of right valve of a small specimen, from Shacklewell, London.
d. Outer surface of right valve, from Erith, Kent.)

TABLE 8/1. DATES OF SPECIFIC NAMES.

COLUMN 1 : SPECIES.

COLUMN 2 : DATE.

LIVING:

Tellina fluminalis, O.F. Muller : 1774.
Venus fluminalis Euphratis, Chemnitz : 1782.
Cyclas Euphratica, Lam. : 1806.
Cyrena cor, Lam. (Nile): 1818.
Cyrena consobrina, Caillaud (Nile) : 1823.
Cyrena Cashmiriensis, Desh. :
Corbicuia fluminalis, Muhlfeldt. : 1811.

FOSSIL:

Cyrena trigonula, S. Woodward : 1834.
Cyrena Gemmellarii, Philippi : 1836.
Cyrena Duchastelii, Nyst : 1838.

The following marine shells occur mixed with the freshwater species above enumerated:--Buccinum undatum, Littorina littorea, Nassa reticulata, Purpura lapillus, Tellina solidula, Cardium edule, and fragments of some others. Several of these I have myself collected entire, though in a state of great decomposition, lying in the white sand called "sable aigre" by the workmen. They are all littoral species now proper to the contiguous coast of France. Their occurrence in a fossil state associated with freshwater shells at Menchecourt had been noticed as long ago as 1836 by MM. Ravin and Baillon, before M. Boucher de Perthes commenced the researches which have since made the locality so celebrated.* (* D'Archiac, "Histoire des Progres" etc. volume 2 page 154.) The numbers since collected preclude all idea of their having been brought inland as eatable shells by the fabricators of the flint hatchets found at the bottom of the fluvio-marine sands. From the

same beds, and in marls alternating with the sands, remains of the elephant, rhinoceros, and other mammalia have been exhumed.

Above the fluvio-marine strata are those designated Number 2 in the section (Figure 16), which are almost devoid of stratification, and probably formed of mud or sediment thrown down by the waters of the river when they overflowed the ancient alluvial plain of that day. Some land shells, a few river shells, and bones of mammalia, some of them extinct, occur in Number 2. Its upper surface has been deeply furrowed and cut into by the action of water, at the time when the earthy matter of Number 1 was superimposed. The materials of this uppermost deposit are arranged as if they had been the result of land floods, taking place after the formations 2 and 3 had been raised, or had become exposed to denudation.

The fluvio-marine strata and overlying loam of Menchecourt recur on the opposite or left bank of the alluvial plain of the Somme, at a distance of 2 or 3 miles. They are found at Mautort, among other places, and I obtained there the flint hatchet shown in Figure 9, of an oval form. It was extracted from gravel, above which were strata containing a mixture of marine and freshwater shells, precisely like those of Menchecourt. In the alluvium of all parts of the valley, both at high and low levels, rolled bones are sometimes met with in the gravel. Some of the flint tools in the gravel of Abbeville have their angles very perfect, others have been much triturated, as if in the bed of the main river or some of its tributaries.

The mammalia most frequently cited as having been found in the deposits Numbers 2 and 3 at Menchecourt, are the following:--

Elephas primigenius.
Rhinoceros tichorhinus.
Equus fossilis, Owen.
Bos primigenius.
Cervus somonensis, Cuvier.
C. tarandus priscus, Cuvier.
Felis spelaea.
Hyaena spelaea.

The Ursus spelaeus has also been mentioned by some writers; but M. Lartet says he has sought in vain for it among the osteological treasures sent from Abbeville to Cuvier at Paris, and in other collections. The same palaeontologist, after a close scrutiny of the bones sent formerly to the Paris Museum from the valley of the Somme, observed that some of them bore the evident marks of an instrument, agreeing well with incisions such as a rude flint-saw would produce. Among other bones mentioned as having been thus artificially cut, are those of a Rhinoceros tichorhinus, and the antlers of Cervus somonensis.* (* "Quarterly Journal of the Geological Society" volume 16 1860 page 471.)

The evidence obtained by naturalists that some of the extinct mammalia of Menchecourt really lived and died in this part of France, at the time of the embedding of the flint tools in fluviatile strata, is most satisfactory; and not the less so for having been put on record long before any suspicion was entertained that works of art would ever be detected in the same beds. Thus M. Baillon, writing in 1834 to M. Ravin, says: "They begin to meet

with fossil bones at the depth of 10 or 12 feet in the Menchecourt sand-pits, but they find a much greater quantity at the depth of 18 and 20 feet. Some of them were evidently broken before they were embedded, others are rounded, having, without doubt, been rolled by running water. It is at the bottom of the sand-pits that the most entire bones occur. Here they lie without having undergone fracture or friction, and seem to have been articulated together at the time when they were covered up. I found in one place a whole hind limb of a rhinoceros, the bones of which were still in their true relative position. They must have been joined together by ligaments, and even surrounded by muscles at the time of their interment. The entire skeleton of the same species was lying at a short distance from the spot."* (* "Societe Roy. d'Emulation d'Abbeville" 1834 page 197.)

If we suppose that the greater number of the flint implements occurring in the neighbourhood of Abbeville and Amiens were brought by river action into their present position, we can at once explain why so large a proportion of them are found at considerable depths from the surface, for they would naturally be buried in gravel and not in fine sediment, or what may be termed "inundation mud," such as Number 2 (Figure 16), a deposit from tranquil water, or where the stream had not sufficient force or velocity to sweep along Chalk flints, whether wrought or unwrought. Hence we have almost always to pass down through a mass of incumbent loam with land shells, or through fine sand with freshwater molluscs, before we get into the beds of gravel containing hatchets. Occasionally a weapon used as a projectile may have fallen into quiet water, or may have dropped from a canoe to the bottom of the river, or may have been floated by ice, as are some stones occasionally by the Thames in severe winters, and carried over the meadows bordering its banks; but such cases are exceptional, though helping to explain how isolated flint tools or pebbles and angular stones are now and then to be seen in the midst of the finest loams.

The endless variety in the sections of the alluvium of the valley of the Somme, may be ascribed to the frequent silting up of the main stream and its tributaries during different stages of the excavation of the valley, probably also during changes in the level of the land. As a rule, when a river attacks and undermines one bank, it throws down gravel and sand on the opposite side of its channel, which is growing somewhere shallower, and is soon destined to be raised so high as to form an addition to the alluvial plain, and to be only occasionally inundated. In this way, after much encroachment on cliff or meadow at certain points, we find at the end of centuries that the width of the channel has not been enlarged, for the new made ground is raised after a time to the average height of the older alluvial tract. Sometimes an island is formed in midstream, the current flowing for a while on both sides of it, and at length scooping out a deeper channel on one side so as to leave the other to be gradually filled up during freshets and afterwards elevated by inundation mud, or "brick-earth." During the levelling up of these old channels, a flood sometimes cuts into and partially removes portions of the previously stratified matter, causing those repeated signs of furrowing and filling up of cavities, those memorials of doing and undoing, of which the tool-bearing sands and gravels of Abbeville and Amiens afford such reiterated illustrations, and of which a parallel is furnished by the ancient alluvium of the Thames valley, where similar bones of

extinct mammalia and shells, including Cyrena fluminalis, are found.

Professor Noeggerath, of Bonn, informs me that, about the year 1845, when the bed of the Rhine was deepened artificially by the blasting and removal of rock in the narrows at Bingerloch, not far from Bingen, several flint hatchets and an extraordinary number of iron weapons of the Roman period were brought up by the dredge from the bed of the great river. The decomposition of the iron had caused much of the gravel to be cemented together into a conglomerate. In such a case we have only to suppose the Rhine to deviate slightly from its course, changing its position, as it has often done in various parts of its plain in historical times, and then tools of the stone and iron periods would be found in gravel at the bottom with a great thickness of sand and overlying loam deposited above them.

Changes in a river plain, such as those above alluded to, give rise frequently to ponds, swamps, and marshes, marking the course of old beds or branches of the river not yet filled up, and in these depressions shells proper both to running and stagnant water may be preserved, and quadrupeds may be mired. The latest and uppermost deposit of the series will be loam or brick-earth, with land and amphibious shells (Helix and Succinea), while below will follow strata containing freshwater shells, implying continuous submergence; and lowest of all in most sections will be the coarse gravel accumulated by a current of considerable strength and velocity.

When the St. Katharine docks were excavated at London, and similar works executed on the banks of the Mersey, old ships were dug out, as I have elsewhere noticed,* (* "Principles of Geology" 10th edition volume 2 page 547.) showing how the Thames and Mersey have in modern times been shifting their channels. Recently, an old silted-up bed of the Thames has been discovered by boring at Shoeburyness at the mouth of the river opposite Sheerness, as I learn from Mr. Mylne. The old deserted branch is separated from the new or present channel of the Thames, by a mass of London Clay which has escaped denudation. The depth of the old branch, or the thickness of fluviatile strata with which it has been filled up, is 75 feet. The actual channel in the neighbourhood is now 60 feet deep, but there is probably 10 or 15 feet of stratified sand and gravel at the bottom; so that, should the river deviate again from its course, its present bed might be the receptacle of a fluvio-marine formation 75 feet thick, equal to the former one of Shoeburyness, and more considerable than that of Abbeville. It would consist both of freshwater and marine strata, as the salt water is carried by the tide far up above Sheerness; but in order that such deposits should resemble, in geological position, the Menchecourt beds, they must be raised 10 or 15 feet above their present level, and be partially eroded. Such erosion they would not fail to suffer during the process of upheaval, because the Thames would scour out its bed, and not alter its position relatively to the sea, while the land was gradually rising.

Before the canal was made at Abbeville, the tide was perceptible in the Somme for some distance above that city. It would only require, therefore, a slight subsidence to allow the salt water to reach Menchecourt, as it did in the Pleistocene period. As a stratum

containing exclusively land and freshwater shells usually underlies the fluvio-marine sands at Menchecourt, it seems that the river first prevailed there, after which the land subsided; and then there was an upheaval which raised the country to a greater height than that at which it now stands, after which there was a second sinking, indicated by the position of the peat, as already explained. All these changes happened since Man first inhabited this region.

At several places in the environs of Abbeville there are fluviatile deposits at a higher level by 50 feet than the uppermost beds at Menchecourt, resting in like manner on the Chalk. One of these occurs in the suburbs of the city at Moulin Quignon, 100 feet above the Somme and on the same side of the valley as Menchecourt, and containing flint implements of the same antique type and the bones of elephants; but no marine shells have been found there, nor in any gravel or sand at higher elevations than the Menchecourt marine shells.

It has been a matter of discussion among geologists whether the higher or the lower sands and gravels of the Somme valley are the more ancient. As a general rule, when there are alluvial formations of different ages in the same valley, those which occupy a more elevated position above the river plain are the oldest. In Auvergne and Velay, in Central France, where the bones of fossil quadrupeds occur at all heights above the present rivers from 10 to 1000 feet, we observe the terrestrial fauna to depart in character from that now living in proportion as we ascend to higher terraces and platforms. We pass from the lower alluvium, containing the mammoth, tichorhine rhinoceros, and reindeer, to various older groups of fossils, till, on a tableland 1000 feet high (near Le Puy, for example), the abrupt termination of which overlooks the present valley, we discover an old extinct river-bed covered by a current of ancient lava, showing where the lowest level was once situated. In that elevated alluvium the remains of a Tertiary mastodon and other quadrupeds of like antiquity are embedded.

If the Menchecourt beds had been first formed, and the valley, after being nearly as deep and wide as it is now, had subsided, the sea must have advanced inland, causing small delta-like accumulations at successive heights, wherever the main river and its tributaries met the sea. Such a movement, especially if it were intermittent, and interrupted occasionally by long pauses, would very well account for the accumulation of stratified debris which we encounter at certain points in the valley, especially around Abbeville and Amiens. But we are precluded from adopting this theory by the entire absence of marine shells, and the presence of freshwater and land species, and mammalian bones, in considerable abundance, in the drift both of higher and lower levels above Abbeville. Had there been a total absence of all organic remains, we might have imagined the former presence of the sea, and the destruction of such remains might have been ascribed to carbonic acid or other decomposing causes; but the Pleistocene and implement-bearing strata can be shown by their fossils to be of fluviatile origin.

FLINT IMPLEMENTS IN GRAVEL NEAR AMIENS. GRAVEL OF ST. ACHEUL.

When we ascend the valley of the Somme, from Abbeville to Amiens, a

distance of about 25 miles, we observe a repetition of all the same alluvial phenomena which we have seen exhibited at Menchecourt and its neighbourhood, with the single exception of the absence of marine shells and of Cyrena fluminalis. We find lower-level gravel, such as Number 2, Figure 7, and higher-level alluvium, such as Number 3, the latter rising to 100 feet above the plain, which at Amiens is about 50 feet above the level of the river at Abbeville. In both the upper and lower gravels, as Dr. Rigollot stated in 1854, flint tools and the bones of extinct animals, together with river shells and land shells of living species, abound.

(FIGURE 18.* Elephas primigenius.
Penultimate molar, lower jaw, right side, one-third of natural size, Pleistocene. Co-existed with Man.)

(FIGURE 19.* Elephas antiquus, Falconer.
Penultimate molar, lower jaw, right side, one-third of natural size, Pleistocene and Newer Pliocene. Co-existed with Man.)

(FIGURE 20.* Elephas meridionalis, Nesti.
Penultimate molar, lower jaw, right side, one-third of natural size, Newer Pliocene, Saint Prest, near Chartres, and Norwich Crag. Not yet proved to have coexisted with Man.)

(* For Figure 20 I am indebted to M. Lartet, and Figure 18 will be found in his paper in "Bulletin de la Societe Geologique de France" March 1859. Figure 19 is from Falconer and Cautley "Fauna Sivalensis.")

Immediately below Amiens, a great mass of stratified gravel, slightly elevated above the alluvial plain of the Somme, is seen at St. Roch, and half a mile farther down the valley at Montiers. Between these two places a small tributary stream, called the Celle, joins the Somme. In the gravel at Montiers, Mr. Prestwich and I found some flint knives, one of them flat on one side, but the other carefully worked, and exhibiting many fractures, clearly produced by blows skilfully applied. Some of these knives were taken from so low a level as to satisfy us that this great bed of gravel at Montiers, as well as that of the contiguous quarries of St. Roch, which seems to be a continuation of the same deposit, may be referred to the human period. Dr. Rigollot had already mentioned flint hatchets as obtained by him from St. Roch, but as none have been found there of late years, his statement was thought to require confirmation. The discovery, therefore, of these flint knives in gravel of the same age was interesting, especially as many tusks of a hippopotamus have been obtained from the gravel of St. Roch--some of these recently by Mr. Prestwich; while M. Garnier of Amiens has procured a fine elephant's molar from the same pits, which Dr. Falconer refers to Elephas antiquus, see Figure 19. Hence I infer that both these animals co-existed with Man.

The alluvial formations of Montiers are very instructive in another point of view. If, leaving the lower gravel of that place, which is topped with loam or brick-earth (of which the upper portion is about 30 feet above the level of the Somme), we ascend the Chalk slope to the height of about 80 feet, another deposit of gravel and sand, with fluviatile shells in a perfect condition, occurs, indicating most clearly an ancient river-bed, the waters of which ran habitually at that higher level before the valley had been

scooped out to its present depth. This superior deposit is on the same side of the Somme, and about as high, as the lowest part of the celebrated formation of St. Acheul, 2 or 3 miles distant, to which I shall now allude.

The terrace of St. Acheul may be described as a gently sloping ledge of Chalk, covered with gravel, topped as usual with loam or fine sediment, the surface of the loam being 100 feet above the Somme, and about 150 above the sea.

Many stone coffins of the Gallo-Roman period have been dug out of the upper portion of this alluvial mass. The trenches made for burying them sometimes penetrate to the depth of 8 or 9 feet from the surface, entering the upper part of Number 3 of the sections Figures 21 and 22. They prove that when the Romans were in Gaul they found this terrace in the same condition as it is now, or rather as it was before the removal of so much gravel, sand, clay, and loam, for repairing roads, and for making bricks and pottery.

(FIGURE 21. SECTION OF GRAVEL PIT CONTAINING FLINT IMPLEMENTS AT ST. ACHEUL, NEAR AMIENS, OBSERVED IN JULY 1860.

1. Vegetable soil and made ground, 2 to 3 feet thick.
2. Brown loam with some angular flints, in parts passing into ochreous gravel, filling up indentations on the surface of Number 3, 3 feet thick.
3. White siliceous sand with layers of chalky marl, and included fragments of Chalk, for the most part unstratified, 9 feet.
4. Flint-gravel, and whitish chalky sand, flints subangular, average size of fragments, 3 inches diameter, but with some large unbroken Chalk flints intermixed, cross stratification in parts. Bones of mammalia, grinder of elephant at b, and flint implement at c, 10 to 14 feet.
5. Chalk with flints.

a. Part of elephant's molar, 11 feet from the surface.
b. Entire molar of Elephas primigenius, 17 feet from the surface.
c. Position of flint hatchet, 18 feet from the surface.)

In the annexed section (Figure 21), which I observed during my last visit in 1860, it will be seen that a fragment of an elephant's tooth is noticed as having been dug out of unstratified sandy loam at the point a, 11 feet from the surface. This was found at the time of my visit; and at a lower point, at b, 18 feet from the surface, a large nearly entire and unrolled molar of the same species was obtained, which is now in my possession. It has been pronounced by Dr. Falconer to belong to Elephas primigenius.

A stone hatchet of an oval form, like that represented at Figure 9, was discovered at the same time, about one foot lower down, at c, in densely compressed gravel. The surface of the fundamental Chalk is uneven in this pit, and slopes towards the valley-plain of the Somme. In a horizontal distance of 20 feet, I found a difference in vertical height of 7 feet. In the chalky sand, sometimes occurring in interstices between the separate fragments of flint, constituting the coarse gravel Number 4, entire as well as broken freshwater shells are often met with. To some it may appear enigmatical how such fragile objects could have escaped annihilation in a river-bed, when flint tools and much gravel were shoved along the bottom; but I have seen the dredging instrument

employed in the Thames, above and below London Bridge, to deepen the river, and worked by steam power, scoop up gravel and sand from the bottom, and then pour the contents pell-mell into the boat, and still many specimens of Limnaea, Planorbis, Paludina, Cyclas, and other shells might be taken out uninjured from the gravel.

It will be observed that the gravel Number 4 is obliquely stratified, and that its surface had undergone denudation before the white sandy loam Number 3 was superimposed. The materials of the gravel at d must have been cemented or frozen together into a somewhat coherent mass to allow the projecting ridge, d, to stand up 5 feet above the general surface, the sides being in some places perpendicular. In Number 3 we probably behold an example of a passage from river-silt to inundation mud. In some parts of it, land shells occur.

It has been ascertained by MM. Buteux, Ravin, and other observers conversant with the geology of this part of France, that in none of the alluvial deposits, ancient or modern, are there any fragments of rocks foreign to the basin of the Somme--no erratics which could only be explained by supposing them to have been brought by ice, during a general submergence of the country, from some other hydrographical basin.

But in some of the pits at St. Acheul there are seen in the beds Number 4, Figure 21, not only well-rounded Tertiary pebbles, but great blocks of hard sandstone, of the kind called in the south of England "greywethers," some of which are 3 or 4 feet and upwards in diameter. They are usually angular, and when spherical owe their shape generally to an original concretionary structure, and not to trituration in a river's bed. These large fragments of stone abound both in the higher and lower level gravels round Amiens and at the higher level at Abbeville. They have also been traced far up the valley above Amiens, wherever patches of the old alluvium occur. They have all been derived from the Tertiary strata which once covered the Chalk. Their dimensions are such that it is impossible to imagine a river like the present Somme, flowing through a flat country, with a gentle fall towards the sea, to have carried them for miles down its channel unless ice co-operated as a transporting power. Their angularity also favours the supposition of their having been floated by ice, or rendered so buoyant by it as to have escaped much of the wear and tear which blocks propelled along the bottom of a river channel would otherwise suffer. We must remember that the present mildness of the winters in Picardy and the northwest of Europe generally is exceptional in the northern hemisphere, and that large fragments of granite, sandstone, and limestone are now carried annually by ice down the Canadian rivers in latitudes farther south than Paris.* (* "Principles of Geology" 9th edition page 220.)

(FIGURE 22. CONTORTED FLUVIATILE STRATA AT ST. ACHEUL
(Prestwich, "Philosophical Transactions" 1861, page 299).

1. Surface soil.
2. Brown loam as in Figure 21, thickness, 6 feet.
3. White sand with bent and folded layers of marl, thickness, 6 feet.
4. Gravel, as in Figure 21, with bones of mammalia and flint implements.

A. Graves filled with made ground and human bones.
b and c. Seams of laminated marl often bent round upon themselves.
d. Beds of gravel with sharp curves.)

Another sign of ice agency, of which Mr. Prestwich has given a good illustration in one of his published sections, and which I myself observed in several pits at St. Acheul, deserves notice. It consists in flexures and contortions of the strata of sand, marl, and gravel (as seen at b, c, and d, Figure 22), which they have evidently undergone since their original deposition, and from which both the underlying Chalk and part of the overlying beds of sand Number 3 are usually exempt.

In my former writings I have attributed this kind of derangement to two causes; first, the pressure of ice running aground on yielding banks of mud and sand; and, secondly, the melting of masses of ice and snow of unequal thickness, on which horizontal layers of mud, sand, and other fine and coarse materials had accumulated. The late Mr. Trimmer first pointed out in what manner the unequal failure of support caused by the liquefaction of underlying or intercalated snow and ice might give rise to such complicated foldings.* (* See chapter 12.)

When "ice-jams" occur on the St. Lawrence and other Canadian rivers

(latitude 46 degrees north), the sheets of ice, which become packed or forced under or over one another, assume in most cases a highly inclined and sometimes even a vertical position. They are often observed to be coated on one side with mud, sand, or gravel frozen on to them, derived from shallows in the river on which they rested when congelation first reached the bottom.

As often as portions of these packs melt near the margin of the river, the layers of mud, sand, and gravel, which result from their liquefaction, cannot fail to assume a very abnormal arrangement--very perplexing to a geologist who should undertake to interpret them without having the ice-clue in his mind.

Mr. Prestwich has suggested that ground-ice may have had its influence in modifying the ancient alluvium of the Somme.* (* Prestwich, Memoir read to Royal Society, April 1862.) It is certain that ice in this form plays an active part every winter in giving motion to stones and gravel in the beds of rivers in European Russia and Siberia. It appears that when in those countries the streams are reduced nearly to the freezing point, congelation begins frequently at the bottom; the reason being, according to Arago, that the current is slowest there, and the gravel and large stones, having parted with much of their heat by radiation, acquire a temperature below the average of the main body of the river. It is, therefore, when the water is clear, and the sky free from

clouds, that ground ice forms most readily, and oftener on pebbly than on muddy bottoms. Fragments of such ice, rising occasionally to the surface, bring up with them gravel, and even large stones.

Without dwelling longer on the various ways in which ice may affect the forms of stratification in drift, so as to cause bendings and foldings in which the underlying or over-lying strata do not participate, a subject to which I shall have occasion again to

allude in the sequel, I will state in this place that such contortions, whether explicable or not, are very characteristic of glacial formations. They have also no necessary connection with the transportation of large blocks of stone, and they therefore afford, as Mr. Prestwich remarks, independent proof of ice-action in the Pleistocene gravel of the Somme.

Let us, then, suppose that, at the time when flint hatchets were embedded in great numbers in the ancient gravel which now forms the terrace of St. Acheul, the main river and its tributaries were annually frozen over for several months in winter. In that case, the primitive people may, as Mr. Prestwich hints, have resembled in their mode of life those American Indians who now inhabit the country between Hudson's Bay and the Polar Sea. The habits of those Indians have been well described by Hearne, who spent some years among them. As often as deer and other game become scarce on the land, they betake themselves to fishing in the rivers; and for this purpose, and also to obtain water for drinking, they are in the constant practice of cutting round holes in the ice, a foot or more in diameter, through which they throw baited hooks or nets. Often they pitch their tent on the ice, and then cut such holes through it, using ice-chisels of metal when they can get copper or iron, but when not, employing tools of flint or hornstone.

The great accumulation of gravel at St. Acheul has taken place in part of the valley where the tributary streams, the Noye and the Arve, now join the Somme. These tributaries, as well as the main river, must have been running at the height first of 100 feet, and afterwards at various lower levels above the present valley-plain, in those earlier times when the flint tools of the antique type were buried in successive river beds. I have said at various levels, because there are, here and there, patches of drift at heights intermediate between the higher and lower gravel, and also some deposits, showing that the river once flowed at elevations above as well as below the level of the platform of St. Acheul. As yet, however, no patch of gravel skirting the valley at heights exceeding 100 feet above the Somme has yielded flint tools or other signs of the former sojourn of Man in this region.

Possibly, in the earlier geographical condition of this country, the confluence of tributaries with the Somme afforded inducements to a hunting and fishing tribe to settle there, and some of the same natural advantages may have caused the first inhabitants of Amiens and Abbeville to fix on the same sites for their dwellings. If the early hunting and fishing tribes frequented the same spots for hundreds or thousands of years in succession, the number of the stone implements lost in the bed of the river need not surprise us. Ice-chisels, flint hatchets, and spear-heads may have slipped accidentally through holes kept constantly open, and the recovery of a lost treasure once sunk in the bed of the ice-bound stream, inevitably swept away with gravel on the breaking up of the ice in the spring, would be hopeless. During a long winter, in a country affording abundance of flint, the manufacture of tools would be continually in progress; and, if so, thousands of chips and flakes would be purposely thrown into the ice-hole, besides a great number of implements having flaws, or rejected as too unskilfully made to be worth preserving.

As to the fossil fauna of the drift, considered in relation to the

climate, when, in 1859, I took a collection which I had made of all the more common species of land and freshwater shells from the Amiens and Abbeville drift, to my friend M. Deshayes at Paris, he declared them to be, without exception, the same as those now living in the basin of the Seine. This fact may seem at first sight to imply that the climate had not altered since the flint tools were fabricated; but it appears that all these species of molluscs now range as far north as Norway and Finland, and may therefore have flourished in the valley of the Somme when the river was frozen over annually in winter.* (* See Prestwich, Paper read to the Royal Society in 1862.)

In regard to the accompanying mammalia, some of them, like the mammoth and tichorhine rhinoceros, may have been able to endure the rigours of a northern winter as well as the reindeer, which we find fossil in the same gravel. It is a more difficult point to determine whether the climate of the lower gravels (those of Menchecourt, for example) was more genial than that of the higher ones. Mr. Prestwich inclines to this opinion. None of those contortions of the strata above described have as yet been observed in the lower drift. It contains large blocks of Tertiary sandstone and grit, which may have required the aid of ice to convey them to their present sites; but as such blocks already abounded in the older and higher alluvium, they may simply be monuments of its destruction, having been let down successively to lower and lower levels without making much seaward progress.

The Cyrena fluminalis of Menchecourt and the hippopotamus of St. Roch seem to be in favour of a less severe temperature in winter; but so many of the species of mammalia, as well as of the land and freshwater shells, are common to both formations, and our information respecting the entire fauna is still so imperfect, that it would be premature to pretend to settle this question in the present state of our knowledge. We must be content with the conclusion (and it is one of no small interest), that when Man first inhabited this part of Europe, at the time that the St. Acheul drift was formed, the climate as well as the physical geography of the country differed considerably from the state of things now established there.

Among the elephant remains from St. Acheul, in M. Garnier's collection, Dr. Falconer recognised a molar of the Elephas antiquus, Figure 19, the same species which has been already mentioned as having been found in the lower-level gravels of St. Roch. This species, therefore, endured while important changes took place in the geographical condition of the valley of the Somme. Assuming the lower-level gravel to be the newer, it follows that the Elephas antiquus and the hippopotamus of St. Roch continued to flourish long after the introduction of the mammoth, a well characterised tooth of which, as I before stated, was found at St. Acheul at the time of my visit in 1860.

As flint hatchets and knives have been discovered in the alluvial deposits both at high and low levels, we may safely affirm that Man was as old an inhabitant of this region as were any of the fossil quadrupeds above enumerated, a conclusion which is independent of any difference of opinion as to the relative age of the higher and lower gravels.

The disappearance of many large pachyderms and beasts of prey from Europe has often been attributed to the intervention of Man, and no doubt he played his part in hastening the era of their extinction; but there is good reason for suspecting that other causes co-operated to the same end. No naturalist would for a moment suppose that the extermination of the Cyrena fluminalis throughout the whole of Europe--a species which co-existed with our race in the valley of the Somme, and which was very abundant in the waters of the Thames at the time when the elephant, rhinoceros, and hippopotamus flourished on its banks--was accelerated by human agency. The great modification in climate and in other conditions of existence which affected this aquatic mollusc, may have mainly contributed to the gradual dying out of many of the large mammalia.

We have already seen that the peat of the valley of the Somme is a formation which, in all likelihood, took thousands of years for its growth. But no change of a marked character has occurred in the mammalian fauna since it began to accumulate. The contrast of the fauna of the ancient alluvium, whether at high or low levels, with the fauna of the oldest peat is almost as great as its contrast with the existing fauna, the memorials of Man being common to the whole series; hence we may infer that the interval of time which separated the era of the large extinct mammalia from that of the earliest peat, was of far longer duration than that of the entire growth of the peat. Yet we by no means need the evidence of the ancient fossil fauna to establish the antiquity of Man in this part of France. The mere volume of the drift at various heights would alone suffice to demonstrate a vast lapse of time during which such heaps of shingle, derived both from the Eocene and the Cretaceous rocks, were thrown down in a succession of river-channels. We observe thousands of rounded and half-rounded flints, and a vast number of angular ones, with rounded pieces of white Chalk of various sizes, testifying to a prodigious amount of mechanical action, accompanying the repeated widening and deepening of the valley, before it became the receptacle of peat; and the position of many of the flint tools leaves no doubt in the mind of the geologist that their fabrication preceded all this reiterated denudation.

ON THE ABSENCE OF HUMAN BONES IN THE ALLUVIUM OF THE SOMME.

It is naturally a matter of no small surprise that, after we have collected many hundred flint implements (including knives, many thousands), not a single human bone has yet been met with in the old alluvial sand and gravel of the Somme. This dearth of the mortal remains of our species holds true equally, as yet, in all other parts of Europe where the tool-bearing drift of the Pleistocene period has been investigated in valley deposits. Yet in these same formations there is no want of bones of mammalia belonging to extinct and living species. In the course of the last quarter of a century, thousands of them have been submitted to the examination of skilful osteologists, and they have been unable to detect among them one fragment of a human skeleton, not even a tooth. Yet Cuvier pointed out long ago, that the bones of Man found buried in ancient battle-fields were not more decayed than those of horses interred in the same graves. We have seen that in the Liege caverns, the skulls, jaws, and teeth, with other bones of the human race, were preserved in the same condition as those of the cave-bear, tiger, and mammoth.

That ere long, now that curiosity has been so much excited on this subject, some human remains will be detected in the older alluvium of European valleys, I confidently expect. In the meantime, the absence of all vestige of the bones which belonged to that population by which so many weapons were designed and executed, affords a most striking and instructive lesson in regard to the value of negative evidence, when adduced in proof of the non-existence of certain classes of terrestrial animals at given periods of the past. It is a new and emphatic illustration of the extreme imperfection of the geological record, of which even they who are constantly working in the field cannot easily form a just conception.

We must not forget that Dr. Schmerling, after finding extinct mammalia and FLINT TOOLS in forty-two Belgian caverns, was only rewarded by the discovery of human bones in three or four of those rich repositories of osseous remains. In like manner, it was not till the year 1855 that the first skull of the musk ox (Bubalus moschatus) was detected in the fossiliferous gravel of the Thames, and not till 1860, as will be seen in the next chapter, that the same quadruped was proved to have co-existed in France with the mammoth. The same theory which will explain the comparative rarity of such species would no doubt account for the still greater scarcity of human bones, as well as for our general ignorance of the Pleistocene terrestrial fauna, with the exception of that part of it which is revealed to us by cavern researches.

In valley drift we meet commonly with the bones of quadrupeds which graze on plains bordering rivers. Carnivorous beasts, attracted to the same ground in search of their prey, sometimes leave their remains in the same deposits, but more rarely. The whole assemblage of fossil quadrupeds at present obtained from the alluvium of Picardy is obviously a mere fraction of the entire fauna which flourished contemporaneously with the primitive people by whom the flint hatchets were made.

Instead of its being part of the plan of nature to store up enduring records of a large number of the individual plants and animals which have lived on the surface, it seems to be her chief care to provide the means of disencumbering the habitable areas lying above and below the waters of those myriads of solid skeletons of animals, and those massive trunks of trees, which would otherwise soon choke up every river, and fill every valley. To prevent this inconvenience she employs the heat and moisture of the sun and atmosphere, the dissolving power of carbonic and other acids, the grinding teeth and gastric juices of quadrupeds, birds, reptiles, and fish, and the agency of many of the invertebrata. We are all familiar with the efficacy of these and other causes on the land; and as to the bottoms of seas, we have only to read the published reports of Mr. MacAndrew, the late Edward Forbes, and other experienced dredgers, who, while they failed utterly in drawing up from the deep a single human bone, declared that they scarcely ever met with a work of art even after counting tens of thousands of shells and zoophytes, collected on a coast line of several hundred miles in extent, where they often approached within less than half a mile of a land peopled by millions of human beings.

LAKE OF HAARLEM.

It is not many years since the Government of Holland resolved to lay dry that great sheet of water formerly called the Lake of Haarlem, extending over 45,000 acres. They succeeded, in 1853, in turning it into dry land, by means of powerful pumps constantly worked by steam, which raised the water and discharged it into a canal running for 20 or 30 miles round the newly-gained land. This land was depressed 13 feet beneath the mean level of the ocean. I travelled, in 1859, over part of the bed of this old lake, and found it already converted into arable land, and peopled by an agricultural population of 5000 souls. Mr. Staring, who had been for some years employed by the Dutch Government in constructing a geological map of Holland, was my companion and guide. He informed me that he and his associates had searched in vain for human bones in the deposits which had constituted for three centuries the bed of the great lake.

There had been many a shipwreck, and many a naval fight in those waters, and hundreds of Dutch and Spanish soldiers and sailors had met there with a watery grave. The population which lived on the borders of this ancient sheet of water numbered between thirty and forty thousand souls. In digging the great canal, a fine section had been laid open, about 30 miles long, of the deposits which formed the ancient bottom of the lake. Trenches, also, innumerable, several feet deep, had been freshly dug on all the farms, and their united length must have amounted to thousands of miles. In some of the sandy soil recently thrown out of the trenches, I observed specimens of freshwater and brackish-water shells, such as Unio and Dreissena, of living species; and in clay brought up from below the sand, shells of Tellina, Lutraria, and Cardium, all of species now inhabiting the adjoining sea.

As the Dreissena is believed by conchologists to have been introduced into Western Europe in very modern times, brought with foreign timber in the holds of vessels from the rivers flowing into the Black Sea, the layer of sand containing it in the Haarlem lake is probably not more than a hundred years old.

One or two wrecked Spanish vessels, and arms of the same period, have rewarded the antiquaries who had been watching the draining operations in the hope of a richer harvest, and who were not a little disappointed at the result. In a peaty tract on the margin of one part of the lake a few coins were dug up; but if history had been silent, and if there had been a controversy whether Man was already a denizen of this planet at the time when the area of the Haarlem lake was under water, the archaeologist, in order to answer this question, must have appealed, as in the case of the valley of the Somme, not to fossil bones, but to works of art embedded in the superficial strata.

Mr. Staring, in his valuable memoir on the "Geological Map of Holland," has attributed the general scarcity of human bones in Dutch peat, notwithstanding the many works of art preserved in it, to the power of the humic and sulphuric acids to dissolve bones, the peat in question being plentifully impregnated with such acids. His theory may be correct, but it is not applicable to the gravel of the valley of the Somme, in which the bones of fossil mammalia are frequent, nor to the uppermost freshwater strata forming the

bottom of a large part of the Haarlem Lake, in which it is not pretended that such acids occur.

The primitive inhabitants of the valley of the Somme may have been too wary and sagacious to be often surprised and drowned by floods, which swept away many an incautious elephant or rhinoceros, horse and ox. But even if those rude hunters had cherished a superstitious veneration for the Somme, and had regarded it as a sacred river (as the modern Hindoos revere the Ganges), and had been in the habit of committing the bodies of their dead or dying to its waters--even had such funeral rites prevailed, it by no means follows that the bones of many individuals would have been preserved to our time.

A corpse cast into the stream first sinks, and must then be almost immediately overspread with sediment of a certain weight, or it will rise again when distended with gases, and float perhaps to the sea before it sinks again. It may then be attacked by fish of marine species, some of which are capable of digesting bones. If, before being carried into the sea and devoured, it is enveloped with fluviatile mud and sand, the next flood, if it lie in mid-channel, may tear it out again, scatter all the bones, roll some of them into pebbles, and leave others exposed to destroying agencies; and this may be repeated annually, till all vestiges of the skeleton may disappear. On the other hand, a bone washed through a rent into a subterranean cavity, even though a rarer contingency, may have a greater chance of escaping destruction, especially if there be stalactite dropping from the roof of the cave or walls of a rent, and if the cave be not constantly traversed by too strong a current of engulfed water.

CHAPTER 9.

WORKS OF ART IN PLEISTOCENE ALLUVIUM OF FRANCE AND ENGLAND.

FLINT IMPLEMENTS IN PLEISTOCENE ALLUVIUM IN THE BASIN OF THE SEINE.

In the ancient alluvium of the valleys of the Seine and its principal tributaries, the same assemblage of fossil animals, which has been alluded to in the last chapter as characterising the gravel of Picardy, has long been known; but it was not till the year 1860, and when diligent search had been expressly made for them, that flint implements of the Amiens type were discovered in this part of France.

In the neighbourhood of Paris deposits of drift occur answering both to those of the higher and lower levels of the basin of the Somme before described.* (* Prestwich, "Proceedings of the Royal Society" 1862.) In both are found, mingled with the wreck of the Tertiary and Cretaceous rocks of the vicinity, a large quantity of granitic sand and pebbles, and occasionally large blocks of granite, from a few inches to a foot or more in diameter. These blocks are peculiarly abundant in the lower drift commonly called the "diluvium gris." The granitic materials are traceable to a chain of hills called the Morvan, where the head waters of the Yonne take their rise, 150 miles to the south-south-east of Paris.

It was in this lowest gravel that M. H.T. Gosse, of Geneva, found, in April 1860, in the suburbs of Paris, at La Motte Piquet, on the left bank of the Seine, one or two well-formed flint implements of the Amiens type, accompanied by a great number of ruder tools or attempts at tools. I visited the spot in 1861 with M. Hebert, and saw the stratum from which the worked flints had been extracted, 20 feet below the surface, and near the bottom of the "grey diluvium,"

a bed of gravel from which I have myself, in and near Paris, frequently collected the bones of the elephant, horse, and other mammalia.

More recently, M. Lartet has discovered at Clichy, in the environs of Paris, in the same lower gravel, a well-shaped flint implement of the Amiens type, together with remains both of Elephas primigenius and E. antiquus. No tools have yet been met with in any of the gravels occurring at the higher levels of the valley of the Seine; but no importance can be attached to this negative fact, as so little search has yet been made for them.

Mr. Prestwich has observed contortions indicative of ice-action, of the same kind as those near Amiens, in the higher-level drift of Charonne, near Paris; but as yet no similar derangement has been seen in the lower gravels--a fact, so far as it goes, in unison with the phenomena observed in Picardy.

In the cavern of Arcy-sur-Yonne a series of deposits have lately been investigated by the Marquis de Vibraye, who discovered human bones in the lowest of them, mixed with remains of quadrupeds of extinct and recent species. This cavern occurs in Jurassic limestone, at a slight elevation above the Cure, a small tributary of the Yonne, which last joins the Seine near Fontainebleau about 40 miles south of Paris. The lowest formation in the cavern resembles the "diluvium gris" of Paris, being composed of granitic materials, and like it derived chiefly from the waste of the crystalline rocks of the Morvan. In it have been found the two branches of a human lower jaw with teeth well-preserved, and the bones of the Elephas primigenius, Rhinoceros tichorhinus, Ursus spelaeus, Hyaena spelaea, and Cervus tarandus, all specifically determined by M. Lartet. I have been shown this collection of fossils by M. de Vibraye, and remarked that the human and other remains were in the same condition and of the same colour.

Above the grey gravel is a bed of red alluvium, made up of fragments of Jurassic limestone, in a red argillaceous matrix, in which were embedded several flint knives, with bones of the

reindeer and horse, but no extinct mammalia. Over this, in a higher bed of alluvium, were several polished hatchets of the more modern type called "celts," and above all loam or cave-mud, in which were Gallo-Roman antiquities.* (* "Bulletin de la Societe Geologique de France" 1860.)

The French geologists have made as yet too little progress in identifying the age of the successive deposits of ancient alluvium of various parts of the basin of the Seine, to enable us to speculate with confidence as to the coincidence in date of the granitic gravel with human bones of the Grotte d'Arcy and the stone-hatchets buried in "grey diluvium" of La Motte Piquet, before mentioned; but as the associated extinct mammalia are of the same species in both localities, I feel strongly inclined to believe that the stone hatchets found by M. Gosse at Paris, and the human bones discovered by M. de Vibraye, may be referable to the same period.

VALLEY OF THE OISE.

A flint hatchet, of the old Abbeville and Amiens type, was found lately by M. Peigne Delacourt at Precy, near Creil, on the Oise, in gravel, resembling, in its geological position, the lower-level gravels of Montiers, near Amiens, already described. I visited these extensive gravel-pits in 1861, in company with Mr. Prestwich; but we remained there too short a time to entitle us to expect to find a flint implement, even if they had been as abundant as at St. Acheul.

In 1859, I examined, in a higher part of the same valley of the Oise, near Chauny and Noyon, some fine railway cuttings, which passed continuously through alluvium of the Pleistocene period for half a mile. All this alluvium was evidently of fluviatile origin, for, in the interstices between the pebbles, the Ancylus fluviatilis and other freshwater shells were abundant. My companion, the Abbe E. Lambert, had collected from the gravel a great many fossil bones, among which M. Lartet has recognised both Elephas primigenius and E. antiquus, besides a species of hippopotamus (H. major ?), also the reindeer, horse, and the musk ox (Bubalus moschatus). The latter seems never to have been seen before in the old alluvium of France.* (* Lartet, "Annales des Sciences Naturelles Zoologiques" tome 15 page 224.) Over the gravel above mentioned, near Chauny, are seen dense masses of loam like the loess of the Rhine, containing shells of the genera Helix and Succinea. We may suppose that the gravel containing the flint hatchet at Precy is of the same age as that of Chauny, with which it is continuous, and that both of them are coeval with the tool-bearing beds of Amiens, for the basins of the Oise and the Somme are only separated by a narrow water-shed, and the same fossil quadrupeds occur in both.

The alluvium of the Seine and its tributaries, like that of the Somme, contains no fragments of rocks brought from any other hydrographical basin; yet the shape of the land, or fall of the river, or the climate, or all these conditions, must have been very different when the grey alluvium in which the flint tools occur at Paris was formed. The great size of some of the blocks of granite, and the distance which they have travelled, imply a power in the river which it no longer possesses. We can hardly doubt that

river-ice once played a much more active part than now in the transportation of such blocks, one of which may be seen in the Museum of the Ecole des Mines at Paris, 3 or 4 feet in diameter.

PLEISTOCENE ALLUVIUM OF ENGLAND, CONTAINING WORKS OF ART.

In the ancient alluvium of the basin of the Thames, at moderate heights above the main river and its tributaries, we find fossil bones of the same species of extinct and living mammalia, accompanied by recent species of land and freshwater shells, as we have shown to be characteristic of the basins of the Somme and the Seine. We can scarcely therefore doubt that these quadrupeds, during some part of the Pleistocene period, ranged freely from the continent of Europe to England, at a time when there was an uninterrupted communication by land between the two countries. The reader will not therefore be surprised to learn that flint implements of the same antique type as those of the valley of the Somme have been detected in British alluvium.

The most marked feature of this alluvium in the Thames valley is that great bed of ochreous gravel, composed chiefly of broken and slightly worn Chalk flints, on which a great part of London is built. It extends from above Maidenhead through the metropolis to the sea, a distance from west to east of 50 miles, having a width varying from 2 to 9 miles. Its thickness ranges commonly from 5 to 15 feet.* (* Prestwich, "Quarterly Journal of the Geological Society" volume 12 1856 page 131.) Interstratified with this gravel, in many places, are beds of sand, loam, and clay, the whole containing occasionally remains of the mammoth and other extinct quadrupeds. Fine sections have been exposed to view, at different periods, at Brentford and Kew Bridge, others in London itself, and below it at Erith in Kent, on the right bank of the Thames, and at Ilford and Gray's Thurrock in Essex, on the left bank. The united thickness of the beds of sand, gravel, and loam amounts sometimes to 40 or even 60 feet. They are for the most part elevated above, but in some cases they descend below, the present level of the overflowed plain of the Thames.

If the reader will refer to the section of the Pleistocene sands and gravels of Menchecourt, near Abbeville, given at page 96, he will perfectly understand the relations of the ancient Thames alluvium to the modern channel and plain of the river, and their relation, on the other hand, to the boundary formations of older date, whether Tertiary or Cretaceous.

So far as they are known, the fossil mollusca and mammalia of the two districts also agree very closely, the Cyrena fluminalis being common to both, and being the only extra-European shell, this and all the species of testacea being Recent. Of this agreement with the living fauna there is a fine illustration in Essex; for the determination of which we are indebted to the late Mr. John Brown, F.G.S., who collected at Copford, in Essex, from a deposit containing bones of the mammoth, a large bear (probably Ursus spelaeus), a beaver, stag, and aurochs, no less than sixty-nine species of land and freshwater shells. Forty-eight of these were terrestrial, and two of them, Helix incarnata and H. ruderata, no longer inhabit the British Isles, but are still living on the continent, ruderata in high northern latitudes.* (* "Quarterly Journal of the Geological Society" volume 8 1852 page 190. Mr.

Brown calls them extinct species, which may mislead some readers, but he merely meant extinct in England. See also Jeffreys, "Brit. Conch." page 174.) The Cyrena fluminalis and the Unio littoralis, to which last I shall presently allude, were not among the number.

I long ago suggested the hypothesis, that in the basin of the Thames there are indications of a meeting in the Pleistocene period of a northern and southern fauna. To the northern group may have belonged the mammoth (Elephas primigenius) and the Rhinoceros tichorhinus, both of which Pallas found in Siberia, preserved with their flesh in the ice. With these are occasionally associated the reindeer. In 1855 the skull of the musk ox (Bubalus moschatus) was also found in the ochreous gravel of Maidenhead, by the Reverend C. Kingsley and Mr. Lubbock; the identification of this fossil with the living species being made by Professor Owen. A second fossil skull of the same arctic animal was afterwards found by Mr. Lubbock near Bromley, in the valley of a small tributary of the Thames; and two other skulls, those of a bull and a cow were dug up near Bath Easton from the gravel of the valley of the Avon by Mr. Charles Moore. Professor Owen has truly said, that "as this quadruped has a constitution fitting it at present to inhabit the high northern regions of America, we can hardly doubt that its former companions, the warmly-clad mammoth and the two-horned woolly rhinoceros (R. tichorhinus), were in like manner capable of supporting life in a cold climate."* (* "Quarterly Journal of the Geological Society" volume 12 1856 page 124.)

I have already alluded to the recent discovery of this same ox near Chauny, in the valley of the Oise, in France; and in 1856 I found a skull of it preserved in the museum at Berlin, which Professor Quenstedt, the curator, had correctly named so long ago as 1836, when the fossil was dug out of drift, in the hill called the Kreuzberg, in the southern suburbs of that city. By an account published at the time, we find that the mammalia which accompanied the musk ox were the mammoth and tichorhine rhinoceros, with the horse and ox;* (* "Leonhard and Bronn's Jahrbuch" 1836 page 215.) but I can find no record of the occurrence of a hippopotamus, nor of Elephas antiquus or Rhinoceros leptorhinus, in the drift of the north of Germany, bordering the Baltic.

On the other hand, in another locality in the same drift of North Germany, Dr. Hensel, of Berlin, detected, near Quedlinburg, the Norwegian Lemming (Myodes lemmus), and another species of the same family called by Pallas Myodes torquatus (by Hensel, Misothermus torquatus)--a still more arctic quadruped, found by Parry in latitude 82 degrees, and which never strays farther south than the northern borders of the woody region. Professor Beyrich also informs me that the remains of the Rhinoceros tichorhinus were obtained at the same place.* (* "Zeitschrift der Deutschen Geologischen Gesellschaft" volume 7 1855 page 497 etc.)

As an example of what may possibly have constituted a more southern fauna in the valley of the Thames, I may allude to the fossil remains found in the fluviatile alluvium of Gray's Thurrock, in Essex, situated on the left bank of the river, 21 miles below London. The strata of brick-earth, loam, and gravel exposed to view in artificial excavations in that spot, are precisely such as would be formed by the silting up of an old river channel. Among the mammalia are Elephas antiquus, Rhinoceros leptorhinus (R.

megarhinus, Christol), Hippopotamus major, species of horse, bear, ox, stag, etc., and, among the accompanying shells, Cyrena fluminalis, which is extremely abundant, instead of being scarce, as at Abbeville. It is associated with Unio littoralis also in great numbers and with both valves united. This conspicuous freshwater mussel is no longer an inhabitant of the British Isles, but still lives in the Seine, and is still more abundant in the Loire. Another freshwater univalve (Paludina marginata, Michaud), not British, but common in the south of France, likewise occurs, and a peculiar variety of Cyclas amnica, which by some naturalists has been regarded as a distinct species. With these, moreover, is found a peculiar variety of Valvata piscinalis.

If we consult Dr. Von Schrenck's account of the living mammalia of Mongolia, lying between latitude 45 and 55 degrees north, we learn that, in that part of North-Eastern Asia recently annexed to the Russian empire, no less than thirty-four out of fifty-eight living quadrupeds are identical with European species, while some of those which do not extend their range to Europe are arctic, others tropical forms. The Bengal tiger ranges northwards occasionally to latitude 52 degrees north, where he chiefly subsists on the flesh of the reindeer, and the same tiger abounds in latitude 48 degrees, to which the small tailless hare or pika, a polar resident, sometimes wanders southwards.* (* Mammalia of Amoorland, "Natural History Review" volume 1 1861 page 12.) We may readily conceive that the countries now drained by the Thames, the Somme, and the Seine, were, in the Pleistocene period, on the borders of two distinct zoological provinces, one lying to the north, the other to the south, in which case many species belonging to each fauna endowed with migratory habits, like the living musk-ox or the Bengal tiger, may have been ready to take advantage of any, even the slightest, change in their favour to invade the neighbouring province, whether in the summer or winter months, or permanently for a series of years, or centuries. The Elephas antiquus and its associated Rhinoceros leptorhinus may have preceded the mammoth and tichorhine rhinoceros in the valley of the Thames, or both may have alternately prevailed in the same area in the Pleistocene period.

In attempting to settle the chronology of fluviatile deposits, it is almost equally difficult to avail ourselves of the evidence of organic remains and of the superposition of the strata, for we may find two old river-beds on the same level in juxtaposition, one of them perhaps many thousands of years posterior in date to the other. I have seen an example of this at Ilford, where the Thames, or a tributary stream, has at some former period cut through sands containing Cyrena fluminalis, and again filled up the channel with argillaceous matter, evidently derived from the waste of the Tertiary London Clay. Such shiftings of the site of the main channel of the river, the frequent removal of gravel and sand previously deposited, and the throwing down of new alluvium, the flooding of tributaries, the rising and sinking of the land, fluctuations in the cold and heat of the climate--all these changes seem to have given rise to that complexity in the fluviatile deposits of the Thames, which accounts for the small progress we have hitherto made in determining their order of succession, and that of the imbedded groups of quadrupeds. It may happen, as at Brentford and Ilford, that sand-pits in two adjoining fields may each contain distinct species of elephant and rhinoceros; and the fossil remains in both cases may occur at the same depth from the

surface, yet may be severally referable to different parts of the Pleistocene epoch, separated by thousands of years.

The relation of the glacial period to alluvial deposits, such as that of Gray's Thurrock, where the Cyrena fluminalis, Unio littoralis, and the hippopotamus seem rather to imply a warmer climate, has been a matter of long and animated discussion. Patches of the northern drift, at elevations of about 200 feet above the Thames, occur in the neighbourhood of London, as at Muswell Hill, near Highgate. In this drift, blocks of granite, syenite, greenstone, Coal-measure sandstone with its fossils, and other Palaeozoic rocks, and the wreck of Chalk and Oolite, occur confusedly mixed together. The same glacial formation is also found capping some of the Essex hills farther to the east, and extending some way down their southern slopes towards the valley of the Thames. Although no fragments washed out of these older and upland drifts have been found in the gravel of the Thames containing elephants' bones, it is fair to presume, as Mr. Prestwich has contended,* that the glacial formation is the older of the two. (* Prestwich, "Quarterly Journal of the Geological Society" volume 11 1855 page 110; ibid. volume 12 1856 page 133; ibid. volume 17 1861 page 446.) In short, we must suppose that the basin of the Thames and all its fluviatile deposits are post-glacial, in the modified sense of that term; i.e. that they were subsequent to the drift of the central and northern counties.

Having offered these general remarks on the alluvium of the Thames, I may now say something of the implements hitherto discovered in it. In the British Museum there is a flint weapon of the spear-headed form, such as is represented in Figure 8, which we are told was found with an elephant's tooth at Black Mary's, near Gray's Inn Lane, London. In a letter dated 1715, printed in Herne's edition of "Leland's Collectanea," volume 1 page 73, it is stated to have been found in the presence of Mr. Conyers, with the skeleton of an elephant.* (* Evans, "Archaeologia" 1860.) So many bones of the elephant, rhinoceros, and hippopotamus have been found in the gravel on which London stands, that there is no reason to doubt the statement as handed down to us. Fossil remains of all these three genera have been dug up on the site of Waterloo Place, St. James's Square, Charing Cross, the London Docks, Limehouse, Bethnal Green, and other places within the memory of persons now living. In the gravel and sand of Shacklewell, in the north-east district of London, I have myself collected specimens of the Cyrena fluminalis in great numbers (see Figure 17 c), with the bones of deer and other mammalia.

In the alluvium also of the Wey, near Guildford, in a place called Pease Marsh, a wedge-shaped flint implement, resembling one brought from St. Acheul by Mr. Prestwich, and compared by some antiquaries to a sling-stone, was obtained in 1836 by Mr. Whitburn, 4 feet deep in sand and gravel, in which the teeth and tusks of elephants had been found. The Wey flows through the gorge of the North Downs at Guildford to join the Thames. Mr. Austen has shown that this drift is so ancient that one part of it had been disturbed and tilted before another part was thrown down.* (* "Quarterly Journal of the Geological Society" volume 7 1851 page 278.)

Among other places where flint tools of the antique type have been met with in the course of the last three years, I may mention one

of an oval form found by Mr. Whitaker in the valley of the Darent, in Kent, and another which Mr. Evans found lying on the shore at Swalecliff, near Whitstable, in the same county, where Mr. Prestwich had previously described a freshwater deposit, resting on the London Clay, and consisting chiefly of gravel, in which an elephant's tooth and the bones of a bear were embedded. The flint implement was deeply discoloured and of a peculiar bright light-brown colour, similar to that of the old fluviatile gravel in the cliff.

Another flint implement was found in 1860 by Mr. T. Leech, at the foot of the cliff between Herne Bay and the Reculvers, and on further search five other specimens of the spear-head pattern so common at Amiens. Messrs. Prestwich and Evans have since found three other similar tools on the beach, at the base of the same wasting cliff, which consists of sandy Eocene strata, covered by a gravelly deposit of freshwater origin, about 50 feet above the sea-level, from which the flint weapons must have been derived. Such old alluvial deposits now capping the cliffs of Kent seem to have been the river-beds of tributaries of the Thames before the sea encroached to its present position and widened its estuary. On following up one of these freshwater deposits westward of the Reculvers, Mr. Prestwich found in it, at Chislet, near Grove Ferry, the Cyrena fluminalis among other shells.

The changes which have taken place in the physical geography of this part of England during, or since, the Pleistocene period, have consisted partly of such encroachments of the sea on the coast as are now going on, and partly of a general subsidence of the land. Among the signs of the latter movement may be mentioned a freshwater formation at Faversham, below the level of the sea. The gravel there contains exclusively land and fluviatile shells of the same species as those of other localities of the Pleistocene alluvium before mentioned, and must have been formed when the river was at a higher level and when it extended farther east. At that era it was probably a tributary of the Rhine, as represented by Mr. Trimmer in his ideal restoration of the geography of the olden time.* (* "Quarterly Journal of the Geological Society" volume 9 1853 Plate 8 Number 4.) For England was then united to the continent, and what is now the North Sea was land. It is well known that in many places, especially near the coast of Holland, elephants' tusks and other bones are often dredged up from the bed of that shallow sea, and the reader will see in the map given in Chapter 13 how vast would be the conversion of sea into land by an upheaval of 600 feet. Vertical movements of much less than half that amount would account for the annexation of England to the continent, and the extension of the Thames and its valley far to the north-east, and the flowing of rivers from the easternmost parts of Kent and Essex into the Thames, instead of emptying themselves into its estuary.

More than a dozen flint weapons of the Amiens type have already been found in the basin of the Thames; but the geological position of no one of them has as yet been ascertained with the same accuracy as that of many of the tools dug up in the valley of the Somme.

FLINT IMPLEMENTS OF THE VALLEY OF THE OUSE, NEAR BEDFORD.

The ancient fluviatile gravel of the valley of the Ouse, around Bedford, has been noted for the last thirty years for yielding to collectors a rich harvest of the bones of extinct mammalia. By observations made in 1854 and 1858, Mr. Prestwich had ascertained that the valley was bounded on both sides by Oolitic strata, capped by boulder clay, and that the gravel Number 3, Figure 23, contained bones of the elephant, rhinoceros, hippopotamus, ox, horse, and deer, which animals he therefore inferred must have been posterior in date to the boulder clay, through which, as well as the subjacent Oolite, the valley had been excavated. Mr. Evans had found in the same gravel many land and freshwater shells, and these discoveries induced Mr. James Wyatt, of Bedford, to pay two visits to St. Acheul in order to compare the implement-bearing gravels of the Somme with the drift of the valley of the Ouse. After his return he resolved to watch carefully the excavation of the gravel-pits at Biddenham, 2 miles west-north-west of Bedford, in the hope of finding there similar works of art. With this view he paid almost daily visits for months in succession to those pits, and was at last rewarded by the discovery of two well-formed implements, one of the spear-head and the other of the oval shape, perfect counterparts of the two prevailing French types. Both specimens were thrown out by the workmen on the same day from the lowest bed of stratified gravel and sand, 13 feet thick, containing bones of the elephant, deer, and ox, and many freshwater shells. The two implements occurred at the depth of 13 feet from the surface of the soil, and rested immediately on solid beds of Oolitic limestone, as represented in the accompanying section (Figure 23).

Having been invited by Mr. Wyatt to verify these facts, I went to Biddenham within a fortnight of the date of his discovery (April 1861), and, for the first time, saw evidence which satisfied me of the chronological relations of those three phenomena, the antique tools, the extinct mammalia, and the glacial formation. On that occasion I examined the pits in company with Messrs. Prestwich, Evans, and Wyatt, and we collected ten species of shells from the stratified drift Number 3, or the beds overlying the lowest gravel from which the flint implements had been exhumed. They were all of common fluviatile and land species now living in the same part of England. Since our visit, Mr. Wyatt has added to them Paludina marginata, Michaud (Hydrobia of some authors), a species of the South of France no longer inhabiting the British Isles. The same geologist has also found, since we were at Biddenham, several other flint tools of corresponding type, both there and at other localities in the valley of the Ouse, near Bedford.

(FIGURE 23. SECTION ACROSS THE VALLEY OF THE OUSE, TWO MILES WEST-NORTH-WEST OF BEDFORD.*

(* Prestwich, "Quarterly Journal of the Geological Society" volume 17 1861 page 364; and Wyatt, "Geologist" 1861 page 242.)

1. Oolitic strata.
2. Boulder clay, or marine northern drift, rising to about ninety feet above the Ouse.
3. Ancient gravel, with elephant bones, freshwater shells, and flint implements.
4. Modern alluvium of the Ouse.

a. Biddenham gravel pits, at the bottom of which flint tools were found.)

The boulder clay Number 2 extends for miles in all directions, and was evidently once continuous from b to c before the valley was scooped out. It is a portion of the great marine glacial drift of the midland counties of England, and contains blocks, some of large size, not only of the Oolite of the neighbourhood, but of Chalk and other rocks transported from still greater distances, such as syenite, basalt, quartz, and New Red Sandstone. These erratic blocks of foreign origin are often polished and striated, having undergone what is called glaciation, of which more will be said by and by. Blocks of the same mineral character, embedded at Biddenham in the gravel Number 3, have lost all signs of this striation by the friction to which they were subjected in the old river bed.

The great width of the valley of the Ouse, which is sometimes 2 miles, has not been expressed in the diagram. It may have been shaped out by the joint action of the river and the tides when this part of England was emerging from the waters of the glacial sea, the boulder clay being first cut through, and then an equal thickness of underlying Oolite. After this denudation, which may have accompanied the emergence of the land, the country was inhabited by the primitive people who fashioned the flint tools. The old river, aided perhaps by the continued upheaval of the whole country, or by oscillations in its level, went on widening and deepening the valley, often shifting its channel, until at length a broad area was covered by a succession of the earliest and latest deposits, which may have corresponded in age to the higher and lower gravels of the valley of the Somme, already described.

At Biddenham, and elsewhere in the same gravel, remains of Elephas antiquus have been discovered, and Mr. Wyatt obtained, January 1863, a flint implement associated with bones and teeth of hippopotamus from gravel at Summerhouse hill, which lies east of Bedford, lower down the valley of the Ouse, and 4 miles from Biddenham.

One step at least we gain by the Bedford sections, which those of Amiens and Abbeville had not enabled us to make. They teach us that the fabricators of the antique tools, and the extinct mammalia coeval with them, were all post-glacial.

FLINT IMPLEMENTS IN A FRESHWATER DEPOSIT AT HOXNE IN SUFFOLK [NOTE 17].

So early as the first year of the nineteenth century, a remarkable paper was communicated to the Society of Antiquaries by Mr. John Frere, in which he gave a clear description of the discovery at Hoxne, near Diss, in Suffolk, of flint tools of the type since found at Amiens, adding at the same time good geological reasons

for presuming that their antiquity was very great, or, as he expressed it, beyond that of the present world, meaning the actual state of the physical geography of that region. "The flints," he said, "were evidently weapons of war, fabricated and used by a people who had not the use of metals. They lay in great numbers at the depth of about 12 feet in a stratified soil which was dug into for the purpose of raising clay for bricks. Under a foot and a half of vegetable earth was clay 7 1/2 feet thick, and beneath this one foot of sand with shells, and under this 2 feet of gravel, in which

the shaped flints were found generally at the rate of 5 or 6 in a square yard. In the sandy beds with shells were found the jawbone and teeth of an enormous unknown animal. The manner in which the flint weapons lay would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit. Their numbers were so great that the man who carried on the brick-work told me that before he was aware of their being objects of curiosity, he had emptied baskets full of them into the ruts of the adjoining road."

Mr. Frere then goes on to explain that the strata in which the flints occur are disposed horizontally, and do not lie at the foot of any higher ground, so that portions of them must have been removed when the adjoining valley was hollowed out. If the author had not mistaken the freshwater shells associated with the tools for marine species, there would have been nothing to correct in his account of the geology of the district, for he distinctly perceived that the strata in which the implements were embedded had, since that time, undergone very extensive denudation.* (* Frere, "Archaeologia" volume 13 1800 page 206.) Specimens of the flint spear-heads, sent to London by Mr. Frere, are still preserved in the British Museum, and others are in the collection of the Society of Antiquaries.

(FIGURE 24. SECTION SHOWING THE POSITION OF THE FLINT WEAPONS AT HOXNE, NEAR DISS, SUFFOLK.
See Prestwich "Philosophical Transactions" Plate 11 1860.)

1. Gravel of Gold Brook, a tributary of the Waveney.
2. Higher-level gravel overlying the freshwater deposit.
3 and 4. Sand and gravel, with freshwater shells, and flint implements, and bones of mammalia.
5. Peaty and clayey beds, with same fossils.
6. Boulder clay or glacial drift.
7. Sand and gravel below boulder clay.
8. Chalk with flints.)

Mr. Prestwich's attention was called by Mr. Evans to these weapons, as well as to Mr. Frere's memoir after his return from Amiens in 1859, and he lost no time in visiting Hoxne, a village five miles eastward of Diss. It is not a little remarkable that he should have found, after a lapse of sixty years, that the extraction of clay was still going on in the same brick-pit. Only a few months before his arrival, two flint instruments had been dug out of the clay, one from a depth of 7 and the other of 10 feet from the surface. Others have since been disinterred from undisturbed beds of gravel in the same pit. Mr. Amyot of Diss has also obtained from the underlying freshwater strata the astragalus of an elephant, and bones of the deer and horse; but although many of the old implements have recently been discovered in situ in regular strata and preserved by Sir Edward Kerrison, no bones of extinct mammalia seem as yet to have been actually seen in the same stratum with one of the tools.

By reference to the annexed section, the geologist will see that the basin-shaped hollow a, b, c has been filled up gradually with the freshwater strata 3, 4, 5, after the same cavity a, b, c had been previously excavated out of the more ancient boulder clay Number 6. The relative position of these formations will be better

understood when I have described in the twelfth chapter the structure of Norfolk and Suffolk as laid open in the sea-cliffs at Mundesley, about 30 miles distant from Hoxne, in a north-north-east direction.

I examined the deposits at Hoxne in 1860, when I had the advantage of being accompanied by the Reverend J. Gunn and the Reverend S.W. King. In the loamy beds 3 and 4, Figure 24, we observed the common river shell Valvata piscinalis in great numbers. With it, but much more rare, were Limnaea palustris, Planorbis albus, P. Spirorbis, Succinea putris, Bithynia tentaculata, Cyclas cornea; and Mr. Prestwich mentions Cyclas amnica and fragments of a Unio, besides several land shells. In the black peaty mass Number 5, fragments of wood of the oak, yew, and fir have been recognised. The flint weapons which I have seen from Hoxne are so much more perfect, and have their cutting edge so much sharper than those from the valley of the Somme, that they seem neither to have been used by Man, nor to have been rolled in the bed of a river. The opinion of Mr. Frere, therefore, that there may have been a manufactory of weapons on the spot, appears probable.

FLINT IMPLEMENTS AT ICKLINGHAM IN SUFFOLK.

In another part of Suffolk, at Icklingham, in the valley of the Lark, below Bury St. Edmund's, there is a bed of gravel, in which teeth of Elephas primigenius and several flint tools, chiefly of a lance-head form, have been found. I have twice visited the spot, which has been correctly described by Mr. Prestwich.* (* "Quarterly Journal of the Geological Society" volume 17 1861, page 364.)

The section of the Bedford tool-bearing alluvium, given in Figure 23, may serve to illustrate that of Icklingham, if we substitute Chalk for Oolite, and the river Lark for the Ouse. In both cases, the present bed of the river is about 30 feet below the level of the old gravel, and the Chalk hill, which bounds the valley of the Lark on the right side, is capped like the Oolite of Biddenham by boulder clay, which rises to the height of 100 feet above the Lark. About twelve years ago, a large erratic block, above 4 feet in diameter, was dug out of the boulder clay at Icklingham, which I found to consist of a hard siliceous schist, which must have come from a remote region. The tool-bearing gravel here, as in the case to which it has been compared near Bedford, is proved to be newer than the glacial drift, by containing pebbles of basalt and other rocks derived from that formation.

CHAPTER 10.

CAVERN DEPOSITS, AND PLACES OF SEPULTURE OF THE PLEISTOCENE PERIOD.

Flint Implements in Cave containing Hyaena and other extinct Mammalia in Somersetshire.
Caves of the Gower Peninsula in South Wales.
Rhinoceros hemitoechus.
Ossiferous Caves near Palermo.
Sicily once part of Africa.
Rise of Bed of the Mediterranean to the Height of three hundred Feet in the Human Period in Sardinia.

Burial-place of Pleistocene Date of Aurignac in the South of France.
Rhinoceros tichorhinus eaten by Man.
M. Lartet on extinct Mammalia and Works of Art found in the Aurignac Cave.
Relative Antiquity of the same considered.

WORKS OF ART ASSOCIATED WITH EXTINCT MAMMALIA IN A CAVERN IN SOMERSETSHIRE.

The only British cave from which implements resembling those of Amiens have been obtained, since the attention of geologists has been awakened to the importance of minutely observing the position of such relics relatively to the associated fossil mammalia, is that recently opened near Wells in Somersetshire. It occurs near the cave of Wookey Hole, from the mouth of which the river Axe issues on the southern flanks of the Mendips. No one had suspected that on the left side of the ravine, through which the river flows after escaping from its subterranean channel, there were other caves and fissures concealed beneath the green sward of the steep sloping bank. About ten years ago, a canal was made, several hundred yards in length, for the purpose of leading the waters of the Axe to a paper-mill, now occupying the middle of the ravine. In carrying out this work, about 12 feet of the left bank was cut away, and a cavernous fissure, choked up to the roof with ossiferous loam, was then, for the first time, exposed to view. This great cavity, originally 9 feet high and 36 wide, traversed the Dolomitic Conglomerate; and fragments of that rock, some angular and others water-worn, were scattered through the red mud of the cave, in which fossil remains were abundant. For an account of them and the position they occupied we are indebted to Mr. Dawkins, F.G.S., who, in company with Mr. Williamson, explored the cavern in 1859, and obtained from it the bones of the Hyaena spelaea in such numbers as to lead him to conclude that the cavern had for a long time been a hyaena's den. Among the accompanying animals found fossil in the same bone-earth, were observed Elephas primigenius, Rhinoceros tichorhinus, Ursus spelaeus, Bos primigenius, Megaceros hibernicus, Cervus tarandus (and other species of Cervus), Felis spelaea, Canis lupus, Canis vulpes, and teeth and bones of the genus Equus in great numbers.

Intermixed with the above fossil bones were some arrowheads, made of bone, and many chipped flints, and chipped pieces of chert, a white or bleached flint weapon of the spearhead Amiens type, which was taken out of the undisturbed matrix by Mr. Williamson himself, together with a hyaena's tooth, showing that Man had either been contemporaneous with or had preceded the extinct fauna. After penetrating 34 feet from the entrance, Mr. Dawkins found the cave bifurcating into two branches, one of which was vertical. By this rent, perhaps, some part of the contents of the cave may have been introduced.* (* Boyd Dawkins, "Proceedings of the Geological Society" January 1862.)

When I examined the spot in 1860, after I had been shown some remains of the hyaena collected there, I felt convinced that a complete revolution must have taken place in the topography of the district since the time of the extinct quadrupeds. I was not aware at the time that flint tools had been met with in the same bone-deposit.

CAVES OF GOWER IN GLAMORGANSHIRE, SOUTH WALES.

The ossiferous caves of the peninsula of Gower in Glamorganshire have been diligently explored of late years by Dr. Falconer and Lieutenant-Colonel E.R. Wood, who have thoroughly investigated the contents of many which were previously unknown. Among these Dr. Falconer's skilled eye has recognised the remains of almost every quadruped which he had elsewhere found fossil in British caves: in some places the Elephas primigenius, accompanied by its usual companion, the Rhinoceros tichorhinus, in others Elephas antiquus, associated with Rhinoceros hemitoechus, Falconer; the extinct animals being often embedded, as in the Belgian caves, in the same matrix with species now living in Europe, such as the common badger (Meles taxus), the common wolf, and the fox.

In a cavernous fissure called the Raven's Cliff, teeth of several individuals of Hippopotamus major, both young and old, were found; and this in a district where there is now scarce a rill of running water, much less a river in which such quadrupeds could swim. In one of the caves, called Spritsail Tor, bones of the elephants above named were observed, with a great many other quadrupeds of Recent and extinct species.

From one fissure, called Bosco's Den, no less than one thousand antlers of the reindeer, chiefly of the variety called Cervus Guettardi, were extracted by the persevering exertions of Colonel Wood, who estimated that several hundred more still remained in the bone-earth of the same rent.

They were mostly shed horns, and of young animals; and had been washed into the rent with other bones, and with angular fragments of limestone, and all enveloped in the same ochreous mud. Among the other bones, which were not numerous, were those of the cave-bear, wolf, fox, ox, stag, and field-mouse.

But the discovery of most importance, as bearing on the subject of the present work, is the occurrence in a newly-discovered cave, called Long Hole, by Colonel Wood, in 1861, of the remains of two species of rhinoceros, R. tichorhinus and R. hemitoechus, Falconer, in an undisturbed deposit, in the lower part of which were some well-shaped flint knives, evidently of human workmanship. It is clear from their position that Man was coeval with these two species. We have elsewhere independent proofs of his co-existence with every other species of the cave-fauna of Glamorganshire; but this is the first well-authenticated example of the occurrence of R. hemitoechus in connection with human implements.

In the fossil fauna of the valley of the Thames, Rhinoceros leptorhinus was mentioned as occurring at Gray's Thurrock with Elephas antiquus. Dr. Falconer, in a memoir which he is now preparing for the press on the European Pliocene and Pleistocene species of the genus Rhinoceros, has shown that, under the above name of R. leptorhinus, three distinct species have been confounded by Cuvier, Owen, and other palaeontologists:--

1. R. megarhinus, Christol, being the original and typical R. leptorhinus of Cuvier, founded on Cortesi's Monte Zago cranium, and the ONLY Pliocene, or Pleistocene European species, that had not a nasal septum.--Gray's Thurrock, etc.

2. R. hemitoechus, Falconer, in which the ossification of the septum dividing the nostrils is incomplete in the middle, besides other cranial and dental characters distinguishing it from R. tichorhinus, accompanies Elephas antiquus in most of the oldest British bone-caves, such as Kirkdale, Cefn, Durdham Down, Minchin Hole, and other Gower caverns--also found at Clacton, in Essex, and in Northamptonshire.

3. R. etruscus, Falconer, a comparatively slight and slender form, also with an incomplete bony septum,* (* Falconer, "Quarterly Journal of the Geological Society" volume 15 1859 page 602.) occurs deep in the Val d'Arno deposits, and in the "Forest bed," and superimposed blue clays, with lignite, of the Norfolk coast, but nowhere as yet found in the ossiferous caves in Britain.

Dr. Falconer announced in 1860 his opinion that the filling up of the Gower caves in South Wales took place after the deposition of the marine boulder clay,* (* Ibid. volume 16 1860 page 491.) an opinion in harmony with what we have since learnt from the section of the gravels near Bedford, given above (Figure 23), where a fauna corresponding to that of the Welsh caves characterises the ancient alluvium, and is shown to be clearly post-glacial, in the sense of being posterior in date to the boulder-clay of the midland counties. In the same sense the late Edward Forbes declared, in 1846, his conviction that not only the Cervus megaceros, but also the mammoth and other extinct pachyderms and carnivora, had lived in Britain in post-glacial times.* (* "Memoir of the Geological Survey" pages 394 to 397.) The Gower caves in general have their floors strewed over with sand, containing marine shells, all of living species; and there are raised beaches on the adjoining coast, and other geological signs of great alteration in the relative level of land and sea, since that country was inhabited by the extinct mammalia, some of which, as we have seen, were certainly coeval with Man.

OSSIFEROUS CAVES IN THE NORTH OF SICILY.

Geologists have long been familiar with the fact that on the northern coast of Sicily, between Termini on the east, and Trapani on the west, there are several caves containing the bones of extinct animals. These caves are situated in rocks of Hippurite limestone, a member of the Cretaceous series, and some of them may be seen on both sides of the Bay of Palermo. If in the neighbourhood of that city we proceed from the sea inland, ascending a sloping terrace, composed of the marine Newer Pliocene strata, we reach about a mile from the shore, and at the height of about 180 feet above it a precipice of limestone, at the base of which appear the entrances of several caves. In that of San Ciro, on the east side of the bay, we find at the bottom sand with marine shells, forty species of which have been examined, and found almost all to agree specifically with mollusca now inhabiting the Mediterranean. Higher in position, and resting on the sand, is a breccia, composed of pieces of limestone, quartz, and schist in a matrix of brown marl, through which land shells are dispersed, together with bones of two species of hippopotamus, as determined by Dr. Falconer. Certain bones of the skeleton were counted in such numbers as to prove that they must have belonged to several hundred individuals. With these were associated the remains of Elephas

antiquus, and bones of the genera Bos, Cervus, Sus, Ursus, Canis, and a large Felis. Some of these bones have been rolled as if partially subjected to the action of water, and may have been introduced by streams through rents in the Hippurite limestone; but there is now no running water in the neighbourhood, no river such as the hippopotamus might frequent, not even a small brook, so that the physical geography of the district must have been altogether changed since the time when such remains were swept into fissures, or into the channels of engulfed rivers.

No proofs seem yet to have been found of the existence of Man at the period when the hippopotamus and Elephas antiquus flourished at San Ciro. But there is another cave called the Grotto di Maccagnone, which much resembles it in geological position, on the opposite or west side of the Bay of Palermo, near Carini. In the bottom of this cave a bone deposit like that of San Ciro occurs, and above it other materials reaching to the roof, and evidently washed in from above, through crevices in the limestone. In this upper and newer breccia Dr. Falconer discovered flint knives, bone splinters, bits of charcoal, burnt clay, and other objects indicating human intervention, mingled with entire land shells, teeth of horses, coprolites of hyaenas, and other bones, the whole agglutinated to one another and to the roof by the infiltration of water holding lime in solution. The perfect condition of the large fragile helices (Helix vermiculata) afforded satisfactory evidence, says Dr. Falconer, that the various articles were carried into the cave by the tranquil agency of water, and not by any tumultuous action. At a subsequent period other geographical changes took place, so that the cave, after it had been filled, was washed out again, or emptied of its contents with the exception of those patches of breccia which, being cemented together by stalactite, still adhere to the roof.* (* "Quarterly Journal of the Geological Society" volume 16 1860 page 105.)

Baron Anca, following up these investigations, explored, in 1859, another cave at Mondello, west of Palermo, and north of Mount Gallo, where he discovered molars of the living African elephant, and afterwards additional specimens of the same species in the neighbouring grotto of Olivella. In reference to this elephant, Dr. Falconer has reminded us that the distance between the nearest part of Sicily and the coast of Africa, between Marsala and Cape Bon, is not more than 80 miles, and Admiral Smyth, in his Memoir on the Mediterranean, states (page 499) that there is a subaqueous plateau, named by him Adventure Bank, uniting Sicily to Africa by a succession of ridges which are not more than from 40 to 50 fathoms under water.* (* Cited by Horner, "Presidential Address to the Geological Society" 1861 page 42.) Sicily therefore might be re-united to Africa by movements of upheaval not greater than those which are already known to have taken place within the human period on the borders of the Mediterranean, of which I shall now proceed to cite a well-authenticated example, observed in Sardinia.

RISE OF THE BED OF THE SEA TO THE HEIGHT OF 300 FEET, IN THE HUMAN PERIOD, IN SARDINIA.

Count Albert de la Marmora, in his description of the geology of Sardinia,* (* "Partie Geologique" volume 1 pages 382 and 387.) has shown that on the southern coast of that island, at Cagliari and in the neighbourhood, an ancient bed of the sea, containing marine

shells of living species, and numerous fragments of antique pottery, has been elevated to the height of from 230 to 324 feet above the present level of the Mediterranean. Oysters and other shells, of which a careful list has been published, including the common mussel (Mytilus edulis), many of them having both valves united, occur, embedded in a breccia in which fragments of limestone abound. The mussels are often in such numbers as to impart, when they have decomposed, a violet colour to the marine stratum. Besides pieces of coarse pottery, a flattened ball of baked earthenware, with a hole through its axis, was found in the midst of the marine shells. It is supposed to have been used for weighting a fishing net. Of this and of one of the fragments of ancient pottery Count de la Marmora has given figures.

The upraised bed of the sea probably belongs in this instance to the Pleistocene period, for in a bone breccia, filling fissures in the rocks around Cagliari, the remains of extinct mammalia have been detected; among which is a new genus of carnivorous quadruped, named Cynotherium by M. Studiati, and figured by Count de la Marmora in his Atlas (Plate 7), also an extinct species of Lagomys, determined by Cuvier in 1825. Embedded in the same bone-breccia, and enveloped with red earth like the mammalian remains, were detected shells of the Mytilus edulis before mentioned, implying that the marine formation containing shells and pottery had been already upheaved and exposed to denudation before the remains of quadrupeds were washed into these rents and included in the red earth. In the vegetable soil covering the upraised marine stratum, fragments of Roman pottery occur.

If we assume the average rate of upheaval to have been, as before hinted, 2 1/2 feet in a century, 300 feet would give an antiquity of 12,000 years to the Cagliari pottery, even if we simply confine our estimate to the upheaval above the sea-level, without allowing for the original depth of water in which the mollusca lived. Even then our calculation would merely embrace the period during which the upward movement was going on; and we can form at present no conjecture as to the probable era of its commencement or termination.

I learn from Captain Spratt, R.N., that the island of Crete or Candia, about 135 miles in length, has been raised at its western extremity about 25 feet; so that ancient ports are now high and dry above the sea, while at its eastern end it has sunk so much that the ruins of old towns are seen under water. Revolutions like these in the physical geography of the countries bordering the Mediterranean, may well help us to understand the phenomena of the Palermo caves, and the presence in Sicily of African species of mammalia.

CLIMATE AND HABITS OF THE HIPPOPOTAMUS.

As I have alluded more than once in this chapter to the occurrence of the remains of the hippopotamus in places where there are now no rivers, not even a rill of water, and as other bones of the same genus have been met with in the lower-level gravels of the Somme where large blocks of sandstone seem to imply that ice once played a part in their transportation, it may be well to consider, before proceeding farther, what geographical and climatal conditions are indicated by the presence of these fossil pachyderms.

It is now very generally conceded that the mammoth and tichorhine rhinoceros were fitted to inhabit northern regions, and it is therefore natural to begin by asking whether the extinct hippopotamus may not in like manner have flourished in a cold climate. In answer to this inquiry, it has been remarked that the living hippopotami, anatomically speaking so closely allied to the extinct species, are so aquatic and fluviatile in their habits as to make it difficult to conceive that their congeners could have thriven all the year round in regions where, during winter, the rivers were frozen over for months. Moreover, I have been unable to learn that, in any instance, bones of the hippopotamus have been found in the drift of northern Germany associated with the remains of the mammoth, tichorhine rhinoceros, musk-ox, reindeer, lemming, and other arctic quadrupeds before alluded to; yet, though not proved to have ever made a part of such a fauna, the presence of the fossil hippopotamus north of the fiftieth parallel of latitude naturally tempts us to speculate on the migratory powers and instincts of some of the extinct species of the genus. They may have resembled, in this respect, the living musk-ox, herds of which pass for hundreds of miles over the ice to the rich pastures of Melville Island, and then return again to southern latitudes before the ice breaks up.

We are indebted to Sir Andrew Smith,* (* "Illustrations of the Zoology of South Africa": article "Hippopotamus.") an experienced zoologist, for having given us an account of the migratory habits of the living hippopotamus of Southern Africa (H. amphibius, Linn.).

He states that, when the Dutch first colonised the Cape of Good Hope, this animal abounded in all the great rivers, as far south as the land extends; whereas, in 1849, they had all disappeared, scarcely one remaining even within a moderate distance of the colony. He also tells us that this species evinces great sagacity in changing its quarters whenever danger threatens, quitting every district invaded by settlers bearing fire-arms. Bulky as they are, they can travel speedily for miles over land from one pool of a dried-up river to another; but it is by water that their powers of locomotion are surpassingly great, not only in rivers, but in the sea, for they are far from confining themselves to fresh water. Indeed, Sir A. Smith finds it "difficult to decide whether, during the daytime and when not feeding, they prefer the pools of rivers or the waters of the ocean for their abode." In districts where they have been disturbed by Man, they feed almost entirely in the night, chiefly on certain kinds of grass, but also on brushwood. Sir A. Smith relates that, in an expedition which he made north of Port Natal, he found them swarming in all the rivers about the tropic of Capricorn. Here they were often seen to have left their footprints on the sands, entering or coming out of the salt water; and on one occasion Smith's party tried in vain to intercept a female with her young as she was making her way to the sea. Another female, which they had wounded on her precipitate retreat to the sea, was afterwards shot in that element.

The geologist, therefore, may freely speculate on the time when herds of hippopotami issued from North African rivers, such as the Nile, and swam northwards in summer along the coasts of the Mediterranean, or even occasionally visited islands near the shore.

Here and there they may have landed to graze or browse, tarrying awhile and afterwards continuing their course northwards. Others may have swum in a few summer days from rivers in the south of Spain or France to the Somme, Thames, or Severn, making timely retreat to the south before the snow and ice set in.

BURIAL-PLACE AT AURIGNAC, IN THE SOUTH OF FRANCE, OF PLEISTOCENE DATE.

I have alluded in the beginning of the fourth chapter to a custom prevalent among rude nations of consigning to the tomb works of art, once the property of the dead, or objects of their affection, and even of storing up, in many cases, animal food destined for the manes of the defunct in a future life. I also cited M. Desnoyers' comments on the absence among the bones of wild and domestic animals found in old Gaulish tombs of all intermixture of extinct species of quadrupeds, as proving that the oldest sepulchral monuments then known in France (1845) had no claims to high antiquity founded on palaeontological data.

M. Lartet, however, has recently published a circumstantial account of what seems clearly to have been a sepulchral vault of the Pleistocene period, near Aurignac, not far from the foot of the Pyrenees. I have had the advantage of inspecting the fossil bones and works of art obtained by him from that grotto, and of conversing and corresponding with him on the subject, and can see no grounds for doubting the soundness of his conclusions.* (* See Lartet, "Annales des Sci. Nat." 4mo. Ser. Zoologie volume 15 page 177 translated in "Natural History Review" London January 1862.)

(FIGURE 25. SECTION OF PART OF THE HILL OF FAJOLES PASSING THROUGH THE SEPULCHRAL GROTTO OF AURIGNAC (E. Lartet).

a. Part of the vault in which the remains of seventeen human skeletons were found.
b. Layer of made ground, two feet thick, inside the grotto in which a few human bones, with entire bones of extinct and living species of animals, and many works of art were embedded.
c. Layers of ashes and charcoal, six inches thick, with broken, burnt, and gnawed bones of extinct and Recent mammalia; also hearth-stones and works of art; no human bones.
d. Deposit with similar contents and a few scattered cinders.
e. Talus of rubbish washed down from the hill above.
f, g. Slab of rock which closed the vault, not ascertained whether it extended to h.
f i. Rabbit burrow which led to the discovery of the grotto.
h, k. Original terrace on which the grotto opened.
N. Nummulitic limestone of hill of Fajoles.)

The town of Aurignac is situated in the department of the Haute-Garonne, near a spur of the Pyrenees; adjoining it is the small flat-topped hill of Fajoles, about 60 feet above the brook called Rodes, which flows at its foot on one side. It consists of Nummulitic limestone, presenting a steep escarpment towards the north-west, on which side in the face of the rock, about 45 feet above the brook, is now visible the entrance of a grotto a, Figure 25, which opened originally on the terrace h, c, k, which slopes gently towards the valley.

Until the year 1852, the opening into this grotto was masked by a talus of small fragments of limestone and earthy matter e, such as the rain may have washed down the slope of the hill. In that year a labourer named Bonnemaison, employed in repairing the roads, observed that rabbits, when hotly pursued by the sportsman, ran into a hole which they had burrowed in the talus, at i f, Figure 25. On reaching as far into the opening as the length of his arm, he drew out, to his surprise, one of the long bones of the human skeleton; and his curiosity being excited, and having a suspicion that the hole communicated with a subterranean cavity, he commenced digging a trench through the middle of the talus, and in a few hours found himself opposite a large heavy slab of rock f h, placed vertically against the entrance. Having removed this, he discovered on the other side of it an arched cavity a, 7 or 8 feet in its greatest height, 10 in width, and 7 in horizontal depth. It was almost filled with bones, among which were two entire skulls, which he recognised at once as human. The people of Aurignac, astonished to hear of the occurrence of so many human relics in so lonely a spot, flocked to the cave, and Dr. Amiel, the Mayor, ordered all the bones to be taken out and reinterred in the parish cemetery. But before this was done, having as a medical man a knowledge of anatomy, he ascertained by counting the homologous bones that they must have formed parts of no less than seventeen skeletons of both sexes, and all ages; some so young that the ossification of some of the bones was incomplete. Unfortunately the skulls were injured in the transfer; and what is worse, after the lapse of eight years, when M. Lartet visited Aurignac, the village sexton was unable to tell him in what exact place the trench was dug, into which the skeletons had been thrown, so that this rich harvest of ethnological knowledge seems for ever lost to the antiquary and geologist.

M. Lartet having been shown, in 1860, the remains of some extinct animals and works of art, found in digging the original trench made by Bonnemaison through the bed d under the talus, and some others brought out from the interior of the grotto, determined to investigate systematically what remained intact of the deposits outside and inside the vault, those inside, underlying the human skeletons, being supposed to consist entirely of made ground. Having obtained the assistance of some intelligent workmen, he personally superintended their labours, and found outside the grotto, resting on the sloping terrace h k, the layer of ashes and charcoal c, about 6 inches thick, extending over an area of 6 or 7 square yards, and going as far as the entrance of the grotto and no farther, there being no cinders or charcoal in the interior. Among the cinders outside the vault were fragments of fissile sandstone, reddened by heat, which were observed to rest on a levelled surface of Nummulitic limestone and to have formed a hearth. The nearest place from whence such slabs of sandstone could have been brought was the opposite side of the valley.

Among the ashes, and in some overlying earthy layers, d, separating the ashes from the talus e, were a great variety of bones and implements; amongst the latter not fewer than a hundred flint articles--knives, projectiles, sling stones, and chips, and among them one of those siliceous cores or nuclei with numerous facets, from which flint flakes or knives had been struck off, seeming to prove that some instruments were occasionally manufactured on the very spot.

Among other articles outside the entrance was found a stone of a circular form, and flattened on two sides, with a central depression, composed of a tough rock which does not belong to that region of the Pyrenees. This instrument is supposed by the Danish antiquaries to have been used for removing by skilful blows the edges of flint knives, the fingers and thumb being placed in the two opposite depressions during the operation. Among the bone instruments were arrows without barbs, and other tools made of reindeer horn, and a bodkin formed out of the more compact horn of the roedeer. This instrument was well shaped, and sharply pointed, and in so good a state of preservation that it might still be used for piercing the tough skins of animals.

Scattered through the same ashes and earth were the bones of the various species of animals enumerated in the subjoined lists, with the exception of two, marked with an asterisk, which only occurred in the interior of the grotto:--

TABLE 10/1. NUMBERS OF INDIVIDUALS, BONES OF WHICH WERE FOUND IN THE AURIGNAC CAVE.

COLUMN 1 : NAME OF SPECIES.

COLUMN 2 : NUMBER OF INDIVIDUALS.

1. CARNIVORA

1. Ursus spelaeus (cave-bear) : 5 to 6.
2. Ursus arctos ? (brown bear) : 1.
3. Meles taxus (badger) : 1 to 2.
4. Putorius vulgaris (polecat) : 1.
5. *Felis spelaea (cave-lion) : 1.
6. Felis catus ferus (wild cat) : 1.
7. Hyaena spelaea (cave-hyaena) : 5 to 6.
8. Canis lupus (wolf) : 3.
9. Canis vulpes (fox) : 18 to 20.

2. HERBIVORA.

1. Elephas primigenius (mammoth, two molars).
2. Rhinoceros tichorhinus (Siberian rhinoceros) : 1.
3. Equus caballus (horse) : 12 to 15.
4. Equus asinus (?) (ass) : 1.
5. *Sus scrofa (pig, two incisors).
6. Cervus elaphus (stag) : 1.
7. Megaceros hibernicus (gigantic Irish deer) : 1.
8. C. capreolus (roebuck) : 3 to 4.
9. C. tarandus (reindeer) : 10 to 12.
10. Bison europaeus (aurochs) : 12 to 15.

The bones of the herbivora were the most numerous, and all those on the outside of the grotto which had contained marrow were invariably split open, as if for its extraction, many of them being also burnt. The spongy parts, moreover, were wanting, having been eaten off and gnawed after they were broken, the work, according to M. Lartet, of hyaenas, the bones and coprolites of which were mixed with the cinders, and dispersed through the overlying soil d. These beasts of prey are supposed to have prowled about the spot and fed

on such relics of the funeral feasts as remained after the retreat of the human visitors, or during the intervals between successive funeral ceremonies which accompanied the interment of the corpses within the sepulchre. Many of the bones were also streaked, as if the flesh had been scraped off by a flint instrument.

Among the various proofs that the bones were fresh when brought to the spot, it is remarked that those of the herbivora not only bore the marks of having had the marrow extracted and having afterwards been gnawed and in part devoured as if by carnivorous beasts, but that they had also been acted upon by fire (and this was especially noticed in one case of a cave-bear's bone), in such a manner as to show that they retained in them at the time all their animal matter.

Among other quadrupeds which appear to have been eaten at the funeral feasts, and of which the bones occurred among the ashes, were those of a young Rhinoceros tichorhinus, the bones of which had been, like those of the accompanying herbivora, broken and gnawed by a beast of prey at both extremities.

Outside of the great slab of stone forming the door, not one human bone occurred; inside of it there were found, mixed with loose soil, the remains of as many as seventeen human individuals, besides some works of art and bones of animals. We know nothing of the arrangement of these bones when they were first broken into. M. Lartet inferred at first that the bodies were bent down upon themselves in a squatting attitude, a posture known to have been adopted in most of the sepulchres of primitive times; and he has so represented them in his restoration of the cave: but this opinion he has since retracted. His artist also has inadvertently, in the same drawing, delineated the arched grotto as if it were shaped very regularly and smoothly, like a finished piece of masonry, whereas the surface was in truth as uneven and irregular as are the roofs of all natural grottos.

There was no stalagmite in the grotto, and M. Lartet, an experienced investigator of ossiferous caverns in the south of France, came to the conclusion that all the bones and soil found in the inside were artificially introduced. The substratum b, Figure 25, which remained after the skeletons had been removed, was about 2 feet thick. In it were found about ten detached human bones, including a molar tooth; and M. Delesse ascertained by careful analysis of one of these, as well as of the bones of a rhinoceros, bear, and some other extinct animals, that they all contained precisely the same proportion of nitrogen, or had lost an equal amount of their animal matter. My friend Mr. Evans, before cited, has suggested to me that such a fact, taken alone, may not be conclusive in favour of the equal antiquity of the human and other remains. No doubt, had the human skeletons been found to contain more gelatine than those of the extinct mammalia, it would have shown that they were the more modern of the two; but it is possible that after a bone has gone on losing its animal matter up to a certain point, it may then part with no more so long as it continues enveloped in the same matrix. If this be so, it follows that bones of very different degrees of antiquity, after they have lain for many thousands of years in a particular soil, may all have reached long ago the maximum of decomposition attainable in such a matrix. In the present case, however, the proof of the

contemporaneousness of Man and the extinct animals does not depend simply on the identity of their mineral condition. The chemical analysis of M. Delesse is only a fact in corroboration of a great mass of other evidence.

Mixed with the human bones inside the grotto first removed by Bonnemaison, were eighteen small, round, and flat plates of a white shelly substance, made of some species of cockle (Cardium), pierced through the middle as if for being strung into a bracelet. In the substratum also in the interior examined by M. Lartet was found the tusk of a young Ursus spelaeus, the crown of which had been stripped of its enamel, and which had been carved perhaps in imitation of the head of a bird. It was perforated lengthwise as if for suspension as an ornament or amulet. A flint knife also was found in the interior which had evidently never been used; in this respect, unlike the numerous worn specimens found outside, so that it is conjectured that it may, like other associated works of art, have been placed there as part of the funeral ceremonies.

A few teeth of the cave-lion, Felis spelaea, and two tusks of the wild boar, also found in the interior, were memorials perhaps of the chase. No remains of the same animals were met with among the external relics.

On the whole, the bones of animals inside the vault offer a remarkable contrast to those of the exterior, being all entire and uninjured, none of them broken, gnawed, half-eaten, scraped, or burnt like those lying among the ashes on the other side of the great slab which formed the portal. The bones of the interior seem to have been clothed with their flesh when buried in the layer of loose soil strewed over the floor. In confirmation of this idea, many bones of the skeleton were often observed to be in juxtaposition, and in one spot all the bones of the leg of an Ursus spelaeus were lying together uninjured. Add to this, the entire absence in the interior of cinders and charcoal, and we can scarcely doubt that we have here an example of an ancient place of sepulture, closed at the opening so effectually against the hyaenas or other carnivora that no marks of their teeth appear on any of the bones, whether human or brute.

John Carver, in his travels in the interior of North America in a 1766-68 (chapter 15.), gave a minute account of the funeral rites of an Indian tribe which inhabited the country now called Iowa, at the junction of the St. Peter's River with the Mississippi; and Schiller, in his famous "Nadowessische Todtenklage," has faithfully embodied in a poetic dirge all the characteristic features of the ceremonies so graphically described by the English traveller, not omitting the many funeral gifts which, we are told, were placed "in a cave" with the bodies of the dead. The lines beginning, "Bringet her die letzten Gaben," have been thus translated, truthfully, and with all the spirit of the original, by Sir E. L. Bulwer*:--

"Here bring the last gifts!--and with these
The last lament be said;
Let all that pleased, and yet may please,
Be buried with the dead.

"Beneath his head the hatchet hide,
That he so stoutly swung;

And place the bear's fat haunch beside--
The journey hence is long!

"And let the knife new sharpened be
That on the battle-day
Shore with quick strokes--he took but three--
The foeman's scalp away!

"The paints that warriors love to use,
Place here within his hand,
That he may shine with ruddy hues
Amidst the spirit-land."

(* "Poems and Ballads of Schiller.")

If we accept M. Lartet's interpretation of the ossiferous deposits of Aurignac, both inside and outside the grotto, they add nothing to the palaeontological evidence in favour of Man's antiquity, for we have seen all the same mammalia associated elsewhere with flint implements, and some species, such as the Elephas antiquus, Rhinoceros hemitoechus, and Hippopotamus major, missing here, have been met with in other places. An argument, however, having an opposite leaning may perhaps be founded on the phenomena of Aurignac. It may--indeed it has been said, that they imply that some of the extinct mammalia survived nearly to our times:

First--Because of the modern style of the works of art at Aurignac.

Secondly--Because of the absence of any signs of change in the physical geography of the country since the cave was used for a place of sepulture.

In reference to the first of these propositions, the utensils, it is said, of bone and stone indicate a more advanced state of the arts than the flint implements of Abbeville and Amiens. M. Lartet, however, is of opinion that they do not, and thinks that we have no right to assume that the fabricators of the various spear-headed and other tools of the Valley of the Somme possessed no bone instruments or ornaments resembling those discovered at Aurignac. These last, moreover, he regards as extremely rude in comparison with others of the stone period in France, which can be proved palaeontologically, at least by strong negative evidence, to be of subsequent date. Thus, for example, at Savigne, near Civray, in the department of Vienne, there is a cave in which there are no extinct mammalia, but where remains of the reindeer abound. The works of art of the stone period found there indicate considerable progress in skill beyond that attested by the objects found in the Aurignac grotto. Among the Savigne articles, there is the bone of a stag, on which figures of two animals, apparently meant for deer, are engraved in outline, as if by a sharp-pointed flint. In another cave, that of Massat, in the department of Ariege, which M. Lartet ascribes to the period of the aurochs, a quadruped which survived the reindeer in the south of France, there are bone instruments of a still more advanced state of the arts, as, for example, barbed arrows with a small canal in each, believed to have served for the insertion of poison; also a needle of bird's bone, finely shaped, with an eye or perforation at one end, and a stag's horn, on which is carved a representation of a bear's head, and a hole at one end as if for suspending it. In this figure we see, says M. Lartet,

what may perhaps be the earliest known example of lines used to express shading.

The fauna of the aurochs (Bison europaeus) agrees with that of the earlier lake dwellings in Switzerland, in which hitherto the reindeer is wanting; whereas the reindeer has been found in a Swiss cave, in Mont Saleve, supposed by Lartet to be more ancient than the lake dwellings.

According to this view, the mammalian fauna has undergone at least two fluctuations since the remains of some extinct quadrupeds were eaten, and others buried as funeral gifts in the sepulchral vault of Aurignac.

As to the absence of any marked changes in the physical configuration of the district since the same grotto was a place of sepulture, we must remember that it is the normal state of the earth's surface to be undergoing great alterations in one place, while other areas, often in close proximity, remain for ages without any modification. In one region, rivers are deepening and widening their channels, or the waves of the sea are undermining cliffs, or the land is sinking beneath or rising above the waters, century after century, or the volcano is pouring forth torrents of lava or showers of ashes; while, in tracts hard by, the ancient forest, or extensive heath, or the splendid city continue scatheless and motionless. Had the talus which concealed from view the ancient hearth with its cinders and the massive stone portal of the Aurignac grotto escaped all human interference for thousands of years to come, there is no reason to suppose that the small stream at the foot of the hill of Fajoles would have undermined it. At the end of a long period the only alteration might have been the thickening of the talus which protected the loose cinders and bones from waste. We behold in many a valley of Auvergne, within 50 feet of the present river channel, a volcanic cone of loose ashes, with a crater at its summit, from which powerful currents of basaltic lava have poured, usurping the ancient bed of the torrent. By the action of the stream, in the course of ages, vast masses of the hard columnar basalt have been removed, pillar after pillar, and much vesicular lava, as in the case, for example, of the Puy Rouge, near Chalucet, and of the Puy de Tartaret, near Nechers.* (* Scrope's "Volcanoes of Central France" 1858 page 97.) The rivers have even in some cases, as the Sioule, near Chalucet, cut through not only the basalt which dispossessed them of their ancient channels, but have actually eaten 50 feet into the subjacent gneiss; yet the cone, an incoherent heap of scoriae and spongy ejectamenta, stands unmolested. Had the waters once risen, even for a day, so high as to reach the level of the base of one of these cones--had there been a single flood 50 or 60 feet in height since the last eruption occurred, a great part of these volcanoes must inevitably have been swept away as readily as all traces of the layer of cinders; and the accompanying bones would have been obliterated by the Rodes near Aurignac, had it risen, since the days of the mammoth, rhinoceros, and cave-bear, 50 feet above its present level.

The Aurignac cave adds no new species to the list of extinct quadrupeds, which we have elsewhere, and by independent evidence, ascertained to have once flourished contemporaneously with Man. But if the fossil memorials have been correctly interpreted--if we have

here before us at the northern base of the Pyrenees a sepulchral vault with skeletons of human beings, consigned by friends and relatives to their last resting-place--if we have also at the portal of the tomb the relics of funeral feasts, and within it indications of viands destined for the use of the departed on their way to a land of spirits; while among the funeral gifts are weapons wherewith in other fields to chase the gigantic deer, the cave-lion, the cave-bear, and woolly rhinoceros--we have at last succeeded in tracing back the sacred rites of burial, and, more interesting still, a belief in a future state, to times long anterior to those of history and tradition. Rude and superstitious as may have been the savage of that remote era, he still deserved, by cherishing hopes of a hereafter, the epithet of "noble," which Dryden gave to what he seems to have pictured to himself as the primitive condition of our race,

"as Nature first made Man
When wild in woods the noble savage ran."*
(* "Siege of Granada" Part 1 Act 1 Scene 1.)

CHAPTER 11.

AGE OF HUMAN FOSSILS OF LE PUY IN CENTRAL FRANCE AND OF NATCHEZ ON THE MISSISSIPPI DISCUSSED.

Question as to the Authenticity of the Fossil Man of Denise, near Le Puy-en-Velay, considered.
Antiquity of the Human Race implied by that Fossil.
Successive Periods of Volcanic Action in Central France.
With what Changes in the Mammalian Fauna they correspond.
The Elephas meridionalis anterior in Time to the Implement-bearing Gravel of St. Acheul.
Authenticity of the Human Fossil of Natchez on the Mississippi discussed.
The Natchez Deposit, containing Bones of Mastodon and Megalonyx, probably not older than the Flint Implements of St. Acheul.

Among the fossil remains of the human species supposed to have claims to high antiquity, and which have for many years attracted attention, two of the most prominent examples are:--

First--"The fossil man of Denise," comprising the remains of more than one skeleton, found in a volcanic breccia near the town of Le Puy-en-Velay, in Central France.

Secondly--The fossil human bone of Natchez, on the Mississippi, supposed to have been derived from a deposit containing remains of Mastodon and Megalonyx. Having carefully examined the sites of both of these celebrated fossils, I shall consider in this chapter the nature of the evidence on which the remote date of their entombment is inferred.

FOSSIL MAN OF DENISE.

An account of the fossil remains, so called, was first published in 1844 by M. Aymard of Le Puy, a writer of deservedly high authority both as a palaeontologist and archaeologist.* (* "Bulletin de la Societe Geologique de France" 1844, 1845, 1847.) M. Pictet, after

visiting Le Puy and investigating the site of the alleged discovery, was satisfied that the fossil bones belonged to the period of the last volcanic eruptions of Velay; but expressly stated in his important treatise on palaeontology that this conclusion, though it might imply that Man had co-existed with the extinct elephant, did not draw with it the admission that the human race was anterior in date to the filling of the caverns of France and Belgium with the bones of extinct mammalia.* (* "Traite de Paleontologie" volume 1 1853 page 152.)

At a meeting of the "Scientific Congress" of France, held at Le Puy in 1856, the question of the age of the Denise fossil bones was fully gone into, and in the report of their proceedings published in that year, the opinions of some of the most skilful osteologists respecting the point in controversy are recorded. The late Abbe Croizet, a most experienced collector of fossil bones in the volcanic regions of Central France, and an able naturalist, and the late M. Laurillard, of Paris, who assisted Cuvier in modelling many fossil bones, and in the arrangement of the museum of the Jardin, declared their opinion that the specimen preserved in the museum of Le Puy is no counterfeit. They believed the human bones to have been enveloped by natural causes in the tufaceous matrix in which we now see them.

In the year 1859, Professor Hebert and M. Lartet visited Le Puy, expressly to investigate the same specimen, and to inquire into the authenticity of the bones and their geological age. Later in the same year, I went myself to Le Puy, having the same object in view, and had the good fortune to meet there my friend Mr. Poulett Scrope, with whom I examined the Montagne de Denise, where a peasant related to us how he had dug out the specimen with his own hands and in his own vineyard, not far from the summit of the volcano. I employed a labourer to make under his directions some fresh excavations, following up those which had been made a month earlier by MM. Hebert and Lartet, in the hope of verifying the true position of the fossils, but all of us without success. We failed even to find in situ any exact counterpart of the stone of the Le Puy Museum.

The osseous remains of that specimen consist of a frontal and some other parts of the skull, including the upper jaw with teeth, both of an adult and young individual; also a radius, some lumbar vertebrae, and some metatarsal bones. They are all embedded in a light porous tuff, resembling in colour and mineral composition the ejectamenta of several of the latest eruptions of Denise. But none of the bones penetrate into another part of the same specimen, which consists of a more compact rock thickly laminated. Nevertheless, I agree with the Abbe Croizet and M. Aymard, that it is not conceivable even that the less coherent part of the museum Specimen which envelopes the human bones should have been artificially put together, whatever may have been the origin of certain other slabs of tuff which were afterwards sold as coming from the same place, and which also contained human remains. Whether some of these were spurious or not is a question more difficult to decide. One of them, now in the possession of M. Pichot-Dumazel, an advocate of Le Puy, is suspected of having had some plaster of Paris introduced into it to bind the bones more firmly together in the loose volcanic tuff. I was assured that a dealer in objects of natural history at Le Puy had been in the

habit of occasionally securing the cohesion in that manner of fragments of broken bones, and the juxtaposition of uninjured ones found free and detachable in loose volcanic tuffs. From this to the fabrication of a factitious human fossil was, it is suggested, but a short step. But in reference to M. Pichot's specimen, an expert anatomist remarked to me that it would far exceed the skill, whether of the peasant who owned the vineyard or of the dealer above mentioned, to put together in their true position all the thirty-eight bones of the hand and fingers, or the sixteen of the wrist, without making any mistake, and especially without mixing those of the right with the homologous bones of the left hand, assuming that they had brought bones, from some other spot, and then artificially introduced them into a mixture of volcanic tuff and plaster of Paris.

Granting, however, that the high prices given for "human fossils" at Le Puy may have led to the perpetration of some frauds, it is still an interesting question to consider whether the admission of the genuineness of a single fossil, such as that now in the museum at Le Puy, would lead us to assign a higher antiquity to the existence of Man in France than is deducible from many other facts explained in the last seven chapters. In reference to this point, I may observe that although I was not able to fix with precision the exact bed in the volcanic mountain from which the rock containing the human bones was taken, M. Felix Robert has, nevertheless, after studying "the volcanic alluviums" of Denise, ascertained that, on the side of Cheyrac and the village of Malouteyre, blocks of tuff frequently occur exactly like the one in the museum. That tuff he considers a product of the latest eruption of the volcano. In it have been found the remains of Hyaena spelaea and Hippopotamus major. The eruptions of steam and gaseous matter which burst forth from the crater of Denise broke through laminated Tertiary clays, small pieces of which, some of them scarcely altered, others half converted into scoriae, were cast out in abundance, while other portions must have been in a state of argillaceous mud. Showers of such materials would be styled by the Neapolitans "aqueous lava" or "lava d'aqua," and we may well suppose that some human individuals, if any existed, would, together with wild animals, be occasionally overwhelmed in these tuffs. From near the place on the mountain whence the block with human bones now in the museum is said to have come, a stream of lava, well marked by its tabular structure, flowed down the flanks of the hill, within a few feet of the alluvial plain of the Borne, a small tributary of the Loire, on the opposite bank of which stands the town of Le Puy. Its continuous extension to so low a level clearly shows that the valley had already been deepened to within a few feet of its present depth at the time of the flowing of the lava.

We know that the alluvium of the same district, having a similar relation to the present geographical outline of the valleys, is of Pleistocene date, for it contains around Le Puy the bones of Elephas primigenius and Rhinoceros tichorhinus; and this affords us a palaeontological test of the age of the human skeleton of Denise, if the latter be assumed to be coeval with the lava stream above referred to.

It is important to dwell on this point, because some geologists have felt disinclined to believe in the genuineness of the "fossil man of Denise," on the ground that, if conceded, it would imply

that the human race was contemporary with an older fauna, or that of the Elephas meridionalis. Such a fauna is found fossil in another layer of tuff covering the slope of Denise, opposite to that where the museum specimen was exhumed. The quadrupeds obtained from that more ancient tuff comprise Elephas meridionalis, Hippopotamus major, Rhinoceros megarhinus, Antilope torticornis, Hyaena brevirostris, and twelve others of the genera horse, ox, stag, goat, tiger, etc., all supposed to be of extinct species. This tuff, found between Malouteyre and Polignac, M. Robert regards as the product of a much older eruption, and referable to the neighbouring Montagne de St. Anne, a volcano in a much more wasted and denuded state than Denise, and classed by M. Bertrand de Doue as of intermediate age between the ancient and modern cones of Velay.

The fauna to which Elephas meridionalis and its associates belong, can be shown to be of anterior date, in the north of France, to the flint implements of St. Acheul, by the following train of reasoning. The valley of the Seine is not only geographically contiguous to the valley of the Somme, but its ancient alluvium contains the same mammoth and other fossil species. The Eure, one of the tributaries of the Seine, in its way to join that river, flows in a valley which follows a line of fault in the Chalk; and this valley is seen to be comparatively modern, because it intersects at St. Prest, 4 miles below Chartres, an older valley belonging to an anterior system of drainage, which has been filled by a more ancient fluviatile alluvium, consisting of sand and gravel, 90 feet thick. I have examined the site of this older drift, and the fossils have been determined by Dr. Falconer. They comprise Elephas meridionalis, a species of rhinoceros (not R. tichorhinus), and other mammalia differing from those of the implement-bearing gravels of the Seine and Somme. The latter, belonging to the period of the mammoth, might very well have been contemporary with the modern volcanic eruptions of Central France; and we may presume, even without the aid of the Denise fossil, that Man may have witnessed these. But the tuffs and gravels in which the Elephas meridionalis are embedded were synchronous with an older epoch of volcanic action, to which the cone of St. Anne, near Le Puy, and many other mountains of M. Bertrand de Doue's middle period belong, having cones and craters, which have undergone much waste by aqueous erosion. We have as yet no proof that Man witnessed the origin of these hills of lava and scoriae of the middle phase of volcanic action.

Some surprise was expressed in 1856, by several of the assembled naturalists at Le Puy, that the skull of the "fossil man of Denise," although contemporary with the mammoth, and coeval with the last eruptions of the Le Puy volcanoes [Note 18], should be of the ordinary Caucasian or European type; but the observations of Professor Huxley on the Engis skull, cited in the fifth chapter, showing the near approach of that ancient cranium to the European standard, will help to remove this source of perplexity.

HUMAN FOSSIL OF NATCHEZ ON THE MISSISSIPPI.

I have already alluded to Dr. Dowler's attempt to calculate, in years, the antiquity of the human skeleton said to have been buried under four cypress forests in the delta of the Mississippi, near New Orleans (see above, Chapter 3). In that case no remains of

extinct animals were found associated with those of Man: but in another part of the basin of the Mississippi, a human bone, accompanied by bones of Mastodon and Megalonyx, is supposed to have been washed out of a more ancient alluvial deposit.

After visiting the spot in 1846, I described the geological position of the bones, and discussed their probable age, with a stronger bias, I must confess, as to the antecedent improbability of the contemporaneous entombment of Man and the mastodon than any geologist would now be justified in entertaining.

(FIGURE 26. SECTION THROUGH THE ALLUVIAL PLAIN OF THE MISSISSIPPI.

1. Modern alluvium of the Mississippi.
2. Loam or loess.
3, f. Eocene.
4. Cretaceous.)

In the latitude of Vicksburg, 32 degrees 50 minutes north, the broad, flat, alluvial plain of the Mississippi, a b, Figure 26, is bounded on its eastern side by a table-land d e, about 200 feet higher than the river, and extending 12 miles eastward with a gentle upward slope. This elevated platform ends abruptly at d, in a line of perpendicular cliffs or bluffs, the base of which is continually undermined by the great river.

The table-land d-e consists at Vicksburg, through which the annexed section, Figure 26, passes, of loam, overlying the Tertiary strata f-f. Between the loam and the Tertiary formation there is usually a deposit of stratified sand and gravel, containing large fragments of silicified corals and the wreck of older Palaeozoic rocks. The age of this underlying drift, which is 140 feet thick at Natchez, has not yet been determined; but it may possibly belong to the glacial period. Natchez is about 80 miles in a straight line south of Vicksburg, on the same left bank of the Mississippi. Here there is a bluff, the upper 60 feet of which consists of a continuous portion of the same calcareous loam as at Vicksburg, equally resembling the Rhenish loess in mineral character and in being sometimes barren of fossils, sometimes so full of them that bleached land-shells stand out conspicuously in relief in the vertical and weathered face of cliffs which form the banks of streams, everywhere intersecting the loam.

So numerous are the shells that I was able to collect at Natchez, in a few hours, in 1846, no less than twenty species of the genera Helix, Helicina, Pupa, Cyclostoma, Achatina, and Succinea, all identical with shells now living in the same country; and in one place I observed (as happens also occasionally in the valley of the Rhine) a passage of the loam with land-shells into an underlying marly deposit of subaqueous origin, in which shells of the genera Limnaea, Planorbis, Paludina, Physa, and Cyclas were embedded, also consisting of recent American species. Such deposits, more distinctly stratified than the loam containing land-shells, are produced, as before stated, in all great alluvial plains, where the river shifts its position, and where marshes, ponds, and lakes are formed in its old deserted channels. In this part of America, however, it may have happened that some of these lakes were caused by partial subsidences, such as were witnessed, during the earthquakes of 1811-12, around New Madrid, in the valley of the

Mississippi.

Owing to the destructible nature of the yellow loam, d e, Figure 26, every streamlet flowing over the platform has cut for itself, in its way to the Mississippi, a deep gully or ravine; and this erosion has of late years, especially since 1812, proceeded with accelerated speed, ascribable in some degree to the partial clearing of the native forest, but partly also to the effects of the earthquake of 1811-12. By that convulsion the region around Natchez was rudely shaken and much fissured. One of the narrow valleys near Natchez, due to this fissuring, is now called the Mammoth Ravine. Though no less than 7 miles long, and in some parts 60 feet deep, I was assured by a resident proprietor, Colonel Wiley, that it had no existence before 1812. With its numerous ramifications, it is said to have been entirely formed since the earthquake at New Madrid. Before that event, Colonel Wiley had ploughed some of the land exactly over a spot now traversed by part of this water-course.

I satisfied myself that the ravine had been considerably enlarged and lengthened a short time before my visit, and it was then freshly undermined and undergoing constant waste. From a clayey deposit immediately below the yellow loam, bones of the Mastodon ohioticus, a species of Megalonyx, bones of the genera Equus, Bos, and others, some of extinct and others presumed to be of living species, had been detached, and had fallen to the base of the cliffs. Mingled with the rest, the pelvic bone of a man, os innominatum, was obtained by Dr. Dickeson of Natchez, in whose collection I saw it. It appeared to be quite in the same state of preservation, and was of the same black colour as the other fossils, and was believed to have come like them from a depth of about 30 feet from the surface. In my "Second Visit to America," in 1846, I suggested, as a possible explanation of this association of a human bone with remains of Mastodon and Megalonyx, that the former may possibly have been derived from the vegetable soil at the top of the cliff, whereas the remains of extinct mammalia were dislodged from a lower position, and both may have fallen into the same heap or talus at the bottom of the ravine. The pelvic bone might, I conceived, have acquired its black colour by having lain for years or centuries in a dark superficial peaty soil, common in that region. I was informed that there were many human bones, in old Indian graves in the same district, stained of as black a dye. On suggesting this hypothesis to Colonel Wiley of Natchez, I found that the same idea had already occurred to his mind. No doubt, had the pelvic bone belonged to any recent mammifer other than Man, such a theory would never have been resorted to; but so long as we have only one isolated case, and are without the testimony of a geologist who was present to behold the bone when still engaged in the matrix, and to extract it with his own hands, it is allowable to suspend our judgment as to the high antiquity of the fossil.

If, however, I am asked whether I consider the Natchez loam, with land-shells and the bones of Mastodon and Megalonyx, to be more ancient than the alluvium of the Somme containing flint implements and the remains of the mammoth and hyaena, I must declare that I do not. Both in Europe and America the land and freshwater shells accompanying the extinct pachyderms are of living species, and I could detect no shell in the Natchez loam so foreign to the basin of the Mississippi as is the Cyrena fluminalis to the rivers of

modern Europe. If, therefore, the relative ages of the Picardy and Natchez alluvium were to be decided on conchological data alone, the fluvio-marine beds of Abbeville might rank as a shade older than the loess of Natchez. My reluctance in 1846 to regard the fossil human bone as of Pleistocene date arose in part from the reflection that the ancient loess of Natchez is anterior in time to the whole modern delta of the Mississippi. The table-land, d e, Figure 26, was, I believe, once a part of the original alluvial plain or delta of the great river before it was upraised. It has now risen more than 200 feet above its pristine level. After the upheaval, or during it, the Mississippi cut through the old fluviatile formation of which its bluffs are now formed, just as the Rhine has in many parts of its valley excavated a passage through the ancient loess. If I was right in calculating that the present delta of the Mississippi must have required many tens of thousands of years for its growth, and if the claims of the Natchez man to have co-existed with the mastodon are admitted, it would follow that North America was peopled by the human race many tens of thousands of years before our time. But even were that true, we could not presume, reasoning from ascertained geological data, that the Natchez bone was anterior in date to the antique flint hatchets of St. Acheul. When we ascend the Mississippi from Natchez to Vicksburg, and then enter the Ohio, we are accompanied everywhere by a continuous fringe of terraces of sand and gravel at a certain height above the alluvial plain, first of the great river, and then of its tributary. We also find that the older alluvium contains the remains of Mastodon everywhere, and in some places, as at Evansville, those of the Megalonyx. As in the valley of the Somme in Europe, those old Pleistocene gravels often occur at more than one level, and the ancient mounds of the Ohio, with their works of art, are newer than the old terraces of the mastodon period, just as the Gallo-Roman tombs of St. Acheul or the Celtic weapons of the Abbeville peat are more modern than the tools of the mammoth-bearing alluvium.

In the first place, I may remind the reader that the vertical movement of 250 feet, required to elevate the loess of Natchez to its present height, is exceeded by the upheaval which the marine stratum of Cagliari, containing pottery, has been ascertained by Count de la Marmora to have experienced. Such changes of level, therefore, have actually occurred in Europe in the human epoch, and may therefore have happened in America. In the second place, I may observe that if, since the Natchez mastodon was embedded in clay, the delta of the Mississippi has been formed, so, since the mammoth and rhinoceros of Abbeville and Amiens were enveloped in fluviatile mud and gravel, together with flint tools, a great thickness of peat has accumulated in the valley of the Somme; and antecedently to the first growth of peat, there had been time for the extinction of a great many mammalia, requiring, perhaps, a lapse of ages many times greater than that demanded for the formation of 30 feet of peat, for since the earliest growth of the latter there has been no change in the species of mammalia in Europe.

Should future researches, therefore, confirm the opinion that the Natchez man co-existed with the mastodon, it would not enhance the value of the geological evidence in favour of Man's antiquity, but merely render the delta of the Mississippi available as a chronometer, by which the lapse of Pleistocene time could be measured somewhat less vaguely than by any means of measuring which

have as yet been discovered or rendered available in Europe.

CHAPTER 12.

ANTIQUITY OF MAN RELATIVELY TO THE GLACIAL PERIOD AND TO THE EXISTING FAUNA AND FLORA.

Chronological Relation of the Glacial Period, and the earliest known Signs of Man's Appearance in Europe.
Series of Tertiary Deposits in Norfolk and Suffolk immediately antecedent to the Glacial Period.
Gradual Refrigeration of Climate proved by the Marine Shells of successive Groups.
Marine Newer Pliocene Shells of Northern Character near Woodbridge.
Section of the Norfolk Cliffs.
Norwich Crag.
Forest Bed and Fluvio-marine Strata.
Fossil Plants and Mammalia of the same.
Overlying Boulder Clay and Contorted Drift.
Newer freshwater Formation of Mundesley compared to that of Hoxne.
Great Oscillations of Level implied by the Series of Strata in the Norfolk Cliffs.
Earliest known Date of Man long subsequent to the existing Fauna and Flora.

Frequent allusions have been made in the preceding pages to a period called the glacial, to which no reference is made in the Chronological Table of Formations given above (Chapter 1). It comprises a long series of ages, during which the power of cold, whether exerted by glaciers on the land, or by floating ice on the sea, was greater in the northern hemisphere, and extended to more southern latitudes than now. [Note 19.]

It often happens that when in any given region we have pushed back our geological investigations as far as we can in search of evidence of the first appearance of Man in Europe, we are stopped by arriving at what is called the "boulder clay" or "northern drift." This formation is usually quite destitute of organic remains, so that the thread of our inquiry into the history of the animate creation, as well as of man, is abruptly cut short. The interruption, however, is by no means encountered at the same point of time in every district. In the case of the Danish peat, for example, we get no farther back than the Recent period of our Chronologic Table, and then meet with the boulder clay; and it is the same in the valley of the Clyde, where the marine strata contain the ancient canoes before described (Chapter 3), and where nothing intervenes between that Recent formation and the glacial drift. But we have seen that, in the neighbourhood of Bedford the memorials of Man can be traced much farther back into the past, namely, into the Pleistocene epoch, when the human race was contemporary with the mammoth and many other species of mammalia now extinct. Nevertheless, in Bedfordshire as in Denmark, the formation next antecedent in date to that containing the human implements is still a member of the glacial drift, with its erratic blocks.

If the reader remembers what was stated in the eighth chapter as to the absence or extreme scarcity of human bones and works of art in

all strata, whether marine or freshwater, even in those formed in the immediate proximity of land inhabited by millions of human beings, he will be prepared for the general dearth of human memorials in glacial formations, whether Recent, Pleistocene, or of more ancient date. If there were a few wanderers over lands covered with glaciers, or over seas infested with ice-bergs, and if a few of them left their bones or weapons in moraines or in marine drift, the chances, after the lapse of thousands of years, of a geologist meeting with one of them must be infinitesimally small.

It is natural, therefore, to encounter a gap in the regular sequence of geological monuments bearing on the past history of Man, wherever we have proofs of glacial action having prevailed with intensity, as it has done over large parts of Europe and North America, in the Pleistocene period. As we advance into more southern latitudes approaching the 50th parallel of latitude in Europe, and the 40th in North America, this disturbing cause ceases to oppose a bar to our inquiries; but even then, in consequence of the fragmentary nature of all geological annals, our progress is inevitably slow in constructing anything like a connected chain of history, which can only be effected by bringing the links of the chain found in one area to supply the information which is wanting in another.

The least interrupted series of consecutive documents to which we can refer in the British Islands, when we desire to connect the Pliocene with the Pleistocene periods, are found in the counties of Norfolk, Suffolk, and Essex; and I shall speak of them in this chapter, as they have a direct bearing on the relations of the human and glacial periods, which will be the subject of several of the following chapters. The fossil shells of the deposits in question clearly point to a gradual refrigeration of climate, from a temperature somewhat warmer than that now prevailing in our latitudes to one of intense cold; and the successive steps which have marked the coming on of the increasing cold are matters of no small geological interest. [Note 20.]

It will be seen in the Chronological Table, that next before the Pleistocene period stands the Pliocene. The shelly and sandy beds representing these periods in Norfolk and Suffolk are termed provincially Crag, having under the name been long used in agriculture to fertilise soils deficient in calcareous matter, or to render them less stiff and impervious. In Suffolk, the older Pliocene strata called Crag are divisible into the Coralline and the Red Crags, the former being the older of the two. In Norfolk, a more modern formation, commonly termed the "Norwich," or sometimes the "mammaliferous" Crag, which is referable to the newer Pliocene period, occupies large areas.

We are indebted to Mr. Searles Wood, F.G.S., for an admirable monograph on the fossil shells of these British Pliocene formations. He has not himself given us an analysis of the results of his treatise, but the following tables have been drawn up for me by Mr. S.P. Woodward, the well-known author of the "Manual of Mollusca, Recent and Fossil" (London 1851-56), in order to illustrate some of the general conclusions to which Mr. Wood's careful examination of 442 species of mollusca has led.

TABLE 12/1. NUMBER OF KNOWN SPECIES OF MARINE TESTACEA IN THE THREE

ENGLISH PLIOCENE DEPOSITS, CALLED THE NORWICH, THE RED, AND THE CORALLINE CRAGS.

COLUMN 1 : NAME.

COLUMN 2 : NUMBER.

Brachiopoda : 6.
Lamellibranchia : 206.
Gasteropoda : 230.

TOTAL : 442.

TABLE 12/2. DISTRIBUTION OF THE ABOVE MARINE TESTACEA.

COLUMN 1 : NAME.

COLUMN 2 : NUMBER.

Norwich Crag : 81.
Red Crag : 225.
Coralline Crag : 327.

Species common to the Norwich and Red Crag (not in Coralline) : 33.
Species common to the Norwich and Coralline (not in Red) : 4.
Species common to the Red and Coralline (not in Norwich) : 116.
Species common to the Norwich, Red, and Coralline : 19.*
(* These 19 species must be added to the numbers 33, 4, and 116 respectively, in order to obtain the full amount of common species in each of those cases.)

TABLE 12/3. PROPORTION OF RECENT TO EXTINCT SPECIES.

COLUMN 1 : NAME.

COLUMN 2 : NUMBER OF RECENT.

COLUMN 3 : NUMBER OF EXTINCT.

COLUMN 4 : PERCENTAGE OF RECENT.

Norwich Crag : 69 : 12 : 85%.
Red Crag : 130 : 95 : 57%.
Coralline Crag : 168 : 159 : 51%.

TABLE 12/4. RECENT SPECIES NOT LIVING NOW IN BRITISH SEAS.

COLUMN 1 : NAME.

COLUMN 2 : NUMBER OF NORTHERN.

COLUMN 3 : NUMBER OF SOUTHERN.

Norwich Crag : 12 : 0.

Red Crag : 8 : 16.

Coralline Crag : 2 : 27.

In the above list I have not included the shells of the glacial beds of the Clyde and of several other British deposits of newer origin than the Norwich Crag, in which nearly all--perhaps all--the species are Recent. The land and freshwater shells, thirty-two in number, have also been purposely omitted, as well as three species of London Clay shells, suspected by Mr. Wood himself to be spurious.

By far the greater number of the living marine species included in these tables are still inhabitants of the British seas; but even these differ considerably in their relative abundance, some of the commonest of the Crag shells being now extremely scarce; as, for example, Buccinopsis Dalei; and others, rarely met with in a fossil state, being now very common, as Murex erinaceus and Cardium echinatum.

The last table throws light on a marked alteration in the climate of the three successive periods. It will be seen that in the Coralline Crag there are twenty-seven southern shells, including twenty-six Mediterranean, and one West Indian species (Erato Maugeriae). Of these only thirteen occur in the Red Crag, associated with three new southern species, while the whole of them disappear from the Norwich beds. On the other hand, the Coralline Crag contains only two shells closely related to arctic forms of the genera Admete and Limopsis. The Red Crag contains, as stated in the table, eight northern species, all of which recur in the Norwich Crag, with the addition of four others, also inhabitants of the arctic regions; so that there is good evidence of a continual refrigeration of climate during the Pliocene period in Britain. The presence of these northern shells cannot be explained away by supposing that they were inhabitants of the deep parts of the sea; for some of them, such as Tellina calcarea and Astarte borealis, occur plentifully, and sometimes, with the valves united by their ligament, in company with other littoral shells, such as Mya arenaria and Littorina rudis, and evidently not thrown up from deep water. Yet the northern character of the Norwich Crag is not fully shown by simply saying that it contains twelve northern species. It is the predominance of certain genera and species, such as Tellina calcarea, Astarte borealis, Scalaria groenlandica, and Fusus carinatus, which satisfies the mind of a conchologist as to the arctic character of the Norwich Crag. In like manner, it is the presence of such genera as Pyrula, Columbella, Terebra, Cassidaria, Pholadomya, Lingula, Discina, and others which give a southern aspect to the Coralline Crag shells.

The cold, which had gone on increasing from the time of the Coralline to that of the Norwich Crag, continued, though not perhaps without some oscillations of temperature, to become more and more severe after the accumulation of the Norwich Crag, until it reached its maximum in what has been called the glacial epoch. The marine fauna of this last period contains, both in Ireland and Scotland, Recent species of mollusca now living in Greenland and other seas far north of the areas where we find their remains in a fossil state.

The refrigeration of climate from the time of the older to that of the newer Pliocene strata is not now announced for the first time, as it was inferred from a study of the Crag shells in 1846 by the late Edward Forbes.* (* "Memoirs of the Geological Survey" London

1846 page 391.)

The most southern point to which the marine beds of the Norwich Crag have yet been traced is at Chillesford, near Woodbridge, in Suffolk, about 80 miles north-east of London, where, as Messrs. Prestwich and Searles Wood have pointed out,* they exhibit decided marks of having been deposited in a sea of a much lower temperature than that now prevailing in the same latitude. (* "Quarterly Journal of the Geological Society" volume 5 1849 page 345.) Out of twenty-three shells obtained in that locality from argillaceous strata 20 feet thick, two only, namely, Nucula Cobboldiae and Tellina obliqua, are extinct, and not a few of the other species, such as Leda lanceolata, Cardium groenlandicum, Lucina borealis, Cyprina islandica, Panopaea norvegica, and Mya truncata, betray a northern, and some of them an arctic character.

These Chillesford beds are supposed to be somewhat more modern than any of the purely marine strata of the Norwich Crag exhibited by the sections of the Norfolk cliffs north-west of Cromer, which I am about to describe. Yet they probably preceded in date the "Forest Bed" and fluvio-marine deposits of those same cliffs. They are, therefore, of no small importance in reference to the chronology of the glacial period, since they afford evidence of an assemblage of fossil shells with a proportion of between eight and nine in a hundred of extinct species occurring so far south as latitude 53 degrees north, and indicating so cold a climate as to imply that the glacial period commenced before the close of the Pliocene era.

(FIGURE 27. DIAGRAM TO ILLUSTRATE THE GENERAL SUCCESSION OF THE STRATA IN THE NORFOLK CLIFFS, EXTENDING SEVERAL MILES NORTH-WEST AND SOUTH-EAST OF CROMER.

A. Site of Cromer Jetty.
1. Upper Chalk with flints in regular stratification.
2. Norwich Crag, rising from low water at Cromer to the top of the cliffs at Weybourn, seven miles distant.
3. "Forest Bed," with stumps of trees in situ and remains of Elephas meridionalis, E. primigenius, E. antiquus, Rhinoceros etruscus, etc. This bed increases in depth and thickness eastward. No Crag (Number 2) known east of Cromer Jetty.
3 prime. Fluvio-marine series. At Cromer and eastward, with abundant lignite beds and mammalian remains, and with cones of the Scotch and spruce firs and wood. At Runton, north-west of Cromer, expanding into a thick freshwater deposit, with overlying marine strata, elsewhere consisting of alternating sands and clays, tranquilly deposited, some with marine, others with freshwater shells.
4. Boulder clay of glacial period, with far transported erratics, some of them polished and scratched, 20 to 80 feet in thickness.
5. Contorted drift.
6. Superficial gravel and sand with covering of vegetable soil.)

The annexed section (Figure 27) will give a general idea of the ordinary succession of the Pliocene and Pleistocene strata which rest upon the Chalk in the Norfolk and Suffolk cliffs. These cliffs vary in height from fifty to above three hundred feet. At the north-western extremity of the section at Weybourn (beyond the limits of the annexed diagram), and from thence to Cromer, a distance of 7 miles, the Norwich Crag, a marine deposit, reposes

immediately upon the Chalk. A vast majority of its shells are of living species such as Cardium edule, Cyprina islandica, Scalaria groenlandica, and Fusus antiquus, and some few extinct, as Tellina obliqua, and Nucula Cobboldiae. At Cromer jetty this formation thins out, as expressed in the diagram at A; and to the south we find Number 3, or what is commonly called the "Forest Bed," reposing immediately upon the Chalk, and occupying, as it were, the place previously held by the marine Crag Number 2. This buried forest has been traced for more than 40 miles, being exposed at certain seasons and states of the beach between high and low water mark. It extends from Cromer to near Kessingland, and consists of the stumps of numerous trees standing erect, with their roots attached to them, and penetrating in all directions into the loam or ancient vegetable soil on which they grew. They mark the site of a forest which existed there for a long time, since, besides the erect trunks of trees, some of them 2 and 3 feet in diameter, there is a vast accumulation of vegetable matter in the immediately overlying clays. Thirty years ago, when I first examined this bed, I saw many trees, with their roots in the old soil, laid open at the base of the cliff near Happisburgh; and long before my visit, other observers, and among them the late Mr. J.C. Taylor, had noticed the buried forest. Of late years it has been repeatedly seen at many points by Mr. Gunn, and, after the great storms of the autumn of 1861, by Mr. King. In order to expose the stumps to view, a vast body of sand and shingle must be cleared away by the force of the waves. [Note 21.]

As the sea is always gaining on the land, new sets of trees are brought to light from time to time, so that the breadth as well as length of the area of ancient forest land seems to have been considerable. Next above Number 3, we find a series of sands and clays with lignite (Number 3 prime), sometimes 10 feet thick, and containing alternations of fluviatile and marine strata, implying that the old forest land, which may at first have been considerably elevated above the level of the sea, had sunk down so as to be occasionally overflowed by a river, and at other times by the salt waters of an estuary. There were probably several oscillations of level which assisted in bringing about these changes, during which trees were often uprooted and laid prostrate, giving rise to layers of lignite. Occasionally marshes were formed and peaty matter accumulated, after which salt water again predominated, so that species of Mytilus, Mya, Leda, and other marine genera, lived in the same area where the Unio, Cyclas, and Paludina had flourished for a time. That the marine shells lived and died on the spot, and were not thrown up by the waves during a storm, is proved, as Mr. King has remarked, by the fact that at West Runton, north-west of Cromer, the Mya truncata and Leda myalis are found with both valves united and erect in the loam, all with their posterior or siphuncular extremities uppermost. This attitude affords as good evidence to the conchologist that those mollusca lived and died on the spot as the upright position of the trees proves to the botanist that there was a forest over the Chalk east of Cromer.

Between the stumps of the buried forest, and in the lignite above them, are many well-preserved cones of the Scotch and spruce firs, Pinus sylvestris, and Pinus abies. The specific names of these fossils were determined for me in 1840, by a botanist of no less authority than the late Robert Brown; and Professor Heer has lately examined a large collection from the same stratum, and recognised

among the cones of the spruce some which had only the central part or axis remaining, the rest having been bitten off, precisely in the same manner as when in our woods the squirrel has been feeding on the seeds. There is also in the forest-bed a great quantity of resin in lumps, resembling that gathered for use, according to Professor Heer, in Switzerland, from beneath spruce firs.

The following is a list of some of the plants and seeds which were collected by the Reverend S.W. King, in 1861, from the forest bed at Happisburgh, and named by Professor Heer:--

PLANTS AND SEEDS OF THE FOREST AND LIGNITE BEDS BELOW THE GLACIAL DRIFT OF THE NORFOLK CLIFFS.

Pinus sylvestris, Scotch fir.
Pinus abies, spruce fir.
Taxus baccata, yew.
Nuphar luteum, yellow water-lily.
Ceratophyllum demersum, hornwort.
Potamogeton, pondweed.
Prunus spinosus, common sloe.
Menyanthes trifoliata, buckbean.
Nymphaea alba, white water-lily.
Alnus, alder.
Quercus, oak.
Betula, birch.

The insects, so far as they are known, including several species of Donacia, are, like the plants and freshwater shells, of living species. It may be remarked, however, that the Scotch fir has been confined in historical times to the northern parts of the British Isles, and the spruce fir is nowhere indigenous in Great Britain. The other plants are such as might now be found in Norfolk, and many of them indicate fenny or marshy ground.* (* Mr. King discovered in 1863, in the forest bed, several rhizomes of the large British fern Osmunda regalis, of such dimensions as they are known to attain in marshy places. They are distinguishable from those of other British ferns by the peculiar arrangement of the vessels, as seen under the microscope in a cross section.)

When we consider the familiar aspect of the flora, the accompanying mammalia are certainly most extraordinary. There are no less than three elephants, a rhinoceros and hippopotamus, a large extinct beaver, and several large estuarine and marine mammalia, such as the walrus, the narwhal, and the whale.

The following is a list of some of the species of which the bones have been collected by Messrs. Gunn and King.

Those marked (asterisk) have been recorded by Professor Owen in his British Fossil Mammalia. Those marked (dagger) have been recognised by the same authority in the cabinets of Messrs. Gunn and King, or in the Norwich Museum; the other three are given on the authority of Dr. Falconer.

MAMMALIA OF THE FOREST AND LIGNITE BEDS BELOW THE GLACIAL DRIFT OF THE NORFOLK CLIFFS.

Elephas meridionalis.

(asterisk) Elephas primigenius.
Elephas antiquus.
Rhinoceros etruscus.
(asterisk) Hippopotamus (major ?).
(asterisk) Sus scrofa.
(asterisk) Equus (fossilis ?).
(asterisk) Ursus (sp.?).
(dagger) Canis lupus.
(dagger) Bison priscus.
(dagger) Megaceros hibernicus.
(asterisk) Cervus capreolus.
(dagger) Cervus tarandus.
(dagger) Cervus Sedgwickii.
(asterisk) Arvicola amphibia.
(asterisk) Castor (Trogontherium) Cuvieri.
(asterisk) Castor europaeus.
(asterisk) Palaeospalax magnus.
(dagger) Trichecus rosmarus, Walrus.
(dagger) Monodon monoceros, Narwhal.
(dagger) Balaenoptera.

Mr. Gunn informs me that the vertebrae of two distinct whales were found in the fluvio-marine beds at Bacton, and that one of them, shown to Professor Owen, is said by him to imply that the animal was 60 feet long. A narwhal's tusk was discovered by Mr. King near Cromer, and the remains of a walrus. No less than three species of elephant, as determined by Dr. Falconer, have been obtained from the strata 3 and 3 prime, of which, according to Mr. King, E. meridionalis is the most common, the mammoth next in abundance, and the third, E. antiquus, comparatively rare.

The freshwater shells accompanying the fossil quadrupeds, above enumerated, are such as now inhabit rivers and ponds in England; but among them, as at Runton, between the "forest bed" and the glacial deposits, a remarkable variety of the Cyclas amnica occurs (Figure 28), identical with that which accompanies the Elephas antiquus at Ilford and Grays in the valley of the Thames.

All the freshwater shells of the beds intervening between the Forest-bed Number 3, and the glacial formation 4, Figure 27, are of Recent species. As to the small number of marine shells occurring in the same fluvio-marine series, I have seen none which belonged to extinct species, although one or two have been cited by authors. I am in doubt, therefore, whether to class the forest bed and overlying strata as Pleistocene, or to consider them as beds of passage between the Pliocene and Pleistocene periods. The fluvio-marine series usually terminates upwards in finely laminated sands and clays without fossils, on which reposes the boulder clay.

(FIGURE 28. Cyclas (Pisidium) amnica var.?
The two middle figures are of the natural size.)

This formation, Number 4, is of very varying thickness. Its glacial character is shown, not only by the absence of stratification, and the great size and angularity of some of the included blocks of distant origin, but also by the polished and scratched surfaces of such of them as are hard enough to retain any markings.

Near Cromer, blocks of granite from 6 to 8 feet in diameter have

been met with, and smaller ones of syenite, porphyry, and trap, besides the wreck of the London Clay, Chalk, Oolite, and Lias, mixed with more ancient fossiliferous rocks. Erratics of Scandinavian origin occur chiefly in the lower portions of the till. I came to the conclusion in 1834, that they had really come from Norway and Sweden, after having in that year traced the course of a continuous stream of such blocks from those countries to Denmark, and across the Elbe, through Westphalia, to the borders of Holland. It is not surprising that they should then reappear on our eastern coast between the Tweed and the Thames, regions not half so remote from parts of Norway as are many Russian erratics from the sources whence they came. [Note 22.]

(FIGURE 29. CLIFF 50 FEET HIGH BETWEEN BACTON GAP AND MUNDESLEY.
Section through Gravel (top), Sand, Loam and Till (bottom).)

According to the observations of the Reverend J. Gunn and the late Mr. Trimmer, the glacial drift in the cliffs at Lowestoft consists of two divisions, the lower of which abounds in the Scandinavian blocks, supposed to have come from the north-east; while the upper, probably brought by a current from the north-west, contains chiefly fragments of Oolitic rocks, more rolled than those of the lower deposit. The united thickness of the two divisions, without reckoning some interposed laminated beds, is 80 feet, but it probably exceeds 100 feet near Happisburgh.* (* "Quarterly Journal of the Geological Society" volume 7 1851 page 21.) Although these subdivisions of the drift may be only of local importance, they help to show the changes of currents and other conditions, and the great lapse of time which the accumulation of so varied a series of deposits must have required.

The lowest part of the glacial till, resting on the laminated clays before mentioned, is very even and regular, while its upper surface is remarkable for the unevenness of its outline, owing partly, in all likelihood, to denudation, but still more to other causes presently to be discussed.

The overlying strata of sand and gravel, Number 5, Figure 27, often display a most singular derangement in their stratification, which in many places seems to have a very intimate relation to the irregularities of outline in the subjacent till. There are some cases, however, where the upper strata are much bent, while the lower beds of the same series have continued horizontal. Thus the annexed section (Figure 29) represents a cliff about 50 feet high, at the bottom of which is till, or unstratified clay, containing boulders, having an even horizontal surface, on which repose conformably beds of laminated clay and sand about 5 feet thick, which, in their turn, are succeeded by vertical, bent, and contorted layers of sand and loam 20 feet thick, the whole being covered by flint gravel. The curves of the variously coloured beds of loose sand, loam, and pebbles, are so complicated that not only may we sometimes find portions of them which maintain their verticality to a height of 10 or 15 feet, but they have also been folded upon themselves in such a manner that continuous layers might be thrice pierced in one perpendicular boring.

(FIGURE 30. FOLDING OF THE STRATA BETWEEN EAST AND WEST RUNTON.)

(FIGURE 31. SECTION OF CONCENTRIC BEDS WEST OF CROMER.

1. Blue clay.
2. White sand.
3. Yellow Sand.
4. Striped loam and clay.
5. Laminated blue clay.)

At some points there is an apparent folding of the beds round a central nucleus, as at a, Figure 30, where the strata seem bent round a small mass of Chalk, or, as in Figure 31, where the blue clay Number 1 is in the centre; and where the other strata 2, 3, 4, 5 are coiled round it; the entire mass being 20 feet in perpendicular height. This appearance of concentric arrangement around a nucleus is, nevertheless, delusive, being produced by the intersection of beds bent into a convex shape; and that which seems the nucleus being, in fact, the innermost bed of the series, which has become partially visible by the removal of the protuberant portions of the outer layers.

To the north of Cromer are other fine illustrations of contorted drift reposing on a floor of Chalk horizontally stratified and having a level surface. These phenomena, in themselves sufficiently difficult of explanation, are rendered still more anomalous by the occasional enclosure in the drift of huge fragments of Chalk many yards in diameter. One striking instance occurs west of Sheringham, where an enormous pinnacle of Chalk, between 70 and 80 feet in height, is flanked on both sides by vertical layers of loam, clay, and gravel (Figure 32).

(FIGURE 32. INCLUDED PINNACLE OF CHALK AT OLD HYTHE POINT, WEST OF SHERINGHAM.

d. Chalk with regular layers of flints.
c. Layer called "the pan," of Chalk, flints, and marine shells of Recent species, cemented by oxide of iron.)

This chalky fragment is only one of many detached masses which have been included in the drift, and forced along with it into their present position. The level surface of the Chalk in situ (d) may be traced for miles along the coast, where it has escaped the violent movements to which the incumbent drift has been exposed.* (* For a full account of the drift of East Norfolk, see a paper by the author, "Philosophical Magazine" Number 104 May 1840.)

We are called upon, then, to explain how any force can have been exerted against the upper masses, so as to produce movements in which the subjacent strata have not participated. It may be answered that, if we conceive the till and its boulders to have been drifted to their present place by ice, the lateral pressure may have been supplied by the stranding of ice-islands. We learn, from the observations of Messrs. Dease and Simpson in the polar regions, that such islands, when they run aground, push before them large mounds of shingle and sand. It is therefore probable that they often cause great alterations in the arrangement of pliant and incoherent strata forming the upper part of shoals or submerged banks, the inferior portions of the same remaining unmoved. Or many of the complicated curvatures of these layers of loose sand and gravel may have been due to another cause, the melting on the spot

of ice-bergs and coast ice in which successive deposits of pebbles, sand, ice, snow, and mud, together with huge masses of rock fallen from cliffs, may have become interstratified. Ice-islands so constituted often capsize when afloat, and gravel once horizontal may have assumed, before the associated ice was melted, an inclined or vertical position. The packing of ice forced up on a coast may lead to a similar derangement in a frozen conglomerate of sand or shingle, and, as Mr. Trimmer has suggested,* (* "Quarterly Journal of the Geological Society" volume 7 1851 pages 22, 30.) alternate layers of earthy matter may have sunk down slowly during the liquefaction of the intercalated ice so as to assume the most fantastic and anomalous positions, while the strata below, and those afterwards thrown down above, may be perfectly horizontal (see above).

In most cases where the principal contortions of the layers of gravel and sand have a decided correspondence with deep indentations in the underlying till, the hypothesis of the melting of large lumps and masses of ice once mixed up with the till affords the most natural explanation of the phenomena. The quantity of ice now seen in the cliffs near Behring's Straits, in which the remains of fossil elephants are common, and the huge fragments of solid ice which Meyendorf discovered in Siberia, after piercing through a considerable thickness of incumbent soil, free from ice, is in favour of such an hypothesis, the partial failure of support necessarily giving rise to foldings in the overlying and previously horizontal layers, as in the case of creeps in coal mines.* (* See "Manual of Geology" by the author, page 51.)

In the diagram of the cliffs at page 167, the bent and contorted beds Number 5, last alluded to, are represented as covered by undisturbed beds of gravel and sand Number 6. These are usually destitute of organic remains; but at some points marine shells of Recent species are said to have been found in them. They afford evidence at many points of repeated denudation and redeposition, and may be the monuments of a long series of ages.

MUNDESLEY POST-GLACIAL FRESHWATER FORMATION.

In the range of cliffs above described at Mundesley, about 8 miles south-east of Cromer, a fine example is seen of a freshwater formation, newer than all those already mentioned, a deposit which has filled up a depression hollowed out of all the older beds 3, 4, and 5 of the section Figure 27.

(FIGURE 33. SECTION OF THE NEWER FRESHWATER FORMATION I N THE CLIFFS AT MUNDESLEY, EIGHT MILES SOUTH-EAST OF CROMER, DRAWN UP BY THE REVEREND S.W. KING.
Height of cliff where lowest, 35 feet above high water.

OLDER SERIES.
1. Fundamental Chalk, below the beach line.
3. Forest bed, with elephant, rhinoceros, stag, etc., and with tree roots and stumps, also below the beach line.
3 prime. Finely laminated sands and clays, with thin layer of lignite, and shells of Cyclas and Valvata, and with Mytilus in some beds.
4. Glacial boulder till.
5. Contorted drift.

6. Gravel overlying contorted drift.
N.B.--Number 2 of the section, Figure 27, is wanting here.

NEWER FRESHWATER BEDS.
A. Coarse river gravel, with shells of Anodon, Valvata, Cyclas, Succinea, Limnaea, Paludina, etc., seeds of Ceratophyllum demersum, Nuphar lutea, scales and bones of pike, perch, salmon, etc., elytra of Donacia, Copris, Harpalus, and other beetles.
C. Yellow sands.
D. Drift gravel.)

When I examined this line of coast in 1839, the section alluded to was not so clearly laid open to view as it has been of late years, and finding at that period not a few of the fossils in the lignite beds Number 3 prime above the forest bed, identical in species with those from the post-glacial deposits B C, I supposed the whole to have been of contemporaneous origin, and so described them in my paper on the Norfolk cliffs.* (* "Philosophical Magazine" volume 16 1840 page 345.)

Mr. Gunn was the first to perceive this mistake, which he explained to me on the spot when I revisited Mundesley in the autumn of 1859 in company with Dr. Hooker and Mr. King. The last-named geologist has had the kindness to draw up for me the annexed diagram (Figure 33) of the various beds which he has recently studied in detail.* (* Mr. Prestwich has given a correct account of this section in a paper read to the British Association, Oxford, 1860. See "The Geologist" volume 4 1861.)

The formations 3, 4, and 5 already described, Figure 27, were evidently once continuous, for they may be followed for miles north-west and south-east without a break, and always in the same order. A valley or river channel was cut through them, probably during the gradual upheaval of the country, and the hollow became afterwards the receptacle of the comparatively modern freshwater beds A, B, C, and D. They may well represent a silted up river-channel, which remained for a time in the state of a lake or mere, and in which the black peaty mass B accumulated by a very slow growth over the gravel of the river-bed A. In B we find remains of some of the same plants which were enumerated as common in the ancient lignite in 3 prime, such as the yellow water-lily and hornwort, together with some freshwater shells which occur in the same fluvio-marine series 3 prime.

(FIGURE 34. Paludina marginata, Michaud (P. minuta, Strickland). Hydrobia marginata.*

(* This shell is said to have a sub-spiral operculum (not a concentric one, as in Paludina), and therefore to be referable to the Hydrobia, a sub-genus of Rissoa. But this species is always associated with freshwater shells, while the Rissoae frequent marine and brackish waters.)
The middle figure is of the natural size.)

The only shell which I found not referable to a British species is the minute Paludina, Figure 34, already alluded to.

When I showed the scales and teeth of the pike, perch, roach, and

salmon, which I obtained from this formation, to M. Agassiz, he thought they varied so much from their nearest living representatives that they might rank as distinct species; but Mr. Yarrell doubted the propriety of so distinguishing them. The insects, like the shells and plants, are identical, so far as they are known, with living British species. No progress has yet been made at Mundesley in discovering the contemporary mammalia.

By referring to the description and section before given of the freshwater deposit at Hoxne, the reader will at once perceive the striking analogy of the Mundesley and Hoxne deposits, the latter so productive of flint implements of the Amiens type. Both of them, like the Bedford gravel with flint tools and the bones of extinct mammalia, are post-glacial. It will also be seen that a long series of events, accompanied by changes in physical geography, intervened between the "forest bed," Number 3, Figure 27, when the Elephas meridionalis flourished, and the period of the Mundesley fluviatile beds A, B, C; just as in France I have shown that the same E. meridionalis belonged to a system of drainage different from and anterior to that with which the flint implements of the old alluvium of the Somme and the Seine were connected.

Before the growth of the ancient forest, Number 3, Figure 33, the Mastodon arvernensis, a large proboscidian, characteristic of the Norwich Crag, appears to have died out, or to have become scarce, as no remains of it have yet been found in the Norfolk cliffs. There was, no doubt, time for other modifications in the mammalian fauna between the era of the marine beds, Number 2, Figure 27 (the shells of which imply permanent submergence beneath the sea), and the accumulation of the uppermost of the fluvio-marine, and lignite beds, Number 3 prime, which overlie both Numbers 3 and 2, or the buried forest and the Crag. In the interval we must suppose repeated oscillations of level, during which land covered with trees, an estuary with its freshwater shells, and the sea with its Mya truncata and other mollusca still retaining their erect position, gained by turns the ascendency. These changes were accompanied by some denudation followed by a grand submergence of several hundred feet, probably brought about slowly, and when floating ice aided in transporting erratic blocks from great distances. The glacial till Number 4 then originated, and the gravel and sands Number 5 were afterwards superimposed on the boulder clay, first in horizontal beds, which became subsequently contorted. These were covered in their turn by other layers of gravel and sand, Number 6, Figures 27 and 33, the downward movement still continuing.

The entire thickness of the beds above the Chalk at some points near the coast, and the height at which they now are raised, are such as to show that the subsidence of the country after the growth of the forest bed exceeded 400 feet. The re-elevation must have amounted to nearly as many feet, as the site of the ancient forest, originally sub-aerial, has been brought up again to within a few feet of high-water mark. Lastly, after all these events, and probably during the final process of emergence, the valley was scooped out in which the newer freshwater strata of Mundesley, Figure 33, were gradually deposited.

Throughout the whole of this succession of geographical changes, the flora and invertebrate fauna of Europe appear to have undergone

no important revolution in their specific characters. The plants of the forest bed belonged already to what has been called the Germanic flora. The mollusca, the insects, and even some of the mammalia, such as the European beaver and roebuck, were the same as those now co-existing with Man. Yet the oldest memorials of our species at present discovered in Great Britain are post-glacial, or posterior in date to the boulder clay, Number 4, Figures 27 and 33. The position of the Hoxne flint implements corresponds with that of the Mundesley beds, from A to D, Figure 33, and the most likely stratum in which to find hereafter flint tools is no doubt the gravel A of that section, which has all the appearance of an old river-bed. No flint tools have yet been observed there, but had the old alluvium of Amiens or Abbeville occurred in the Norfolk cliffs instead of the valley of the Somme, and had we depended on the waves of the sea instead of the labour of many hundred workmen continued for twenty years, for exposing the flint implements to view, we might have remained ignorant to this day of the fossil relics brought to light by M. Boucher de Perthes and those who have followed up his researches.

Neither need we despair of one day meeting with the signs of Man's existence in the forest bed Number 3, or in the overlying strata 3 prime, on the ground of any uncongeniality in the climate or incongruity in the state of the animate creation with the well-being of our species. For the present we must be content to wait and consider that we have made no investigations which entitle us to wonder that the bones or stone weapons of the era of the Elephas meridionalis have failed to come to light. If any such lie hid in those strata, and should hereafter be revealed to us, they would carry back the antiquity of Man to a distance of time probably more than twice as great as that which separates our era from that of the most ancient of the tool-bearing gravels yet discovered in Picardy, or elsewhere. But even then the reader will perceive that the age of Man, though pre-glacial, would be so modern in the great geological calendar, as given in Chapter 1, that he would scarcely date so far back as the commencement of the Pleistocene period.

CHAPTER 13.

CHRONOLOGICAL RELATIONS OF THE GLACIAL PERIOD AND THE EARLIEST SIGNS OF MAN'S APPEARANCE IN EUROPE.

Chronological Relations of the Close of the Glacial Period and the earliest geological Signs of the Appearance of Man.
Effects of Glaciers and Icebergs in polishing and scoring Rocks.
Scandinavia once encrusted with Ice like Greenland.
Outward Movement of Continental Ice in Greenland.
Mild Climate of Greenland in the Miocene Period.
Erratics of Recent Period in Sweden.
Glacial State of Sweden in the Pleistocene Period.
Scotland formerly encrusted with Ice.
Its subsequent Submergence and Re-elevation.
Latest Changes produced by Glaciers in Scotland.
Remains of the Mammoth and Reindeer in Scotch Boulder Clay.
Parallel Roads of Glen Roy formed in Glacier Lakes.
Comparatively modern Date of these Shelves.

The chronological relations of the human and glacial periods were

frequently alluded to in the last chapter, and the sections obtained near Bedford, and at Hoxne, in Suffolk, and a general view of the Norfolk cliffs, have taught us that the earliest signs of Man's appearance in the British isles, hitherto detected, are of post-glacial date. We may now therefore inquire whether the peopling of Europe by the human race and by the mammoth and other mammalia now extinct, was brought about during the concluding phases of the glacial epoch.

Although it may be impossible in the present state of our knowledge to come to a positive conclusion on this head, I know of no inquiry better fitted to clear up our views respecting the geological state of the northern hemisphere at the time when the fabricators of the flint implements of the Amiens type flourished. I shall therefore now proceed to consider the chronological relations of that ancient people with the final retreat of the glaciers from the mountains of Scandinavia, Scotland, Wales, and Switzerland.

SUPERFICIAL MARKINGS AND DEPOSITS LEFT BY GLACIERS AND ICEBERGS.

In order fully to discuss this question, I must begin by referring to some of the newest theoretical opinions entertained on the glacial question. When treating of this subject in the "Principles of Geology," chapter 15, and in the "Manual (or Elements) of Geology," chapter 11, I have stated that the whole mass of the ice in a glacier is in constant motion, and that the blocks of stone detached from boundary precipices, and the mud and sand swept down by avalanches of snow, or by rain from the surrounding heights, are lodged upon the surface and slowly borne along in lengthened mounds, called in Switzerland moraines. These accumulations of rocky fragments and detrital matter are left at the termination of the glacier, where it melts in a confused heap called the "terminal moraine," which is unstratified, because all the blocks, large and small, as well as the sand and the finest mud, are carried to equal distances and quietly deposited in a confused mass without being subjected to the sorting power of running water, which would convey the finer materials farther than the coarser ones, and would produce, as the strength of the current varied from time to time in the same place, a stratified arrangement.

In those regions where glaciers reach the sea, and where large masses of ice break off and float away, moraines, such as I have just alluded to, may be transported to indefinite distances, and may be deposited on the bottom of the sea wherever the ice happens to melt. If the liquefaction take place when the berg has run aground and is stationary, and if there be no current, the heap of angular and rounded stones, mixed with sand and mud, may fall to the bottom in an unstratified form called "till" in Scotland, and which has been shown in the last chapter to abound in the Norfolk cliffs; but should the action of a current intervene at certain points or at certain seasons, then the materials will be sorted as they fall, and arranged in layers according to their relative weight and size. Hence there will be passages from till to stratified clay, gravel, and sand.

Some of the blocks of stone with which the surfaces of glaciers are loaded, falling occasionally through fissures in the ice, get fixed and frozen into the bottom of the moving mass, and are pushed along under it. In this position, being subjected to great pressure, they

scoop out long rectilinear furrows or grooves parallel to each other on the subjacent solid rock. Smaller scratches and striae are made on the polished surface by crystals or projecting edges of the hardest minerals, just as a diamond cuts glass.

In all countries the fundamental rock on which the boulder formation reposes, if it consists of granite, gneiss, marble, or other hard stone capable of permanently retaining any superficial markings which may have been imprinted upon it, is smoothed or polished, and exhibits parallel striae and furrows having a determinate direction. This prevailing direction, both in Europe and North America, is evidently connected with the course taken by the erratic blocks in the same district, and is very commonly from north to south, or if it be twenty or thirty or more degrees to the east or west of north, still always corresponds to the direction in which the large angular and rounded stones have travelled. These stones themselves also are often furrowed and scratched on more than one side, like those already spoken of as occurring in the glacial drift of Bedford, and in that of Norfolk.

When we contemplate the area which is now exposed to the abrading action of ice, or which is the receptacle of moraine matter thrown down from melting glaciers or bergs, we at once perceive that the submarine area is the most extensive of the two. The number of large icebergs which float annually to great distances in the northern and southern hemispheres is extremely great, and the quantity of stone and mud which they carry about with them enormous. Some floating islands of ice have been met with from 2 to 5 miles in length, and from 100 to 225 feet in height above water, the submerged portion, according to the weight of ice relatively to sea water, being from six to eight times more considerable than the part which is visible. Such masses, when they run aground on the bottom of the sea, must exert a prodigious mechanical power, and may polish and groove the subjacent rocks after the manner of glaciers on the land. Hence there will often be no small difficulty in distinguishing between the effects of the submarine and supramarine agency of ice.

SCANDINAVIA ONCE COVERED WITH ICE, AND A CENTRE OF DISPERSION OF ERRATICS.

In the north of Europe, along the borders of the Baltic, where the boulder formation is continuous for hundreds of miles east and west, it has been long known that the erratic blocks, often of very large size, are of northern origin. Some of them have come from Norway and Sweden, others from Finland, and their present distribution implies that they were carried southwards, for a part at least of their way, by floating ice, at a time when much of the area over which they are scattered was under water. But it appears from the observations of Boetlingk, in 1840, and those of more recent inquirers, that while many blocks have travelled to the south, others have been carried northwards, or to the shores of the Polar Sea, and others north-eastward, or to those of the White Sea. In fact, they have wandered towards all points of the compass, from the mountains of Scandinavia as a centre, and the rectilinear furrows imprinted by them on the polished surfaces of the mountains where the rocks are hard enough to retain such markings, radiate in all directions, or point outwards from the highest land, in a manner corresponding to the course of the erratics above mentioned.

* (* Sir R.I. Murchison, in his "Russia and the Ural Mountains" (1845) has indicated on a map not only the southern limits of the Scandinavian drift, but by arrows the direction in which "it proceeded eccentrically from a common central region.")

Before the glacial theory was adopted, the Swedish and Norwegian geologists speculated on a great flood, or the sudden rush of an enormous body of water charged with mud and stones, descending from the central heights or watershed into the adjoining lower lands. The erratic blocks were supposed in their downward passage to have smoothed and striated the rock surfaces over which they were forced along.

It would be a waste of time, in the present state of science, to controvert this hypothesis, as it is now admitted that even if the rush of a diluvial current, invented for the occasion and wholly without analogy in the known course of nature, be granted, it would be inadequate to explain the uniformity, parallelism, persistency, and rectilinearity of the so-called glacial furrows. It is moreover ascertained that heavy masses of rock, not fixed in ice, and moving as freely as they do when simply swept along by a muddy current, do not give rise to such scratches and furrows.

M. Kjerulf of Christiania, in a paper lately communicated to the Geological Society of Berlin,* (* "Zeitschrift der Deutschen Geologischen Gesellschaft" Berlin 1860.) has objected, and perhaps with reason, to what he considers the undue extent to which I have, in some of my writings, supposed the mountains of northern Europe, to have been submerged during the glacial period. He remarks that the signs of glacial action on the Scandinavian mountains ascend as high as 6000 feet, whereas fossil marine shells of the same period never reach elevations exceeding 600 feet. The land, he says, may have been much higher than it now is, but it has evidently not been much lower since the commencement of the glacial period, or marine shells would be traceable to more elevated points. In regard to the absence of marine shells, I shall point out in the sequel how small is the dependence we can place on this kind of negative evidence, if we desire to test by it the extent to which the land has been submerged. I cannot therefore consent to limit the probable depression and re-elevation of Scandinavia to 600 feet. But that the larger part of the glaciation of that country has been supramarine, I am willing to concede. In support of this view M. Kjerulf observes that the direction of the furrows and striae, produced by glacial abrasion, neither conforms to a general movement of floating ice from the Polar regions, nor to the shape of the existing valleys, as it would do if it had been caused by independent glaciers generated in the higher valleys after the land had acquired its actual shape. Their general arrangement and apparent irregularities are, he contends, much more in accordance with the hypothesis of there having been at one time a universal covering of ice over the whole of Norway and Sweden, like that now existing in Greenland, which, being annually recruited by fresh falls of snow, was continually pressing outwards and downwards to the coast and lower regions, after crossing many of the lower ridges, and having no relation to the minor depressions, which were all choked up with ice and reduced to one uniform level.

CONTINENTAL ICE OF GREENLAND.

In support of this view, he appeals to the admirable description of the continental ice of Greenland, lately published by Dr. H. Rink of Copenhagen,* (* "Journal of Royal Geographical Society" volume 23 1853 page 145.) who resided three or four years in the Danish settlements in Baffin's Bay, on the west coast of Greenland, between latitudes 69 and 73 degrees north. "In that country, the land," says Dr. Rink, "may be divided into two regions, the 'inland' and the 'outskirts.' The 'inland,' which is 800 miles from west to east, and of much greater length from north to south, is a vast unknown continent, buried under one continuous and colossal mass of permanent ice, which is always moving seaward, but a small proportion only of it in an easterly direction, since nearly the whole descends towards Baffin's Bay." At the heads of the fjords which intersect the coast, the ice is seen to rise somewhat abruptly from the level of the sea to the height of 2000 feet, beyond which the ice of the interior rises continuously as far as the eye can reach, and to an unknown altitude. All minor ridges and valleys are levelled and concealed, but here and there steep mountains protrude abruptly from the icy slope, and a few superficial lines of stones or moraines are visible at seasons when no recent snow has fallen. [Note 23.]

Although all the ice is moving seaward, the greatest quantity is discharged at the heads of certain large fjords, usually about 4 miles wide, which, if the climate were milder, would be the outlet of as many great rivers. Through these the ice is now protruded in huge blocks, several miles wide, and from 1000 to 1500 feet in height or thickness. When these masses reach the fjords, they do not melt or break up into fragments, but continue their course in a solid form in the salt water, grating along the rocky bottom, which they must polish and score at depths of hundreds and even of more than 1000 feet. At length, when there is water enough to float them, huge portions, having broken off, fill Baffin's Bay with icebergs of a size exceeding any which could be produced by ordinary valley glaciers. Stones, sand, and mud are sometimes included in these bergs which float down Baffin's Bay. At some points, where the ice of the interior of Greenland reaches the coast, Dr. Rink saw mighty springs of clayey water issuing from under the edge of the ice even in winter, showing the grinding action of the glacial mass mixed with sand on the subjacent surface of the rocks.

The "outskirts," where the Danish colonies are stationed, consist of numerous islands, of which Disco island is the largest in latitude 70 degrees north, and of many peninsulas, with fjords from 50 to 100 miles long, running into the land, and through which the ice above alluded to passes on its way to the bay. This area is 30, 000 square miles in extent, and contains in it some mountains 4000 feet to 5000 feet high. The perpetual snow usually begins at the height of 2000 feet, below which level the land is for the most part free from snow between June and August, and supports a vegetation of several hundred species of flowering plants, which ripen their seeds before the winter. There are even some places where phanerogamous plants have been found at an elevation of 4500 feet; a fact which, when we reflect on the immediate vicinity of so large and lofty a region of continental ice in the same latitude, well deserves the attention of the geologist, who should also bear in mind, that while the Danes are settled to the west in the "outskirts," there exists, due east of the most southern portion of

this ice-covered continent, at the distance of about 1200 miles, the home of the Laplanders with their reindeer, bears, wolves, seals, walruses, and whales. If, therefore, there are geological grounds for suspecting that Scandinavia or Scotland or Wales was ever in the same glacial condition as Greenland now is, we must not imagine that the contemporaneous fauna and flora were everywhere poor and stunted, or that they may not, especially at the distance of a few hundred miles in a SOUTHWARD direction, have been very luxuriant. [Note 24.]

Another series of observations made by Captain Graah, during a survey of Greenland between 1823 and 1829, and by Dr. Pingel in 1830-32, adds not a little to the geological interest of the "outskirts," in their bearing on glacial phenomena of ancient date. Those Danish investigators, with one of whom, Dr. Pingel, I conversed at Copenhagen in 1834, ascertained that the whole coast from latitude 60 to about 70 degrees north has been subsiding for the last four centuries, so that some ancient piles driven into the beach to support the boats of the settlers have been gradually submerged, and wooden buildings have had to be repeatedly shifted farther inland.* (* "Principles of Geology" chapter 30.)

In Norway and Sweden, instead of such a subsiding movement, the land is slowly rising; but we have only to suppose that formerly, when it was covered like Greenland with continental ice, it sank at the rate of several feet in a century, and we shall be able to explain why marine deposits are found above the level of the sea, and why these generally overlie polished and striated surfaces of rock.

We know that Greenland was not always covered with snow and ice, for when we examine the Tertiary strata of Disco Island (of the Upper Miocene period) we discover there a multitude of fossil plants, which demonstrate that, like many other parts of the arctic regions, it formerly enjoyed a mild and genial climate. Among the fossils brought from that island, latitude 70 degrees north, Professor Heer has recognised Sequoia Langsdorfii, a coniferous species which flourished throughout a great part of Europe in the Miocene period, and is very closely allied to the living Sequoia sempervirens of California. The same plant has been found fossil by Sir John Richardson within the arctic circle, far to the west on the Mackenzie River, near the entrance of Bear River, also by some Danish naturalists in Iceland to the east. The Icelandic surturbrand, or lignite, of this age has also yielded a rich harvest of plants, more than thirty-one of them, according to Steenstrup and Heer, in a good state of preservation, and no less than fifteen specifically identical with Miocene plants of Europe. Thirteen of the number are arborescent; and amongst others is a tulip-tree (Liriodendron), with its fruit and characteristic leaves, a plane (Platanus), a walnut, and a vine, affording unmistakable evidence of a climate in the parallel of the arctic circle which precludes the supposition of glaciers then existing in the neighbourhood, still less any general crust of continental ice, like that of Greenland.* (* Heer, "Recherches sur la Vegetation du Pays tertiaire" etc. 1861 page 178.)

As the older Pliocene flora of the Tertiary strata of Italy, like the shells of the Coralline Crag, before adverted to, Chapter 12, indicate a temperature milder than that now prevailing in Europe,

though not so warm as that of the Upper Miocene period, it is probable that the accumulation of snow and glaciers on the mountains and valleys of Greenland did not begin till after the commencement of the Pliocene period, and may not have reached its maximum until the close of that period.

Norway and Sweden appear to have passed through all the successive phases of glaciation which Greenland has experienced, and others which that country will one day undergo, if the climate which it formerly enjoyed should ever be restored to it. There must have been first a period of separate glaciers in Scandinavia, then a Greenlandic state of continental ice, and thirdly, when that diminished, a second period of enormous separate glaciers filling many a valley now wooded with fir and birch. Lastly, under the influence of the Gulf Stream, and various changes in the height and extent of land in the arctic circle, a melting of nearly all the permanent ice between latitudes 60 and 70 north, corresponding to the parallels of the continental ice of Greenland, has occurred, so that we have now to go farther north than latitude 70 degrees before we encounter any glacier coming down to the sea coast. Among other signs of the last retreat of the extinct glaciers, Kjerulf and other authors describe large transverse moraines left in many of the Norwegian and Swedish glens.

CHRONOLOGICAL RELATIONS OF THE HUMAN AND GLACIAL PERIODS IN SWEDEN.

We may now consider whether any, and what part, of these changes in Scandinavia may have been witnessed by Man. In Sweden, in the immediate neighbourhood of Upsala, I observed, in 1834, a ridge of stratified sand and gravel, in the midst of which occurs a layer of marl, evidently formed originally at the bottom of the Baltic, by the slow growth of the mussel, cockle, and other marine shells of living species intermixed with some proper to fresh water. The marine shells are all of dwarfish size, like those now inhabiting the brackish waters of the Baltic; and the marl, in which myriads of them are embedded, is now raised more than 100 feet above the level of the Gulf of Bothnia. Upon the top of this ridge (one of those called osars in Sweden) repose several huge erratics consisting of gneiss, for the most part unrounded, from 9 to 16 feet in diameter, and which must have been brought into their present position since the time when the neighbouring gulf was already characterised by its peculiar fauna. Here, therefore, we have proof that the transport of erratics continued to take place, not merely when the sea was inhabited by the existing Testacea, but when the north of Europe had already assumed that remarkable feature of its physical geography, which separates the Baltic from the North Sea, and causes the Gulf of Bothnia to have only one-fourth of the saltness belonging to the ocean.

I cannot doubt that these large erratics of Upsala were brought into their present position during the Recent period, not only because of their moderate elevation above the sea-level in a country where the land is now rising every century, but because I observed signs of a great oscillation of level which had taken place at Sodertelje, south of Stockholm (about 45 miles distant from Upsala), after the country had been inhabited by Man. I described, in the "Philosophical Transactions" for 1835, the section there laid open in digging a level in 1819, which showed that a subsidence followed by a re-elevation of land, each movement

amounting to more than 60 feet, had occurred since the time when a rude hut had been built on the ancient shore. The wooden frame of the hut, with a ring of hearthstones on the floor, and much charcoal, were found, and over them marine strata, more than 60 feet thick, containing the dwarf variety of Mytilus edulis, and other brackish-water shells of the Bothnian Gulf. Some vessels put together with wooden pegs, of anterior date to the use of metals, were also embedded in parts of the same marine formation, which has since been raised, so that the upper beds are more than 60 feet above the sea-level, the hut being thus restored to about its original position relatively to the sea.

We have seen in the account of the Danish kitchen-middens of the Recent period that even at the comparatively late period of their origin the waters of the Baltic had been rendered more salt than they are now. The Upsala erratics may belong to nearly the same era as these. But were we to go back to a long antecedent epoch, or to that of the Belgian and British caves with their extinct animals, and the signs they afford of a state of physical geography departing widely from the present, or to the era of the implement-bearing alluvium of St. Acheul, we might expect to find Scandinavia overwhelmed with glaciers, and the country uninhabitable by Man. At a much remoter period the same country was in the state in which Greenland now is, overspread with one uninterrupted coating of continental ice, which has left its peculiar markings on the highest mountains. This period, probably anterior to the earliest traces yet brought to light of the human race, may have coincided with the submergence of England, and the accumulation of the boulder-clay of Norfolk, Suffolk, and Bedfordshire, before mentioned. It has already been stated that the syenite and some other rocks of the Norfolk till seem to have come from Scandinavia, and there is no era when icebergs are so likely to have floated them so far south as when the whole of Sweden and Norway were enveloped in a massive crust of ice; a state of things the existence of which is deduced from the direction of the glacial furrows, and their frequent unconformity to the shape of the minor valleys.

GLACIAL PERIOD IN SCOTLAND [NOTE 25].

Professor Agassiz, after his tour in Scotland in 1840, announced the opinion that erratic blocks had been dispersed from the Scottish mountains as from an independent centre, and that the capping of ice had been of extraordinary thickness.* (* Agassiz, "Proceedings of the Geological Society" 1840 and "Edinburgh Philosophical Journal" 49 page 79.)

Mr. Robert Chambers, after visiting Norway and Sweden, and comparing the signs of glacial action observed there with similar appearances in the Grampians, came to the conclusion that the Highlands both of Scandinavia and Scotland had once been "moulded in ice," and that the outward and downward movement and pressure of the frozen mass had not only smoothed, polished, and scratched the rocks, but had, in the course of ages, deepened and widened the valleys, and produced much of that denudation which has commonly been ascribed exclusively to aqueous action. The glaciation of the Scotch mountains was traced by him to the height of at least 3000 feet.* (* "Ancient Sea Margins" Edinburgh 1848. Glacial Phenomena "Edinburgh New Philosophical Journal" April 1853 and January 1855.)

Mr. T.F. Jamieson, of Ellon, in Aberdeenshire, has recently brought forward an additional body of facts in support of this theory. According to him the Grampians were at the period of extreme cold enveloped "in one great winding sheet of snow and ice," which reached everywhere to the coast-line, the land being then more elevated than it is now. He describes the glacial furrows sculptured on the solid rocks as pointing in Aberdeenshire to the south-east, those of the valley of the Forth at Edinburgh, from west to east, and higher up the same valley at Stirling, from north-west to south-east, as they should do if the ice had followed the lines of what is now the principal drainage. The observations of Sir James Hall, Mr. Maclaren, Mr. Chambers, and Dr. Fleming, are cited by him in confirmation of this arrangement of the glacial markings, while in Sutherland and Ross-shire he shows that the glacial furrows along the north coast point northwards, and in Argyleshire westwards, always in accordance with the direction of the principal glens and fjords.

Another argument is also adduced by him in proof of the ice having exerted its mechanical force in a direction from the higher and more inland country to the lower region and sea-coast. Isolated hills and minor prominences of rock are often polished and striated on the land side, while they remain rough and jagged on the side fronting the sea. This may be seen both on the east and west coast. Mention is also made of blocks of granite which have travelled from south to north in Aberdeenshire, of which there would have been no examples had the erratics been all brought by floating ice from the arctic regions when Scotland was submerged. It is also urged against the doctrine of attributing the general glaciation to submergence, that the glacial grooves, instead of radiating as they do from a centre, would, if they had been due to ice coming from the north, have been parallel to the coast-line, to which they are now often almost at right angles. The argument, moreover, which formerly had most weight in favour of floating ice, namely, that it explained why so many of the stones did not conform to the contour and direction of the minor hills and valleys, is now brought forward, and with no small effect, in favour of the doctrine of continental ice on the Greenlandic scale, which, after levelling up the lesser inequalities, would occasionally flow in mighty ice-currents, in directions often at a high angle to the smaller ridges and glens.

The application to Scandinavia and Scotland of this theory makes it necessary to reconsider the validity of the proofs formerly relied on as establishing the submergence of a great part of Scotland beneath the sea, at some period subsequent to the commencement of the glacial period. In all cases where marine shells overlie till, or rest on polished and striated surfaces of rock, the evidence of the land having been under water, and having been since upheaved, remains unshaken; but this special proof rarely extends to heights exceeding 500 feet. In the basin of the Clyde we have already seen that Recent strata occur 25 feet above the sea-level, with existing species of marine testacea, and with buried canoes, and other works of art. At the higher level of 50 feet occurs the well-known raised beach of the western coast, which, according to Mr. Jamieson, contains, near Fort William and on Loch Fyne and elsewhere, an assemblage of shells implying a colder climate than that of the 25-foot terrace, or that of the present sea; just as, in the valley

of the Somme, the higher-level gravels are supposed to belong to a colder period than the lower ones, and still more decidedly than that of the present era. At still greater elevations, older beds containing a still more arctic group of shells have been observed at Airdrie, 14 miles south-east of Glasgow, 524 feet above the level of the sea. They were embedded in stratified clays, with the unstratified boulder till both above and below them, and in the overlying unstratified drift were some boulders of granite which must have come from distances of 60 miles at the least.* (* Smith of Jordanhill, "Quarterly Journal of the Geological Society" volume 6 1850 page 387.) The presence of Tellina calcarea, and several other northern shells, implies a climate colder than that of the present Scottish seas. In the north of Scotland, marine shells have been found in deposits of the same age in Caithness and in Aberdeenshire at heights of 250 feet, and on the shores of the Moray Firth, as at Gamrie in Banff, at an elevation of 350 feet; and the stratified sands and beds of pebbles which belong to the same formation ascend still higher--to heights of 500 feet at least.* (* Prestwich, "Proceedings of the Geological Society" volume 2 page 545; Jamieson, "Quarterly Journal of the Geological Society" volume 16 1860.)

At much greater heights, stratified masses of drift occur in which hitherto no organic remains, whether of marine or freshwater animals, have ever been found. It is still an undecided question whether the origin of all such deposits in the Grampians can be explained without the intervention of the sea. One of the most conspicuous examples has been described by Mr. Jamieson as resting on the flank of a hill called Meal Uaine, in Perthshire, on the east side of the valley of the Tummel, just below Killiecrankie. It consists of perfectly horizontal strata, the lowest portion of them 300 feet above the river and 600 feet above the sea. From this elevation to an altitude of nearly 1200 feet the same series of strata is traceable, continuously, up the slope of the mountain, and some patches are seen here and there even as high as 1550 feet above the sea. They are made up in great part of finely laminated silt, alternating with coarser materials, through which stones from 4 to 5 feet in length are scattered. These large boulders, and some smaller ones, are polished on one or more sides, and marked with glacial striae. The subjacent rocks, also, of gneiss, mica slate, and quartz, are everywhere grooved and polished as if by the passage of a glacier.* (* Jamieson, "Quarterly Journal of the Geological Society" volume 16 1860 page 360.)

At one spot a vertical thickness of 130 feet of this series of strata is exposed to view by a mountain torrent, and in all more than 2000 layers of clay, sand, and gravel were counted, the whole evidently accumulated under water. Some beds consist of an impalpable mud, like putty, apparently derived from the grinding down of felspar, and resembling the mud produced by the grinding action of modern glaciers.

Mr. Jamieson, when he first gave an account of this drift, inferred, in spite of the absence of marine shells, that it implied the submergence of Scotland beneath the ocean after the commencement of the glacial period, or after the era of continental ice indicated by the subjacent floor of polished and grooved rock. This conclusion would require a submergence of the land as far up as 1550 feet above the present sea-level, after which a great

re-upheaval must have occurred. But the same author, having lately revisited the valley of the Tummel, suggests another possible, and I think probable, explanation of the same phenomena. The stratified drift in question is situated in a deep depression between two buttresses of rock, and if an enormous glacier be supposed to have once filled the valley of the Tummel to the height of the stratified drift, it may have dammed up the mouth of a mountain torrent by a transverse barrier, giving rise to a deep pond, in which beds of clay and sand brought down by the waters of the torrent were deposited. Charpentier in his work on the Swiss glaciers has described many such receptacles of stratified matter now in progress, and due to such blockages, and he has pointed out the remnants of ancient and similar formations left by extinct glaciers of an earlier epoch. He specially notices that angular stones of various dimensions, often polished and striated, which rest on the glacier and are let fall when the torrent undermines the side of the moving ice, descend into the small lake and become interstratified with the gravel and fine sediment brought down by the torrent into the same.* (* Charpentier, "Essai sur les Glaciers" page 63 1841.)

The evidence of the former sojourn of the sea upon the land after the commencement of the glacial period was formerly inferred from the height to which erratic blocks derived from distant regions could be traced, besides the want of conformity in the glacial furrows to the present contours of many of the valleys. Some of these phenomena may now, as we have seen, be accounted for by assuming that there was once a crust of ice resembling that now covering Greenland.

The Grampians in Forfarshire and in Perthshire are from 3000 to 4000 feet high. To the southward lies the broad and deep valley of Strathmore, and to the south of this again rise the Sidlaw Hills to the height of 1500 feet and upwards. On the highest summits of this chain, formed of sandstone and shale, and at various elevations, I have observed huge angular fragments of mica-schist, some 3 and others 15 feet in diameter, which have been conveyed for a distance of at least 15 miles from the nearest Grampian rocks from which they could have been detached. Others have been left strewed over the bottom of the large intervening vale of Strathmore.* (* "Proceedings of the Geological Society" volume 3 page 344.)

It may be argued that the transportation of such blocks may have been due not to floating ice, but to a period when Strathmore was filled up with land ice, a current of which extended from the Perthshire Highlands to the summit of the Sidlaw Hills, and the total absence of marine or freshwater shells from all deposits, stratified or unstratified, which have any connection with these erratics in Forfarshire and Perthshire may be thought to favour such a theory.

But the same mode of transport can scarcely be imagined for those fragments of mica-schist, one of them weighing from 8 to 10 tons, which were observed much farther south by Mr. Maclaren on the Pentland Hills, near Edinburgh, at the height of 1100 feet above the sea, the nearest mountain composed of this formation being 50 miles distant.* (* Maclaren, "Geology of Fife" etc. page 220.) On the same hills, also, at all elevations, stratified gravels occur which, although devoid of shells, it seems hardly possible to refer

to any but a marine origin.

Although I am willing, therefore, to concede that the glaciation of the Scotch mountains, at elevations exceeding 2000 feet, may be explained by land ice, it seems difficult not to embrace the conclusion that a subsidence took place not merely of 500 or 600 feet, as demonstrated by the marine shells, but to a much greater amount, as shown by the present position of erratics and some patches of stratified drift. The absence of marine shells at greater heights than 525 feet above the sea, will be treated of in a future chapter. It may in part, perhaps, be ascribed to the action of glaciers, which swept out marine strata from all the higher valleys, after the re-emergence of the land.

LATEST CHANGES PRODUCED BY GLACIERS IN SCOTLAND.

We may next consider the state of Scotland after its emergence from the glacial sea, when we cannot fail to be approaching the time when Man co-existed with the mammoth and other mammalia now extinct. In a paper which I published in 1840, on the ancient glaciers of Forfarshire, I endeavoured to show that some of these existed after the mountains and glens had acquired precisely their present shape,* (* "Proceedings of the Geological Society" volume 3 page 337.) and had left moraines even in the minor valleys, just where they would now leave them were the snow and ice again to gain ground. I described also one remarkable transverse mound, evidently the terminal moraine of a retreating glacier, which crosses the valley of the South Esk, a few miles above the point where it issues from the Grampians, and about 6 miles below the Kirktown of Clova. Its central part, at a place called Glenarm, is 800 feet above the level of the sea. The valley is about half a mile broad, and is bounded by steep and lofty mountains, but immediately above the transverse barrier it expands into a wide alluvial plain, several miles broad, which has evidently once been a lake. The barrier itself, about 150 feet high, consists in its lower part of till with boulders, 50 feet thick, precisely resembling the moraine of a Swiss glacier, above which there is a mass of stratified sand, varying in thickness from 50 to 100 feet, which has the appearance of consisting of the materials of the moraine rearranged in a stratified form, possibly by the waters of a glacier lake. The structure of the barrier has been laid open by the Esk, which has cut through it a deep passage about 400 yards wide.

I have also given an account of another striking feature in the physical geography of Perthshire and Forfarshire, which I consider to belong to the same period; namely, a continuous zone of boulder clay, forming ridges and mounds from 50 to 70 feet high (the upper part of the mounds usually stratified), enclosing numerous lakes, some of them several miles long, and many ponds and swamps filled with shell-marl and peat. This band of till, with Grampian boulders and associated river-gravel, may be traced continuously for a distance of 34 miles, with a width of 3 1/2 miles, from near Dunkeld, by Coupar, to the south of Blairgowrie, then through the lowest part of Strathmore, and afterwards in a straight line through the greatest depression in the Sidlaw Hills, from Forfar to Lunan Bay.

Although no great river now takes its course through this line of ancient lakes, moraines, and river gravel, yet it evidently marks

an ancient line by which, first, a great glacier descended from the mountains to the sea, and by which, secondly, at a later period, the principal water drainage of this country was effected. The subsequent modification in geography is comparable in amount to that which has taken place since the higher level gravels of the valley of the Somme were formed, or since the Belgian caves were filled with mud and bone-breccia.

(FIGURE 35. OVAL AND FLATTISH PEBBLES IN DESERTED CHANNELS.)

Mr. Jamieson has remarked, in reference to this and some other extinct river-channels of corresponding date, that we have the means of ascertaining the direction in which the waters flowed by observing the arrangement of the oval and flattish pebbles in their deserted channels; for in the bed of a fast-flowing river such pebbles are seen to dip towards the current, as represented in Figure 35, such being the position of greatest resistance to the stream.* (* Jamieson, "Quarterly Journal of the Geological Society" volume 16 1860 page 349.) If this be admitted, it follows that the higher or mountainous country bore the same relation to the lower lands, at the time when a great river passed through this chain of lakes, as it does at present.

We also seem to have a test of the comparatively modern origin of the mounds of till which surround the above-mentioned chain of lakes (of which that of Forfar is one), in the species of organic remains contained in the shell-marl deposited at their bottom. All the mammalia as well as shells are of recent species. Unfortunately, we have no information as to the fauna which inhabited the country at the time when the till itself was formed. There seem to be only three or four instances as yet known in all Scotland of mammalia having been discovered in boulder clay.

Mr. R. Bald has recorded the circumstances under which a single elephant's tusk was found in the unstratified drift of the valley of the Forth, with the minuteness which such a discovery from its rarity well deserved. He distinguishes the boulder clay, under the name of "the old alluvial cover," from that more modern alluvium, in which the whales of Airthrie, described in Chapter 3, were found. This cover he says is sometimes 160 feet thick. Having never observed any organic remains in it, he watched with curiosity and care the digging of the Union Canal between Edinburgh and Falkirk, which passed for no less than 28 miles almost continuously through it. Mr. Baird, the engineer who superintended the works, assisted in the inquiry, and at one place only in this long section did they meet with a fossil, namely, at Cliftonhall, in the valley of the Almond. It lay at a depth of between 15 and 20 feet from the surface, in very stiff clay, and consisted of an elephant's tusk, 39 inches long and 13 in circumference, in so fresh a state that an ivory turner purchased it and turned part of it into chessmen before it was rescued from destruction. The remainder is still preserved in the museum at Edinburgh, but by exposure to the air it has shrunk considerably.* (* "Memoirs of the Wernerian Society" Edinburgh volume 4 page 58.) In 1817, two other tusks and some bones of the elephant, as we learn from the same authority (Mr. Bald), were met with, 3 1/2 feet long and 13 inches in circumference, lying in an horizontal position, 17 feet deep in clay, with marine shells, at Kilmaurs, in Ayrshire. The species of shells are not given.* (* Ibid. volume 4 page 63.)

In another excavation through the Scotch boulder clay, made in digging the Clyde and Forth Junction Railway, the antlers of a reindeer were found at Croftamie, in Dumbartonshire, in the basin of the river Endrick, which flows into Loch Lomond. They had cut through 12 feet of till with angular and rounded stones, some of large size, and then through 6 feet of underlying clay, when they came upon the deer's horns, 18 feet from the surface, and within a foot of the sandstone on which the till rested. At the distance of a few yards, and in the same position, but a foot or two deeper, were observed marine shells, Cyprina islandica, Astarte elliptica, A. compressa, Fusus antiquus, Littorina littorea, and a Balanus. The height above the level of the sea was between 100 and 103 feet. The reindeer's horn was seen by Professor Owen, who considered it to be that of a young female of the large variety, called by the Hudson's Bay trappers the caribou.

The remains of elephants, now in the museums of Glasgow and Edinburgh, purporting to come from the superficial deposits of Scotland have been referred to Elephas primigenius. In cases where tusks alone have been found unaccompanied by molar teeth, such specific determinations may be uncertain; but if any one specimen be correctly named, the occurrence of the mammoth and reindeer in the Scotch boulder-clay, as both these quadrupeds are known to have been contemporary with Man, favours the idea which I have already expressed, that the close of the glacial period in the Grampians may have coincided in time with the existence of Man in those parts of Europe where the climate was less severe, as, for example, in the basins of the Thames, Somme, and Seine, in which the bones of many extinct mammalia are associated with flint implements of the antique type.

PARALLEL ROADS OF GLEN ROY IN SCOTLAND.

(PLATE 2. VIEW OF THE MOUTHS OF GLEN ROY AND GLEN SPEAN,
BY SIR T. DICK LAUDER.
VV. Hill of Bohuntine.
VVV. Glen Roy.
V(inverted)V. Mealderry.
V. Entrance of Glen Spean
VV(superscript)V. Point of division between Glens Roy and Spean.)

Perhaps no portion of the superficial drift of Scotland can lay claim to so modern an origin on the score of the freshness of its aspect, as that which forms what are called the Parallel Roads of Glen Roy. If they do not belong to the Recent epoch, they are at least posterior in date to the present outline of mountain and glen, and to the time when every one of the smaller burns ran in their present channels, though some of them have since been slightly deepened. The almost perfect horizontality, moreover, of the roads, one of which is continuous for about 20 miles from east to west, and 12 miles from north to south, shows that since the era of their formation no change has taken place in the relative levels of different parts of the district.

(FIGURE 36. MAP OF THE PARALLEL ROADS OF GLEN ROY OR LOCHABER.

A. five miles distant south-west from this point is

Fort William, where the Lochy joins an arm of the sea, called Loch Eil.
Vertical lines. Cols or watersheds at the heads of the glens--once the westward outlet of the lakes.
Dots. Conspicuous delta deposits as laid down by Mr. T.F. Jamieson.)

Glen Roy is situated in the Western Highlands, about 10 miles east-north-east of Fort William, near the western end of the great glen of Scotland, or Caledonian Canal, and near the foot of the highest of the Grampians, Ben Nevis. (See map, Figure 36.) Throughout nearly its whole length, a distance of more than 10 miles, three parallel roads or shelves are traced along the steep sides of the mountains, as represented in the annexed view, Plate 2, by the late Sir T. Dick Lauder, each maintaining a perfect horizontality, and continuing at exactly the same level on the opposite sides of the glen. Seen at a distance, they appear like ledges, or roads, cut artificially out of the sides of the hills; but when we are upon them, we can scarcely recognise their existence, so uneven is their surface, and so covered with boulders. They are from 10 to 60 feet broad, and merely differ from the side of the mountain by being somewhat less steep.

On closer inspection, we find that these terraces are stratified in the ordinary manner of alluvial or littoral deposits, as may be seen at those points where ravines have been excavated by torrents. The parallel shelves, therefore, have not been caused by denudation, but by the deposition of detritus, precisely similar to that which is dispersed in smaller quantities over the declivities of the hills above. These hills consist of clay-slate, mica schist, and granite, which rocks have been worn away and laid bare at a few points immediately above the parallel roads. The lowest of these roads is about 850 feet above the level of the sea, the next about 212 feet higher, and the third 82 feet above the second. There is a fourth shelf, which occurs only in a contiguous valley called Glen Gluoy, which is 12 feet above the highest of all the Glen Roy roads, and consequently about 1156 feet above the level of the sea. * (* Another detached shelf also occurs at Kilfinnan. (See Map, Figure 36.)) One only, the lowest of the three roads of Glen Roy, is continued throughout Glen Spean, a large valley with which Glen Roy unites. (See Plate 2 and map, Figure 36.) As the shelves, having no slope towards the sea like ordinary river terraces, are always at the same absolute height, they become continually more elevated above the river in proportion as we descend each valley; and they at length terminate very abruptly, without any obvious cause, or any change either in the shape of the ground or in the composition or hardness of the rocks.

I should exceed the limits of this work, were I to attempt to give a full description of all the geographical circumstances attending these singular terraces, or to discuss the ingenious theories which have been severally proposed to account for them by Dr. Macculloch, Sir T. Lauder, and Messrs. Darwin, Agassiz, Milne, and Chambers. There is one point, however, on which all are agreed, namely, that these shelves are ancient beaches, or littoral formations, accumulated round the edges of one or more sheets of water which once stood for a long time successively at the level of the several shelves.

(FIGURE 37. SECTION THROUGH SIDE OF LOCH.

AB. Supposed original surface of rock.
CD. Roads or shelves in the outer alluvial covering of the hill.)

It is well known, that wherever a lake or marine fjord exists surrounded by steep mountains subject to disintegration by frost or the action of torrents, some loose matter is washed down annually, especially during the melting of snow, and a check is given to the descent of this detritus at the point where it reaches the waters of the lake. The waves then spread out the materials along the shore, and throw some of them upon the beach; their dispersing power being aided by the ice, which often adheres to pebbles during the winter months, and gives buoyancy to them. The annexed diagram (Figure 37) illustrates the manner in which Dr. MacCulloch and Mr. Darwin suppose "the roads" to constitute mere excrescences of the superficial alluvial coating which rests upon the hillside, and consists chiefly of clay and sharp unrounded stones.

Among other proofs that the parallel roads have really been formed along the margin of a sheet of water, it may be mentioned, that wherever an isolated hill rises in the middle of the glen above the level of any particular shelf, as in Mealderry, Plate 2, a corresponding shelf is seen at the same level passing round the hill, as would have happened if it had once formed an island in a lake or fjord. Another very remarkable peculiarity in these terraces is this; each of them comes in some portion of its course to a col, or parting ridge, between the heads of glens, the explanation of which will be considered in the sequel.

Those writers who first advocated the doctrine that the roads were the ancient beaches of freshwater lakes, were unable to offer any probable hypothesis respecting the formation and subsequent removal of barriers of sufficient height and solidity to dam up the water. To introduce any violent convulsion for their removal was inconsistent with the uninterrupted horizontality of the roads, and with the undisturbed aspect of those parts of the glens where the shelves come suddenly to an end.

Mr. Agassiz and Dr. Buckland, desirous, like the defenders of the lake theory, to account for the limitation of the shelves to certain glens, and their absence in contiguous glens, where the rocks are of the same composition, and the slope and inclination of the ground very similar, first started the theory that these valleys were once blocked up by enormous glaciers descending from Ben Nevis, giving rise to what are called, in Switzerland and in the Tyrol, glacier-lakes. In corroboration of this view, they contended that the alluvium of Glen Roy, as well as of other parts of Scotland, agrees in character with the moraines of glaciers seen in the Alpine valleys of Switzerland. It will readily be conceded that this hypothesis was preferable to any previous lacustrine theory, by accounting more easily for the temporary existence and entire disappearance of lofty transverse barriers, although the height required for the supposed dams of ice appeared very enormous.

Before the idea of glacier-lakes had been suggested by Agassiz, Mr. Darwin examined Glen Roy, and came to the opinion that the shelves were formed when the glens were still arms of the sea, and,

consequently, that there never were any seaward barriers. According to him, the land emerged during a slow and uniform upward movement, like that now experienced throughout a large part of Sweden and Finland; but there were certain pauses in the upheaving process, at which times the waters of the sea remained stationary for so many centuries as to allow of the accumulation of an extraordinary quantity of detrital matter, and the excavation, at many points immediately above the sea-level, of deep notches and bare cliffs in the hard and solid rock.

This theory I adopted in 1841 ("Elements," 2nd edition), as appearing to me less objectionable than any other then proposed. The phenomena most difficult to reconcile with it are, first, the abrupt cessation of the roads at certain points in the different glens; secondly, their unequal number in different valleys connecting with each other, there being three, for example, in Glen Roy, and only one in Glen Spean; thirdly, the precise horizontality of level maintained by the same shelf over a space many leagues in length, requiring us to assume, that during a rise of 1156 feet no one portion of the land was raised even a few yards above another; fourthly, the coincidence of level already alluded to of each shelf with a col, or the point forming the head of two glens, from which the rain-waters flow in opposite directions. This last-mentioned feature in the physical geography of Lochaber Mr. Darwin endeavoured to explain in the following manner. He called these cols "land-straits," and regarding them as having been anciently sounds or channels between islands, he pointed out that there is a tendency in such sounds to be silted up, and always the more so in proportion to their narrowness. In a chart of the Falkland Islands, by Captain Sulivan, R.N., it appears that there are several examples there of straits where the soundings diminish regularly towards the narrowest part. One is so nearly dry that it can be walked over at low water, and another, no longer covered by the sea, is supposed to have recently dried up in consequence of a small alteration in the relative level of sea and land. "Similar straits," observes Mr. Chambers, "hovering, in character, between sea and land, and which may be called fords, are met with in the Hebrides. Such, for example, is the passage dividing the islands of Lewis and Harris, and that between North Uist and Benbecula, both of which would undoubtedly appear as cols, coinciding with a terrace or raised beach, all round the islands if the sea were to subside."* (* R. Chambers, "Ancient Sea Margins" page 114.)

The first of the difficulties above alluded to, namely, the non-extension of the shelves over certain parts of the glens, might be explained, said Mr. Darwin, by supposing in certain places a quick growth of green turf on a good soil, which prevented the rain from washing away any loose materials lying on the surface. But wherever the soil was barren, and where green sward took long to form, there may have been time for the removal of the gravel. In one case an intermediate shelf appears for a short distance (three quarters of a mile) on the face of the mountain called Tombhran, between the two upper shelves, and is seen nowhere else. It occurs where there was the longest space of open water, and where the waves may have acquired a more than ordinary power to heap up detritus.

The unequal number of the shelves in valleys communicating with each other, and in which the boundary rocks are similar in

composition, and the general absence of any shelves at corresponding altitudes in glens on the opposite watershed, like that of the Spey, and in valleys where the waters flow eastward, are difficulties attending the marine theory which have never yet been got over. Mr. T.F. Jamieson, before cited, has, during a late visit to Lochaber, in 1861, observed many facts highly confirmatory of the hypothesis of glacier-lakes which, as I have already stated, was originally advanced by Mr. Agassiz. In the first place, he found much superficial scoring and polishing of rocks, and accumulation of boulders at those points where signs of glacial action ought to appear, if ice had once dammed up the waters of the glens in which the "roads" occur. Ben Nevis may have sent down its glaciers from the south, and Glen Arkaig from the north, for the mountains at the head of the last-mentioned glen are 3000 feet high, and may, together with other tributary glens, have helped to choke up the great Caledonian valley with ice, so as to block up for a time the mouths of the Spean, Roy, and Gluoy. The temporary conversion of these glens into glacier-lakes is the more conceivable, because the hills at their upper ends not being lofty nor of great extent, they may not have been filled with ice at a time when great glaciers were generated in other adjoining and much higher regions.

Secondly. The shelves, says Mr. Jamieson, are more precisely defined and unbroken than any of the raised beaches or acknowledged ancient coast-lines visible on the west of Scotland, as in Argyllshire, for example.

Thirdly. At the level of the lower shelf in Glen Roy, at points where torrents now cut channels through the shelf as they descend the hill-side, there are small delta-like extensions of the shelf, perfectly preserved, as if the materials, whether fine or coarse, had originally settled there in a placid lake, and had not been acted upon by tidal currents, mingling them with the sediment of other streams. These deltas are too entire to allow us to suppose that they have at any time since their origin been exposed to the waves of the sea.

Fourthly. The alluvium on the cols or watersheds, before alluded to, is such as would have been formed if the waters of the rivers had been made to flow east, or out of the upper ends of the supposed glacier-lakes, instead of escaping at the lower ends, in a westerly direction, where the great blockages of ice are assumed to have occurred.

In addition to these arguments of Mr. Jamieson, I may mention that in Switzerland, at present, no testacea live in the cold waters of glacier-lakes; so that the entire absence of fossil shells, whether marine or freshwater, in the stratified materials of each shelf, would be accounted for if the theory above mentioned be embraced.

When I examined "the parallel roads" in 1825, in company with Dr. Buckland, neither this glacier theory nor Mr. Darwin's suggestion of ancient sea-margins had been proposed, and I have never since revisited Lochaber. But I retain in my memory a vivid recollection of the scenery and physical features of the district, and I now consider the glacier-lake theory as affording by far the most satisfactory solution of this difficult problem. The objection to it, which until lately appeared to be the most formidable, and

which led Mr. Robert Chambers in his "Sea Margins," to reject it entirely, was the difficulty of conceiving how the waters could be made to stand so high in Glen Roy as to allow the uppermost shelf to be formed. Grant a barrier of ice in the lower part of the glen of sufficient altitude to stop the waters from flowing westward, still, what prevented them from escaping over the col at the head of Glen Glaster? This col coincides exactly in level, as Mr. Milne Home first ascertained, with the second or middle shelf of Glen Roy. The difficulty here stated appears now to be removed by supposing that the higher lines or roads were formed before the lower ones, and when the quantity of ice was most in excess. We must imagine that at the time when the uppermost shelf of Glen Roy was forming in a shallow lake, the lower part of that glen was filled up with ice, and, according to Mr. Jamieson, a glacier from Loch Treig then protruded itself across Glen Spean and rested on the flank of the hill on the opposite side in such a manner as effectually to prevent any water from escaping over the Glen Glaster col. The proofs of such a glacier having actually existed at the point in question consist, he says, in numerous cross striae observable in the bottom of Glen Spean, and in the presence of moraine matter in considerable abundance on the flanks of the hill extending to heights above the Glen Glaster col. When the ice shrank into less dimensions the second shelf would be formed, having its level determined by the col last mentioned, Glen Spean in the meantime being filled with a glacier. Finally, the ice blockage common to glens Roy, Spean, and Laggan, which consisted probably of a glacier from Ben Nevis, gave rise to the lowest and most extensive lake, the waters of which escaped over the pass of Muckul or the col at the head of Loch Laggan, which, as Mr. Jamieson has now ascertained: agrees precisely in level with the lowest of all the shelves, and where there are unequivocal signs of a river having flowed out for a considerable period.

Dr. Hooker has described some parallel terraces, very analogous in their aspect to those of Glen Roy, as existing in the higher valleys of the Himalaya, of which his pencil has given us several graphic illustrations. He believes these Indian shelves to have originated on the borders of glacier-lakes, the barriers of which were usually formed by the ice and moraines of lateral or tributary glaciers, which descended into and crossed the main valley, as we have supposed in the case of Glen Roy; but others he ascribes to the terminal moraine of the principal glacier itself, which had retreated during a series of milder seasons, so as to leave an interval between the ice and the terminal moraine. This interspace caused by the melting of ice becomes filled with water and forms a lake, the drainage of which usually takes place by percolation through the porous parts of the moraine, and not by a stream overflowing that barrier. Such a glacier-lake Dr. Hooker actually found in existence near the head of the Yangma valley in the Himalaya. It was moreover partially bounded by recently formed marginal terraces or parallel roads, implying changes of level in the barrier of ice and moraine matter.* (* Hooker, "Himalayan Journal" volume 1 page 242; 2 pages 119, 121, 166. I have also profited by the author's personal explanations.)

It has been sometimes objected to the hypothesis of glacier-lakes, as applied to the case of Glen Roy, that the shelves must have taken a very long period for their formation. Such a lapse of time, it is said, might be consistent with the theory of pauses or

stationary periods in the rise of the land during an intermittent upward movement, but it is hardly compatible with the idea of so precarious and fluctuating a barrier as a mass of ice. But the reader will have seen that the permanency of level in such glacier-lakes has no necessary connection with minor changes in the height of the supposed dam of ice. If a glacier descending from higher mountains through a tributary glen enters the main valley in which there happens to be no glacier, the river is arrested in its course and a lake is formed. The dam may be constantly repaired and may vary in height several hundreds of feet without affecting the level of the lake, so long as the surplus waters escape over a col or parting ridge of rock. The height at which the waters remain stationary is determined solely by the elevation of the col, and not by the barrier of ice, provided the barrier is higher than the col.

But if we embrace the theory of glacier-lakes, we must be prepared to assume not only that the sea had nothing to do with the original formation of the "parallel roads," but that it has never, since the disappearance of the lakes, risen in any one of the glens up to the level of the lowest shelf, which is about 850 feet high; for in that case the remarkable persistency and integrity of the roads and deltas, before described, must have been impaired.

We have seen that 50 miles to the south of Lochaber, the glacier formations of Lanarkshire with marine shells of arctic character have been traced to the height of 524 feet. About 50 miles to the south-east in Perthshire are those stratified clays and sands, near Killiecrankie, which were once supposed to be of submarine origin, and which in that case would imply the former submergence of what is now dry land to the extent of 1550 feet, or several hundred feet beyond the highest of the parallel roads. Even granting that these laminated drifts may have had a different origin, as above suggested, there are still many facts connected with the distribution of erratics and the striation of rocks in Scotland which are not easily accounted for without supposing the country to have sunk, since the era of continental ice, to a greater depth than 525 feet, the highest point to which marine shells have yet been traced.

After what was said of the pressure and abrading power of a general crust of ice, like that now covering Greenland, it is almost superfluous to say that the parallel roads must have been of later date than such a state of things, for every trace of them must have been obliterated by the movement of such a mass of ice. It is no less clear that as no glacier-lakes can now exist in Greenland [Note 26], so there could have been none in Scotland, when the mountains were covered with one great crust of ice. It may, however, be contended that the parallel roads were produced when the general crust of ice first gave place to a period of separate glaciers, and that no period of deep submergence ever intervened in Lochaber after the time of the lakes. Even in that case, however, it is difficult not to suppose that the Glen Roy country participated in the downward movement which sank part of Lanarkshire 525 feet beneath the sea, subsequently to the first great glaciation of Scotland. Yet that amount of subsidence might have occurred, and even a more considerable one, without causing the sea to rise to the level of the lowest shelf, or to a height of 850 feet above the present sea-level.

This is a question on which I am not prepared at present to offer a decided opinion.

Whether the horizontality of the shelves or terrace-lines is really as perfect as has been generally assumed is a point which will require to be tested by a more accurate trigonometrical survey than has yet been made. The preservation of precisely the same level in the lowest line throughout the glens of Roy, Spean, and Laggan, for a distance of 20 miles east and west, and 10 or 12 miles north and south, would be very wonderful if ascertained with mathematical precision. Mr. Jamieson, after making in 1862 several measurements with a spirit-level, has been led to suspect a rise in the lowest shelf of one foot in a mile in a direction from west to east, or from the mouth of Glen Roy to a point 6 miles east of it in Glen Spean. To confirm such observations, and to determine whether a similar rate of rise continues eastward, as far as the pass of Muckul, would be most important.

On the whole, I conclude that the Glen Roy terrace-lines and those of some neighbouring valleys, were formed on the borders of glacier-lakes, in times long subsequent to the principal glaciation of Scotland. They may perhaps have been nearly as late, especially the lowest of the shelves, as that portion of the Pleistocene period in which Man co-existed in Europe with the mammoth.

CHAPTER 14.

CHRONOLOGICAL RELATIONS OF THE GLACIAL PERIOD AND THE EARLIEST SIGNS OF MAN'S APPEARANCE IN EUROPE--CONTINUED.

Signs of extinct Glaciers in Wales.
Great Submergence of Wales during the Glacial Period proved by Marine Shells.
Still greater Depression inferred from Stratified Drift.
Scarcity of Organic Remains in Glacial Formations.
Signs of extinct Glaciers in England.
Ice Action in Ireland.
Maps illustrating successive Revolutions in Physical Geography during the Pleistocene Period.
Southernmost Extent of Erratics in England.
Successive Periods of Junction and Separation of England, Ireland, and the Continent.
Time required for these Changes.
Probable Causes of the Upheaval and Subsidence of the Earth's Crust.
Antiquity of Man considered in relation to the Age of the existing Fauna and Flora.

EXTINCT GLACIERS IN WALES.

The considerable amount of vertical movement in opposite directions, which was suggested in the last chapter, as affording the most probable explanation of the position of some of the stratified and fossiliferous drifts of Scotland, formed since the commencement of the glacial period, will appear less startling if it can be shown that independent observations lead us to infer that a geographical revolution of still greater magnitude accompanied the successive phases of glaciation through which the Welsh

mountains have passed.

That Wales was once an independent centre of the dispersion of erratic blocks has long been acknowledged. Dr. Buckland published in 1842 his reasons for believing that the Snowdonian mountains in Caernarvonshire were formerly covered with glaciers, which radiated from the central heights through the seven principal valleys of that chain, where striae and flutings are seen on the polished rocks directed towards as many different points of the compass. He also described the "moraines" of the ancient glaciers, and the rounded masses of polished rock, called in Switzerland "roches moutonnees." His views respecting the old extinct glaciers of North Wales were subsequently confirmed by Mr. Darwin, who attributed the transport of many of the larger erratic blocks to floating ice. Much of the Welsh glacial drift had already been shown by Mr. Trimmer to have had a submarine origin, and Mr. Darwin maintained that when the land rose again to nearly its present height, glaciers filled the valleys, and "swept them clean of all the rubbish left by the sea."* (* "Philosophical Magazine" series 3 volume 21 page 180.)

Professor Ramsay, in a paper read to the Geological Society in 1851, and in a later work on the glaciation of North Wales, described three successive glacial periods, during the first of which the land was much higher than it now is, and the quantity of ice excessive; secondly, a period of submergence when the land was 2300 feet lower than at present, and when the higher mountain tops only stood out of the sea as a cluster of low islands, which nevertheless were covered with snow; and lastly, a third period when the marine boulder drift formed in the middle period was ploughed out of the larger valleys by a second set of glaciers, smaller than those of the first period. This last stage of glaciation may have coincided with that of the parallel roads of Glen Roy, spoken of in the last chapter. In Wales it was certainly preceded by submergence, and the rocks had been exposed to glacial polishing and friction before they sank.

Fortunately the evidence of the sojourn of the Welsh mountains beneath the waters of the sea is not deficient, as in Scotland, in that complete demonstration which the presence of marine shells affords. The late Mr. Trimmer discovered such shells on Moel Tryfan, in North Wales, in drift elevated more than 1300 feet above the level of the sea. It appears from his observations, and those of the late Edward Forbes, corroborated by others of Professor Ramsay and Mr. Prestwich, that about twelve species of shells, including Fusus bamfius, F. antiquus, Venus striatula (Forbes and Hanley), have been met with at heights of between 1000 and 1400 feet, in drift, reposing on a surface of rock which had been previously exposed to glacial friction and striation.* (* Ramsay, "Quarterly Journal of the Geological Society" volume 8 1852 page 372.) The shells, as a whole, are those of the glacial period, and not of the Norwich Crag. Two localities of these shells in Wales, in addition to that first pointed out by Mr. Trimmer, have since been observed by Professor Ramsay, who, however, is of opinion that the amount of submergence can by no means be limited to the extreme height to which the shells happen to have been traced; for drift of the same character as that of Moel Tryfan extends continuously to the height of 2300 feet. [Note 27.]

RARITY OF ORGANIC REMAINS IN GLACIAL FORMATIONS.

The general dearth of shells in such formations, below as well as above the level at which Mr. Trimmer first found them, deserves notice. Whether we can explain it or not, it is a negative character which seems to belong very generally to deposits formed in glacial seas. The porous nature of the strata, and the length of time during which they have been permeated by rain-water, may partly account, as we hinted in a former chapter, for the destruction of organic remains. But it is also possible that they were originally scarce, for we read of the waters of the sea being so freshened and chilled by the melting of ice-bergs in some Norwegian and Icelandic fjords, that the fish are driven away, and all the mollusca killed. The moraines of glaciers are always from the first devoid of shells, and if transported by ice-bergs to a distance, and deposited where the ice melts, may continue as barren of every indication of life as they were when they originated.

Nevertheless, it may be said, on the other hand, that herds of seals and walruses crowd the floating ice of Spitzbergen in latitude 80 degrees north, of which Mr. Lamont has recently given us a lively picture,* (* "Seasons with the Sea-Horses" 1861.) and huge whales fatten on myriads of pteropods in polar regions. It had been suggested that the bottom of the sea, at the era of extreme submergence in Scotland and Wales, was so deep as to reach the zero of animal life, which, in part of the Mediterranean (the Aegean, for example), the late Edward Forbes fixed, after a long series of dredgings, at 300 fathoms. But the shells of the glacial drift of Scotland and Wales, when they do occur, are not always those of deep seas; and, moreover, our faith in the uninhabitable state of the ocean at great depths has been rudely shaken, by the recent discovery of Captain McClintock and Dr. Wallich, of starfish in water more than a thousand fathoms deep (7560 feet!), midway between Greenland and Iceland. That these radiata were really dredged up from the bottom, and that they had been living and feeding there, appeared from the fact that their stomachs were full of Globigerina, of which foraminiferous creatures, both living and dead, the oozy bed of the ocean at that vast depth was found to be exclusively composed. [Note 28.]

Whatever may be the cause, the fact is certain, that over large areas in Scotland, Ireland, and Wales, I might add throughout the northern hemisphere on both sides of the Atlantic, the stratified drift of the glacial period is very commonly devoid of fossils, in spite of the occurrence here and there, at the height of 500, 700, and even 1400 feet, of marine shells. These, when met with, belong, with few exceptions, to known living species. I am therefore unable to agree with Mr. Kjerulf that the amount of former submergence can be measured by the extreme height at which shells happen to have been found.

GLACIAL FORMATIONS IN ENGLAND.

(FIGURE 38. DOME-SHAPED ROCKS, OR "ROCHES MOUTONEES," IN THE VALLEY OF THE ROTHAY, NEAR AMBLESIDE, FROM A DRAWING BY E. HULL, F.G.S.*
(* "Edinburgh New Philosophical Journal" volume 11 Plate 1 page 31 1860.))

The mountains of Cumberland and Westmorland, and the English lake

district, afford equally unequivocal vestiges of ice-action not only in the form of polished and grooved surfaces, but also of those rounded bosses before mentioned as being so abundant in the Alpine valleys of Switzerland, where glaciers exist, or have existed. Mr. Hall has lately published a faithful account of these phenomena, and has given a representation of some of the English "roches moutonnees," which precisely resemble hundreds of dome-shaped protuberances in North Wales, Sweden, and North America.* (* Hull, "Edinburgh New Philosophical Journal" July 1860.)

The marks of glaciation on the rocks, and the transportation of erratics from Cumberland to the eastward, have been traced by Professor Phillips over a large part of Yorkshire, extending to a height of 1500 feet above the sea; and similar northern drift has been observed in Lancashire, Cheshire, Derbyshire, Shropshire, Staffordshire, and Worcestershire. It is rare to find marine shells, except at heights of 200 or 300 feet; but a few instances of their occurrence have been noticed, especially of Turritella communis (a gregarious shell), far in the interior, at elevations of 500 feet, and even of 700 in Derbyshire, and some adjacent counties, as I learn from Mr. Binney and Mr. Prestwich.

Such instances are of no small theoretical interest, as enabling us to account for the scattering of large erratic blocks at equal or much greater elevations, over a large part of the northern and midland counties, such as could only have been conveyed to their present sites by floating ice. Of this nature, among others, is a remarkable angular block of syenit

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