

XVI. *Account of an assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, and Hyæna, and sixteen other animals; discovered in a cave at Kirkdale, Yorkshire, in the year 1821: with a comparative view of five similar caverns in various parts of England, and others on the Continent. By the Rev. WILLIAM BUCKLAND, F. R. S. F. L. S. Vice President of the Geological Society of London, and Professor of Mineralogy and Geology in the University of Oxford, &c. &c. &c.*

Read February 21, 1822.

HAVING been induced in December last to visit Yorkshire, for the purpose of investigating the circumstances of the cave at Kirkdale, near Kirby Moorside, about 25 miles N. N. E. of the city of York, in which a discovery was made last summer of a singular collection of teeth and bones, I beg to lay before the Royal Society the result of my observations on this new and interesting case, and to point out some important general conclusions that arise from it.

The facts I have collected, seem calculated to throw an important light on the state of our planet at a period antecedent to the last great convulsion that has affected its surface; and I may add, in limine, that they afford one of the most complete and satisfactory chains of consistent circumstantial evidence I have ever met with in the course of my geological investigations.

As I shall have frequent occasion to make use of the word

diluvium, it may be necessary to premise, that I apply it to those extensive and general deposits of superficial gravel, which appear to have been produced by the last great convulsion that has affected our planet ; and that with regard to the indications afforded by geology of such a convulsion, I entirely coincide with the views of M. CUVIER, in considering them as bearing undeniable evidence of a recent and transient inundation.* On these grounds I have felt myself fully justified in applying the epithet *diluvial*, to the results of this great convulsion, of *antediluvial*, to the state of things immediately preceding it, and *postdiluvial*, or *alluvial*, to that which succeeded it, and has continued to the present time.

In detailing these observations I propose, first, to submit a short account of the geological position and relations of the rock in which the cavern alluded to is situated ; to proceed, in the next place, to a description of the cavern itself ; then to enter into that which will form the most important part of this communication, a particular enumeration of the animal remains there inhumed, and the very remarkable phenomena with which they are attended ; to review the general inferences to which these phenomena lead ; and conclude with a brief comparative account of analogous animal deposits in other parts of this country, and the Continent.

Kirkdale is situated (as may be seen by reference to the

* Analogous evidences to the same point, collected in this country from the state of the gravel beds and vallies in the midland parts of England, have recently been published by myself in a Paper on the Lickey Hill, in the second part of the fifth Volume of the Geological Transactions, and in the Appendix to an Inaugural Lecture I published at Oxford, in 1820. Another Paper of mine on similar evidences afforded by the vallies that intersect the coast of West Dorset and East Devonshire, will be published in the first part of the sixth Volume of the Geological Transactions.

annexed map, Plate XV.) about 25 miles N.N.E. of the city of York, between Helmsley and Kirby Moorside, near the point at which the east base of the Hambleton hills, looking towards Scarborough, subsides into the vale of Pickering, and on the S. extremity of the mountainous district known by the name of the Eastern and the Cleveland Moorlands.

The substratum of this valley of Pickering is a mass of stratified blue clay, identical with that which at Oxford and Weymouth reposes on a similar lime-stone to that of Kirkdale, and containing, subordinately, beds of inflammable bituminous shale, like that of Kimeridge, in Dorsetshire. Its south boundary is formed by the Howardian hills, and by the elevated escarpment of the chalk that terminates the Wolds towards Scarborough. Its north frontier is composed of a belt of lime-stone, extending eastward 30 miles from the Hambleton hills, near Helmsley, to the sea at Scarborough, and varying in breadth from 4 to 7 miles; this lime-stone is intersected by a succession of deep and parallel vallies, (here called dales) through which the following rivers, from the moorlands, pass down southwards to the vale of Pickering, viz. the Rye, the Rical, the Hodge Beck, the Dove, the Seven Beck, and the Costa; their united streams fall into the Derwent above New Malton, and their only outlet is by a deep gorge, extending from near this town down to Kirkham, the stoppage of which would at once convert the whole vale of Pickering into an immense inland lake; and before the excavation of which, it is probable, that such a lake existed, having its north border nearly along the edge of the belt of lime-stone just described, and at no great distance from the mouth of the cave at Kirkdale.

The position of the cave is at the south and lower extremity of one of these dales (that of the Rical Beck), at the point where it falls into the vale of Pickering, at the distance of about a furlong from the church of Kirkdale, and near the brow of the left flank of the valley, close to the road. This flank slopes towards the river at an angle of 25° , and the height of the brow of the slope above the water may be about 120 feet. (See Plate XVI. fig. 1.)

The rock perforated by the cave is referable to that portion of the oolite formation which, in the south of England, is known by the name of the Oxford oolite and coral rag: its organic remains are identical with those of the Heddington quarries near Oxford, but its substance is harder and more compact, and more interspersed with siliceous matter, forming irregular concretions, beds, and nodules of chert in the lime-stone, and sometimes entirely penetrating its coral-line remains. The most compact beds of this lime-stone resemble the younger alpine lime-stone of Meillierie and Aigle, in Switzerland, and they alternate with and pass gradually into those of a coarser oolitic texture; and both varieties are stratified in beds from one to four feet thick. The cave is situated in one of the compact beds which lies between two others of the coarser oolitic variety; the latter vary in colour from light yellow to blue; the compact beds are of a dark grey passing to black, are extremely fetid, and full of corals and spines of the *echinus cidaris*. The compact portions of this oolite partake of the property common to compact lime-stones of all ages and formations, of being perforated by irregular holes and caverns intersecting them in all directions; the cause of these cavities has never been satisfactorily

ascertained: into this question (which is one of considerable difficulty in geology) it is foreign to my present purpose to enquire, any farther than to state that they were neither produced, enlarged, or diminished by the presence of the animals whose bones we now find in them.

The abundance of such caverns in the lime-stone of the vicinity of Kirkdale, is evident from the fact of the engulfment of several of the rivers above enumerated in the course of their passage across it from the eastern moorlands to the vale of Pickering; and it is important to observe, that the elevation of the Kirkdale cave, above the bed of the Hodge Beck, exceeding 100 feet, excludes the possibility of our attributing the muddy sediment we shall find it to contain, to any land flood or extraordinary rise of the waters of that or any other now existing river.

It was not till the summer of 1821, that the existence of any animal remains, or of the cavern containing them, had been suspected. At this time, in continuing the operations of a large quarry along the brow of the slope just mentioned, (see Plate XVI. fig. 1.) the workmen accidentally intersected the mouth of a long hole or cavern, closed externally with rubbish, and overgrown with grass and bushes. As this rubbish was removed before any competent person had examined it, it is not certain whether it was composed of diluvial gravel and rolled pebbles, or was simply the debris that had fallen from the softer portions of the strata that lay above it; the workmen, however, who removed it, and some gentlemen who saw it, assured me, that it was composed of gravel and sand. In the interior of the cave there was not a single rolled pebble, nor one bone, or fragment of bone, that bears the

slightest mark of having been rolled by the action of water. A few bits of lime-stone and roundish concretions of chert that had fallen from the roof and sides, were the only rocky fragments that occurred, with the exception of stalactite.

About 30 feet of the outer extremity of the cave have now been removed, and the present entrance is a hole in the perpendicular face of the quarry less than 5 feet square, which it is only possible for a man to enter on his hands and knees, and which expands and contracts itself irregularly from 2 to 7 feet in breadth and height, diminishing however as it proceeds into the interior of the hill. The cave is about 15 or 20 feet below the incumbent field, the surface of which is nearly level, and parallel to the stratification of the lime-stone, and to the bottom of the cave. Its main direction is E. S. E. but deviating from a straight line by several zigzags to the right and left (see Pl. XVI. fig. 3.); its greatest length is from 150 to 200 feet. In its interior it divides into several smaller passages, the extent of which has not been ascertained. In its course it is intersected by some vertical fissures, one of which is curvilinear, and again returns to the cave; another has never been traced to its termination; whilst the outer extremity of a third, is probably seen in a crevice or fissure that appears on the face of the quarry, and which closes upwards before it leaves the body of the lime-stone. By removing the sediment and stalactite that now obstruct the smaller passages, a farther advance in them may be rendered practicable. The half corroded fragments of corals, of spines of echini and other organic remains, and the curious ledges of lime-stone and nodules of chert that project along the sides and roof of the cave, together with the small

grooves and pits that cover great part of its interior, show that there was a time when its dimensions were less than at present; though they fail to prove by what cause it was originally produced. There are but two or three places in which it is possible to stand upright, and these are where the cavern is intersected by the fissures; the latter of which continue open upwards to the height only of a few feet, when they gradually close, and terminate in the body of the lime-stone: they are thickly lined with stalactite, and are attended by no fault or slip of either of their sides. Both the roof and floor, for many yards from the entrance, are composed of horizontal strata of lime-stone, uninterrupted by the slightest appearance of fissure, fracture, or stony rubbish of any kind; but farther in, the roof and sides become irregularly arched, presenting a very rugged and grotesque appearance, and being studded with pendent and roundish masses of chert and stalactite; the bottom of the cavern is visible only near the entrance; and its irregularities, though apparently not great, have been filled up throughout to a nearly level surface, by the introduction of a bed of mud or sediment, the history of which, and also of the stalactite, I shall presently describe. (See Plate XVI. fig. 2).

The fact already mentioned of the engulphment of the Rical Beck, and other adjacent rivers, as they cross the lime-stone, showing it to abound with many similar cavities to those at Kirkdale, renders it likely that, hereafter, similar deposits of bones may be discovered in this same neighbourhood; but accident alone can lead to such discovery, as it is probable the mouths of these caverns are buried under diluvian sand and gravel, or post-diluvian detritus; so that nothing but their

casual intersection by some artificial operations, will lead to the knowledge of their existence ; and in this circumstance, we also see a reason why so few caverns of this kind have hitherto been discovered, although it is probable that many such may exist.

In all these cases, the bones found in caverns are never mineralised, but simply in the state of grave bones, or incrusted by stalactite ; and have no farther connection with the rocks themselves, than that arising from the accident of having been lodged in their cavities, at periods long subsequent to the formation and consolidation of the strata in which these cavities occur.

On entering the cave at Kirkdale (see Plate XVI. fig. 2), the first thing we observe is a sediment of mud, covering entirely its whole bottom to the average depth of about a foot, and entirely covering and concealing the subjacent rock, or actual floor of the cavern. Not a particle of mud is found attached either to the sides or roof ; nor is there a trace of it adhering to the sides or upper portions of the transverse fissures, or any thing to suggest the idea that it entered through them. The surface of this sediment when the cave was first entered was nearly smooth and level, except in those parts where its regularity had been broken by the accumulation of stalagmite above it, or ruffled by the dripping of water : its substance is argillaceous and slightly micaceous loam, composed of such minute particles as would easily be suspended in muddy water, and mixt with much calcareous matter, that seems to have been derived in part from the dripping of the roof, and in part from comminuted bones.

Above this mud, on advancing some way into the cave, the

roof and sides are seen to be partially studded and cased over with a coating of stalactite, which is most abundant in those parts where the transverse fissures occur, but in small quantity where the rock is compact and devoid of fissures. Thus far it resembles the stalactite of ordinary caverns; but on tracing it downwards to the surface of the mud, it was there found to turn off at right angles from the sides of the cave, and form above the mud a plate or crust, shooting across like ice on the surface of water, or cream on a pan of milk. (See Plate XVI. fig. 2). The thickness and quantity of this crust varied with that found on the roof and sides, being most abundant, and covering the mud entirely where there was much stalactite on the sides, and more scanty in those places where the roof presented but little: in many parts it was totally wanting both on the roof and surface of the mud and subjacent floor. Great portion of this crust had been destroyed in digging up the mud to extract the bones; it still remained, however, projecting partially in some few places along the sides; and in one or two, where it was very thick, it formed, when I visited the cave, a continuous bridge over the mud entirely across from one side to the other. In the outer portion of the cave, there was a mass of this kind which had been accumulated so high as to obstruct the passage, so that a man could not enter till it had been dug away.

These horizontal incrustations have been formed by the water which, trickling down the sides, was forced to ooze off laterally as soon as it came into contact with the mud; in other parts, where it fell in drops from the roof, stalagmitic accumulations have been raised on its surface, some of which are very large, but more commonly they are of the size and

shape of a cow's pap, a name which the workmen have applied to them. There is no alternation of mud with any repeated beds of stalactite, but simply a partial deposit of the latter on the floor beneath it ; and it was chiefly in the lower part of the sediment above described, and in the stalagmitic matter beneath it, that the animal remains were found : its substance contains no black earth or admixture of animal matter, except an infinity of extremely minute particles of undecomposed bone. In the whole extent of the cave, only a very few large bones have been discovered that are tolerably perfect ; most of them are broken into small angular fragments and chips, the greater part of which lay separately in the mud, whilst others were wholly or partially invested with stalactite ; and some of the latter united with masses of still smaller fragments and cemented by the stalactite, so as to form an osseous breccia, of which I have specimens.

The effect of this mud in preserving the bones from decomposition has been very remarkable ; some that had lain a long time before its introduction were in various stages of decomposition ; but even in these, the farther progress of decay appears to have been arrested by it ; and in the greater number, little or no destruction of their form, and scarcely any of their substance, has taken place. I have found on immersing fragments of these bones in an acid till the phosphate and carbonate of lime were removed, that nearly the whole of their original gelatine has been preserved. Analogous cases of the preservative powers of diluvial mud occur on the coast of Essex, near Walton, and at Lawford, near Rugby, in Warwickshire. Here the bones of the same species of elephant, rhinoceros, and other diluvial animals occur in a state of freshness and freedom from decay, nearly equal

to those in the cave at Kirkdale, and this from the same cause, viz. their having been protected from the access of atmospheric air, or the percolation of water, by the argillaceous matrix in which they have been imbedded: whilst similar bones that have lain the same length of time in diluvial sand, or gravel, and been subject to the constant percolation of water, have lost their compactness and strength and great part of their gelatine, and are often ready to fall to pieces on the slightest touch; and this where beds of clay and gravel occur alternating in the same quarry, as at Lawford.

The workmen on first discovering the bones at Kirkdale, supposed them to have belonged to cattle that died by a murrain in this district a few years ago, and they were for some time neglected, and thrown on the roads with the common lime-stone; they were at length noticed by Mr. HARRISON, a medical gentleman of Kirby Moorside, and have since been collected and dispersed amongst so many individuals, that it is probable nearly all the specimens will in a few years be lost, with the exception of such as may be deposited in public collections. By the kindness and liberality of the Bishop of Oxford (to whom I am also indebted for my first information of the discovery of this cave) and of C. DUNCOMBE, Esq. and Lady CHARLOTTE DUNCOMBE, of Duncombe Park, a nearly complete series of the teeth of all these animals has been presented to the Museum at Oxford; whilst a still better collection both of teeth and bones is in the possession of J. GIBSON, Esq. of Stratford in Essex, to whose exertions we owe the preservation of many valuable specimens, and who is about to present a series of them to our public collections in London. W. SALMOND, Esq. also, since I visited Kirkdale in December last, has been engaged with much zeal and acti-

vity in measuring and exploring new branches of the cave, and making large collections of the teeth and bones, from which I understand he also intends to enrich our public cabinets in the metropolis. I am indebted to him for the annexed ground plan of the cave, and its ramifications, (Plate XVI. fig. 3). Drawings by Mr. CLIFT, of some of the most perfect of Mr. GIBSON'S specimens, have been sent to M. CUVIER, for the new edition of his work on fossil animals; copies of these have been made for me by Miss MORLAND, and appear in the annexed plates, with many other drawings, for which I am indebted to the pencil of Miss DUNCOMBE; and the Rev. GEORGE YOUNG, and Mr. BIRD of Whitby, in their History of the Geology of the coast of Yorkshire, have given engravings of some teeth that remain in their possession.

It appears that the teeth and bones which have as yet been discovered in the cave at Kirkdale, are referable to the following twenty-two species of animals.

- 7 Carnivora. Hyæna, Tiger, Bear, Wolf, Fox, Weasel, and an unknown animal of the size of a Wolf. (See Plates XVII. XVIII. XIX. XX.)
- 4 Pachydermata. Elephant, Rhinoceros, Hippopotamus and Horse. (See Plate XXI.)
- 4 Ruminantia. Ox, and three species of Deer. (See Plates XXII. XXIII.)
- 3 Rodentia. Rabbit, Water-rat and Mouse. (See Plate XXIV. XXV.)
- 4 Birds. Raven, Pigeon, Lark, and a small species of Duck, resembling the *anas sponsor*, or summer Duck. (See Plate XXV.)

The bottom of the cave, on first removing the mud, was

found to be strewed all over like a dog kennel, from one end to the other, with hundreds of teeth and bones, or rather broken and splintered fragments of bones, of all the animals above enumerated; they were found in greatest quantity near its mouth, simply because its area in this part was most capacious; those of the larger animals, elephant, rhinoceros, &c. were found co-extensively with all the rest, even in the inmost and smallest recesses, (see Plate XVI. fig. 3). Scarcely a single bone has escaped fracture, with the exception of the astragalus, and other hard and solid bones of the tarsus and carpus joints, and of the toes (see Plate XXIV. fig. 1 to 5, and fig. 7 to 10, and Plate XIX. fig. 5 to 12). On some of the bones marks may be traced, which, on applying one to the other, appear exactly to fit the form of the canine teeth of the hyæna that occur in the cave. The hyænas' bones have been broken, and apparently gnawed equally with those of the other animals. Heaps of small splinters, and highly comminuted, yet angular fragments of bone, mixed with teeth of all the varieties of animals above enumerated, lay in the bottom of the den, occasionally adhering together by stalactite, and forming, as has been before mentioned, an osseous breccia. Many insulated fragments also are wholly or partially enveloped with stalactite, both externally and internally. Not one skull is to be found entire; and it is so rare to find a large bone of any kind that has not been more or less broken, that there is no hope of obtaining materials for the construction of any thing like a skeleton. The jaw bones also, even of the hyænas, are broken like the rest; and in the case of all the animals, the number of teeth and of solid bones of the tarsus and carpus,

is more than twenty times as great as could have been supplied by the individuals whose other bones we find mixed with them.

Fragments of jaw bones are by no means common; the greatest number I saw belong to the deer, hyæna, and water-rat, and retain their teeth; in all the jaws both teeth and bone are in an equal state of high preservation, and show that their fracture has been the effect of violence, and not of natural decay. I have seen but ten fragments of deers' jaws, and about forty of hyænas', and as many of rats. (See Plate XVIII. fig. 2, 3, and Plate XVII. fig. 3, 4, 5.) The ordinary fate of the jaw bones, as of all the rest, appears to have been to be broken to pieces.

The greatest number of teeth are those of hyænas, and the ruminantia. Mr. GIBSON alone collected more than 300 canine teeth of the hyæna, which at the least must have belonged to 75 individuals, and they are in the same proportion in other collections. The only remains that have been found of the tiger species (see Plate XX. fig. 5, 6, 7), are two large canine teeth, each $\frac{4}{8}$ inches in length, and one molar tooth, exceeding in size that of the largest lion or Bengal tiger. There is one tusk only of a bear (see Plate XX. fig. 1), which exactly resembles those of the extinct *ursus spelæus* of the caves of Germany, the size of which M. CUVIER says must have equalled that of a large horse. Of the wolf and fox there are many teeth (see Plate XX. fig. 8 to 18), and others belonging to an animal which I cannot ascertain: it seems to have been nearly allied to the wolf, but the teeth are much thinner, and less strong. (See Plate XX. fig. 20 to 27). A few jaws and teeth have also been found belonging to the

weasel. (Plate XX. fig. 28, 29.) Teeth of the larger pachydermatous animals are not abundant. I have information of about ten elephants' teeth, but of no tusk; and as very few of these teeth exceed three inches in their longest diameter, they must have belonged to very young animals. (See Plate XXI. fig. 1 and 2). I have seen but six molar teeth of the hippopotamus, and a few fragments of its canine and incisor teeth; some of which latter are in the possession of Mr. THORPE, of York. Teeth of the rhinoceros are not so rare. I have seen 40 or 50, and some of them extremely large ones, and apparently from aged animals. I have heard of only two or three teeth belonging to the horse. Of the teeth of deer there are at least three species (see Plate XXII. fig. 9, 11, 13), the smallest being very nearly of the size and form of those of a fallow deer, the largest agreeing in size, but differing in form from those of the modern elk; and a third being of an intermediate size, and approaching that of a large stag or red deer. I have not ascertained how many species there are of ox, but apparently there are at least two. But the teeth which occur perhaps in greatest abundance, are those of the water-rat (see Pl. XXV. fig. 1 to 5, and 11 to 18;) for in almost every specimen I have collected or seen of the osseous breccia, there are teeth or broken fragments of the bones of this little animal mixed with and adhering to the fragments of all the larger bones. These rats may be supposed to have abounded on the edge of the lake, which I have shown probably to have existed at that time in this neighbourhood: there are also a few teeth and bones of rabbits and mice. (Plate XXIV. fig. 14, 15, 16, 17, 18, and Plate XXV. fig. 7, 8, 9, 10).

Besides the teeth and bones already described, the cave
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contained also remains of horns of at least two species of deer, (see Plate XXIII. fig. 3, 4, and 5.) One of these resembles the horn of the common stag or red deer, the circumference of the base measuring $9\frac{3}{4}$ inches, which is precisely the size of our largest stag. A second (fig. 4.) measures $7\frac{3}{4}$ inches at the same part, and both have two antlers, that rise very near the base. In a smaller species the lowest antler is $3\frac{1}{2}$ inches above the base, the circumference of which is 8 inches, (see fig. 5.) No horns are found entire, but fragments only, and these apparently gnawed to pieces like the bones: their lower extremity nearest the head is that which has generally escaped destruction: and it is a curious fact, that this portion of all the horns I have seen from the cave, shows, by the rounded state of the base, that they had fallen off by absorption or necrosis, and been shed from the head on which they grew, and not broken off by violence.

It must already appear probable, from the facts above described, particularly from the comminuted state and apparently gnawed condition of the bones, that the cave at Kirkdale was, during a long succession of years, inhabited as a den by hyænas, and that they dragged into its recesses the other animal bodies whose remains are found mixed indiscriminately with their own; and this conjecture is rendered almost certain by the discovery I made, of many small balls of the solid calcareous excrement of an animal that had fed on bones, resembling the substance known in the old *Materia Medica* by the name of *album græcum* (see Plate XXIV. fig. 6.): its external form is that of a sphere, irregularly compressed, as in the *fæces* of sheep, and varying from half an inch to an inch in diameter; its colour is yellowish white, its fracture

is usually earthy and compact, resembling steatite, and sometimes granular ; when compact, it is interspersed with minute cellular cavities : it was at first sight recognised by the keeper of the Menagerie at Exeter Change, as resembling, both in form and appearance, the fæces of the spotted or Cape Hyæna, which he stated to be greedy of bones, beyond all other beasts under his care. This information I owe to Dr. WOLLASTON, who has also made an analysis of the substance under discussion, and finds it to be composed of the ingredients that might be expected in fæcal matter derived from bones, viz. phosphate of lime, carbonate of lime, and a very small proportion of the triple phosphate of ammonia and magnesia ; it retains no animal matter, and its originally earthy nature and affinity to bone, will account for its perfect state of preservation.

I do not know what more conclusive evidence than this can be added to the facts already enumerated, to show that the hyænas inhabited this cave, and were the agents by which the teeth and bones of the other animals were there collected ; it may be useful therefore to consider, in this part of our enquiry, what are the habits of modern hyænas, and how far they illustrate the case before us.

The modern hyæna (of which there are only three known species, all of them smaller and different from the fossil one) is an inhabitant exclusively of hot climates ; the most savage, or striped species, abounds in Abyssinia, Nubia, and the adjacent parts of Africa and Asia. The less ferocious, or spotted one, inhabits the Cape of Good Hope, and lives principally on carrion. In bony structure the latter approaches more nearly than the former to the fossil species : to these M. CUVIER adds a third, the red hyæna, which is very rare.

The structure of these animals places them in an intermediate class between the cat and dog tribes ; not feeding, like the former, almost exclusively on living prey, but like the latter, being greedy also of putrid flesh and bones :* their love of putrid flesh induces them to follow armies, and dig up human bodies from the grave. They inhabit holes which they dig in the earth, and chasms of rocks ; are fierce, and of obstinate courage, attacking stronger quadrupeds than themselves, and even repelling lions. Their habit of digging human bodies from the grave, and dragging them to their den, and of accumulating around it the bones of all kinds of animals, is thus described by BUSBEQUIUS, where he is speaking of the Turkish mode of burial in Anatolia, and their custom of laying large stones upon their graves to protect them from the Hyænas. “ Hyæna regionibus iis satis frequens ; sepulchra suffodit, extrahitque cadavera, portatque ad suam speluncam ; juxta quam videre est ingentem cumulum ossium humanorum ‘ veterinariorum’† et reliquorum omne genus animalium.” (Busbeq. Epist. 1. Leg. Turc.) BROWN, also, in his Travels to Darfur, describes the Hyænas’ manner of taking off their prey in the following words :—“ they come in herds of six, eight, and often more, into the villages at night, and carry off with them whatever they are able to master ; they will kill dogs and asses even within the enclosure of houses, and fail not to assemble wherever a dead camel or

* It is quite impossible to mistake the jaw of any species of hyæna for that of the wolf or tiger kind ; the latter having three molar teeth only in the lower jaw, and the former seven ; whilst all the hyæna tribe have four. (See Plate XVIII. fig. 1, 2, 3.)

† Veterinam bestiam jumentum CATO appellavit a vehendo : (quasi veheterinus vel veterinus.) Pomp. Fest.

other animal is thrown, which, acting in concert, they sometimes drag to a prodigious distance." SPARMAN and PENNANT mention that a single hyæna has been known to carry off a living man or woman in the vicinity of the Cape.

The strength of the hyæna's jaw is such, that in attacking a dog, he begins by biting off his leg at a single snap. The capacity of his teeth, for such an operation, is sufficiently obvious from simple inspection, and had long ago attracted the attention of the early naturalists; and, consistent with this strength of teeth and jaw, is the state of the muscles of his neck, being so full and strong, that in early times this animal was fabled to have but one cervical vertebra. They live by day in dens, and seek their prey by night, having large prominent eyes, adapted, like those of the rat and mouse, for seeing in the dark. To animals of such a class, our cave at Kirkdale would afford a most convenient habitation, and the circumstances we find developed in it are entirely consistent with the habits above enumerated.

It appears from the researches of M. CUVIER, that the fossil hyæna was nearly one third larger than the largest of the modern species, that is, the striped or Abyssinian; but, in the structure of its teeth, more nearly resembled that of the Cape animal. (See Plate XVIII. fig. 1, 2, 3.) Its muzzle also was shorter and stronger than in either of them, and consequently its bite more powerful. The length of the largest modern hyæna noticed is 5 feet 9 inches.

The fossil species has been found on the Continent in situations of two kinds, both of them consistent with the circumstances under which it occurs in Yorkshire, and, on comparing the jaws and teeth of the latter with those of the former

engraved in M. CUVIER's *Recherches sur les ossements fossiles*, I find them to be absolutely identical. The two situations are caverns and diluvian gravel.

1. In Franconia, a few bones of hyæna were found mixt with those of an enormous number of bears, in the cave of Gailenreuth.
2. At Muggendorf, in a similar cave.
3. At Bauman, in ditto.
4. At Fouvent, near Gray, in the department of Doubes, bones of hyæna were found mixt with those of the elephant and horse in a fissure of lime-stone rock, which, like that at Kirkdale, was discovered by the accidental digging away of the rock in a garden.
5. At Canstadt, in the valley of the Necker, A. D. 1700, hyænas' bones were found mixt with those of the elephant, rhinoceros, and horse, and with rolled pebbles, in a mass of yellowish clay.
6. Between Hahldorf and Reiterbuck, on the surface of the hills that bound the valley of Eichstadt in Bavaria. These were buried in a bed of sand.

The four first of these cases appear to have been dens, like the cave at Kirkdale; the two latter are deposits of diluvian detritus, like the surface gravel beds of England, in which similar remains of all the other animals have been found, excepting hyænas.

It has been observed when speaking of the den, that the bones of the hyænas are as much broken to pieces as those of the animals that formed their prey; and hence we must infer, that the carcasses even of the hyænas themselves, were eaten up by their survivors. Whether it be the habit of modern

hyænas to devour those of their own species that die in the course of nature ; or under the pressure of extreme hunger to kill and eat the weaker of them, is a point on which it is not easy to obtain positive evidence. Mr. BROWN however asserts, in his journey to Darfur, " that it is related of the hyænas, that upon one of them being wounded, his companions instantly tear him to pieces and devour him." It seems therefore in the highest degree probable, that the mangled relics of hyænas that lie indiscriminately scattered and equally broken with the bones of other animals in the cave of Kirkdale, were reduced to this state by the agency of the surviving individuals of their own species.

A large proportion of the hyænas' teeth bear marks of extreme old age, some being abraded to the very sockets, and the majority having lost the upper portion of their coronary part, and having fangs extremely large : these probably died in the den from mere old age : and if we compare the lacerated condition of the bones that accompany them, with the state of the teeth thus worn down to the very stumps, notwithstanding their prodigious strength, we find in the latter the obvious instruments by which the former were thus comminuted. A great number of other teeth appear to have belonged to young hyænas, for the fangs are not developed, and the points and edges of the crown not the least worn down. I have a fragment of the jaw of an hyæna which died so young, that the second set of its teeth had not been protruded, but were in the act of forming within the jaw. (See Plate XIX. fig. 3, 4.) Others are in various stages of advancement towards maturity ; and the proportion of these is too great for us to attribute them to animals that may have

died in early life from accident or disease. It seems more probable, and the idea is confirmed by the above statement of Mr. BROWN, and by the fact of the hyænas' bones in the den being gnawed and broken to pieces equally with the rest, that they were occasionally killed and devoured by the stronger individuals of their own species.

But, besides the evidence their teeth afford to show that the animals died at various periods of life, they present other appearances (and so likewise do the bones), of having passed through different stages and gradations of decay, arising from the different length of time they had lain exposed in the bottom of the den, before the muddy sediment entered, which, since its introduction, has preserved them from farther decomposition. This observation applies equally to all the animals. I have portions of bone and teeth that are so much decomposed as to be ready to fall to pieces by the slightest touch; these had probably lain a long time unprotected in the bottom of the den; others still older may have entirely perished; but the majority both of teeth and fragments of bone are in a state of the highest preservation; and many thousands have been collected and carried away since the cave was discovered. In all cases the degree of decay is equal in the teeth and jaw bones, or fragments of jaws, to which they are attached.

In many of the most highly preserved bones and teeth, there is a curious circumstance, which, before I visited Kirkdale, had convinced me of the existence of the den, viz. a partial polish and wearing away to a considerable depth of one side only; many straight fragments of the larger bones have one entire side, or the fractured edges of one side rubbed

down and worn completely smooth, whilst the opposite side and ends of the same bone are sharp and untouched; in the same manner as the upper portions of pitching stones in the street become rounded and polished, whilst their lower parts retain the exact form and angles which they possessed when first laid down. This can only be explained by referring the partial destruction of the solid bone to friction from the continual treading of the hyænas, and rubbing of their skin on the side that lay uppermost in the bottom of the den. In many of the smaller and curved bones, also, particularly in those of the lower jaw, (see Plate XIX. fig. 1 and 2.) the convex surface only is uniformly that which has been worn down and polished, whilst the ends and concave surface have suffered no kind of change or destruction, (Plate XIX. fig. 3 and 4.): and this also admits of a similar explanation; for the curvature of the bone would allow it to rest steady under constant treading only in this position; as long as the concave surface was uppermost, pressure on either extremity would cause it to tilt over and throw the convex side upwards; and this done, the next pressure would cause its two extremities to sink into any soft substance that lay beneath, and give it a steady and fixed position. Such seems to have been the process by which the curved fragments I allude to, have not only received a partial polish on the convex side only, but have been submitted to so much friction, that in several instances more than one-fourth of the entire thickness of the bone, and a proportionate quantity of the outer side of the fangs and body of the teeth, have been entirely worn away. (See Plate XIX. fig. 1.) I can imagine no other means than the repeated touch of the living hyænas' feet and skin, by

which this partial wearing away and polish can have been produced:* for the process of rolling by water would have made pebbles of them, or at least would have broken off the edges of the teeth and delicate points of the fractured extremities of the bone, which still remain untouched and sharp.

I have already stated, that the greatest number of teeth (those of the hyæna excepted) belong to the ruminating animals; from which it is to be inferred that they formed the ordinary prey of the hyænas. I have also to add, that very few of the teeth of these animals bear marks of age; they seem to have perished by a violent death in the vigour of life. With respect to the horns of deer that appear to have fallen off by necrosis, it is probable that the hyænas found them thus shed, and dragged them home for the purpose of gnawing them in their den; and to animals so fond of bones, the spongy interior of horns of this kind would not be unacceptable. I found a fragment of stags' horn in so small a recess of the cave, that it never could have been introduced, unless singly, and after separation from the head; and near it was the molar tooth of an elephant. I have seen no remains of horns of oxen, and perhaps there are none, for the bony portion of their interior being of a porous spongy nature, would probably have been eaten by the hyænas, whilst the outer case, being of a similar composition to hair and hoofs,

* I have been informed by an officer in India, that passing by a tiger's den in the absence of the tiger, he examined the interior, and found in the middle of it a large portion of stone on which the tiger reposed, to be worn smooth and polished by the friction of his body. The same thing may be seen on marble steps and altars, and even metallic statues in places of worship that are favourite objects of pilgrimage: they are often deeply worn and polished by the knees, and even lips of pilgrims, to a degree that, without experience of the fact, we could scarcely have anticipated.

would not long have escaped total decomposition. For the same reason the horn of the rhinoceros, being merely a mass of compacted hair-like fibres, has never been found fossil in gravel beds with the bones of that animal, nor does it occur in the cave at Kirkdale. I have been told that sheeps' horns laid on land for manure will be consumed in ten or a dozen years; the calcareous matter of bone being nearly allied to lime-stone, is the only portion of animal bodies that occurs in a fossil state, unless when preserved, like the Siberian elephant, of the same extinct species with that of Kirkdale, by being frozen in ice, or buried in peat.

The extreme abundance of the teeth of water rats has also been alluded to; and though the idea of hyænas eating rats may appear ridiculous, it is consistent with the omnivorous appetite of modern hyænas; nor is the disproportion in size of the animal to that of its prey, greater than that of wolves and foxes, which are supposed by Captain PARRY to feed chiefly on mice during the long winters of Melville Island. Our largest dogs eat rats and mice; jackalls occasionally prey on mice, and dogs and foxes will eat frogs. It is probable, therefore, that neither the size nor aquatic habit of the water rat would secure it from the hyænas. They might occasionally also have eaten mice, weasels, rabbits, foxes, wolves, and birds; and in masticating the bodies of these small animals with their coarse conical teeth, many bones and fragments of bone would be pressed outwards through their lips, and fall neglected to the ground.

The occurrence of birds' bones may be explained by the probability of the hyænas finding them dead, and taking them home, as usual, to eat in their den: and the fact, that four

of the only five bones of birds I have seen from Kirkdale are those of the ulna, may have arisen from the position of the quill feathers on it, and the small quantity of fleshy matter that exists on the outer extremity of the wing of birds; the former affording an obstacle, and the latter no temptation to the hyænas to devour them. Two of the five bones here mentioned (see Plate XXV. fig. 19 to 29), in size and form, and the position of the points at the base of the quills, exactly resemble the ulna of a raven; a third approaches as closely to the Spanish runt, which is one of the largest of the pigeon tribe; a fourth bone is the right ulna of a lark; and a fifth, the coracoid process of the right scapula of a small species of duck resembling the *Anas sponsor*, or summer duck.*

With respect to the bear and tiger, the remains of which are extremely rare, and of which the teeth that have been found (see Plate XX. fig. 1, 5, 6, and 7), indicate a magnitude equal to the great *Ursus spelæus* of the caves of Germany, and of the largest Bengal tiger, it is more probable that the hyænas found their dead carcasses and dragged them to the den, than that they were ever joint tenants of the same cavern. It is however obvious that they were all at the same time inhabitants of antediluvian Yorkshire.

In the case of such minute and burrowing animals as the mouse and weasel, and perhaps the rabbit and fox, it is possible that some of them may have crept into the cave by undiscovered crevices, and there died since the stoppage of its

* For my knowledge of these, and many other bones I have from Kirkdale, I am indebted to a careful examination and comparison of them made by Mr. BROOKS, in his most valuable collection of osteological preparations. Mr. CLIFT also has kindly assisted me at the Royal College of Surgeons in furtherance of the same object.

mouth ; and in such case their bones would have been found lying on the surface of the mud before it was disturbed by digging : as no observations were made in season as to this point, it must remain unsettled, till the opening of another cave may give opportunity for more accurate investigation. This uncertainty, however, applies not to any of the extinct species, or to the larger animals, whose habit it is not to burrow in the ground, nor even to those of the smaller ones, *e. g.* the water rat, fragments of whose bones and teeth are found imbedded in the antediluvian stalagmite, and cemented by it both to the exterior and internal cavities of bones belonging to the hyænas and other extinct species, which, beyond all doubt, were lodged in the den before the period of the introduction of the mud. Should it turn out that since this period the cave has been accessible to foxes and weasels, it is possible that some of the birds also may have been introduced by them. The evidence of this, however, rests on a fact not yet carefully ascertained, *viz.* whether the bones in question were buried, like those of the extinct animals, beneath the mud, or lay on its surface ; the state of one of the ravens' bones, containing stalagmite in its central cavity (see Plate XXV. fig. 22, 23), seems to indicate high antiquity ; and the quarryman, who was the first to enter the cave, assured me, that he has never seen a single bone of any kind on the surface, nor without digging into the substance of the mud.

As ruminating animals form the ordinary food of beasts of prey, it is not surprising that their remains should occur in such abundance in the cave (see Plate XXII. fig. 1 to 14); but it is not so obvious by what means the bones and teeth of the elephant, rhinoceros, and hippopotamus, were conveyed

thither (see Plate XXI. fig. 1 to 6, and 8 to 10.). On the one hand, the cave is in general of dimensions so contracted (often not exceeding three feet in diameter), that it is impossible that living animals of these species could have found an entrance, or the entire carcasses of dead ones been floated into it; moreover, had the bones been washed in, they would probably have been mixed with pebbles and rounded equably by friction, which they are not: on the other hand, it is foreign to the habits of the hyæna to prey on the larger pachydermata, their young perhaps excepted. No other solution of the difficulty presents itself to me, than that the remains in question are those of individuals that died a natural death; for though an hyæna would neither have had strength to kill a living elephant or rhinoceros, or to drag home the entire carcass of a dead one, yet he could carry away, piecemeal, or acting conjointly with others, fragments of the most bulky animals that died in the course of nature, and thus introduce them to the inmost recesses of his den.

Should it be asked why, amidst the remains of so many hundred animals, not a single skeleton of any kind has been found entire, we see an obvious answer, in the power and known habit of hyænas to devour the bones of their prey; and the gnawed fragments on the one hand, and album græcum on the other, afford double evidence of their having largely gratified this natural propensity: the exception of the teeth and numerous small bones of the lower joints and extremities, that remain unbroken, as having been too hard and solid to afford inducement for mastication, is entirely consistent with this solution. And should it be further asked, why we do not find, at least, the entire skeleton of the one or

more hyænas that died last, and left no survivors to devour them ; we find a sufficient reply to this question, in the circumstance of the probable destruction of the last individuals by the diluvian waters : on the rise of these, had there been any hyænas in the den, they would have rushed out, and fled for safety to the hills ; and if absent, they could by no possibility have returned to it from the higher levels : that they did so perish on the continent is obvious, from the discovery of their bones in the diluvial gravel of Germany, as well as in the caves. The same circumstance will also explain the reason why there are no bones found on the outside of the Kirkdale cave, as described by BUSBEQUIUS on the outside of the hyænas' dens in Anatolia ; for every thing that lay without, on the antediluvian surface, must have been swept far away, and scattered by the violence of the diluvian waters ; and there is no reason for believing that hyænas, or any other animals whatever, have occupied the den at any period subsequent to that catastrophe.

Although the evidence to prove the cave to have been inhabited as a den by successive generations of hyænas, appears thus direct, it may be as well to consider what other hypotheses may be suggested, to explain the collection of bones assembled in it.

1st. It may be said, that the various animals had entered the cave spontaneously to die, or had fled into it as a refuge from some general convulsion : but the diameter of the cave, as has been mentioned before, compared with the bulk of the elephant and rhinoceros, renders this solution impossible as to the larger animals ; and with respect to the smaller, we can imagine no circumstances that would collect together,

spontaneously, animals of such dissimilar habits as hyænas, tigers, bears, wolves, foxes, horses, oxen, deer, rabbits, water-rats, mice, weasels, and birds.

2d. It may be suggested, that they were drifted in by the waters of a flood : if so, either the carcasses floated in entire ; or the bones alone were drifted in after separation from the flesh : in the first of these cases, the larger carcasses, as we have already stated, could not have entered at all ; and of the smaller ones, the cave could not have contained a sufficient number to supply one-twentieth part of the teeth and bones ; moreover, the bones would not have been broken to pieces, nor in different stages of decay. And had they been washed in by a succession of floods, we should have had a succession of beds of sediment and stalactite, and the cave would have been filled up by the second or third repetition of such an operation as that which introduced the single stratum of mud, which alone occurs in it. On the other hypothesis, that they were drifted in after separation from the flesh, they would have been mixed with gravel, and at least slightly rolled on their passage ; and it would still remain to be shown by what means they were split and broken to pieces, and the disproportion created which exists between the numbers of the teeth and bones. They could not have fallen in through the fissures, for these are closed upwards in the substance of the rock, and do not reach to the surface.

The 3rd, and only remaining hypothesis that occurs to me is, that they were dragged in for food by the hyænas, who caught their prey in the immediate vicinity of their den ; and as they could not have dragged it home from any very great distance ; it follows, that the animals they fed on all lived

and died not far from the spot where their remains are found.

The accumulation of these bones, then, appears to have been a long process, going on during a succession of years, whilst all the animals in question were natives of this country. The general dispersion of similar bones through the diluvian gravel of high latitudes, over great part of the northern hemisphere, shows that the period in which they inhabited these regions, was that immediately preceding the formation of this gravel, and that they perished by the same waters which produced it. M. CUVIER has moreover ascertained, that the fossil elephant, rhinoceros, hippopotamus, and hyæna, belong to species now unknown; and as there is no evidence that they have at any time, subsequent to the formation of the diluvium, existed in these regions, we may conclude that the period, at which the bones of these extinct species were introduced into the cave at Kirkdale, was antediluvian. Had these species ever re-established themselves in the northern portions of the world since the deluge, it is probable their remains would have been found, like those of the ox, horse, deer, hog, &c. preserved in the post-diluvian accumulations of gravel, sand, silt, mud, and peat, which are referable to causes still in operation, and which, by careful examination of their relations to the adjacent country, can be readily distinguished from those which are of diluvian origin.

The teeth and fragments of bones above described, seem to have lain a long time scattered irregularly over the bottom of the den, and to have been continually accumulating until the introduction of the sediment in which they are now imbedded, and to the protection of which they owe that high state of

preservation they possess. Those that lay long uncovered at the bottom of the den, have undergone a decay proportionate to the time of their exposure; others that have lain only a short time before the introduction of the diluvian mud, have been preserved by it almost from even incipient decomposition.

Thus the phenomena of this cave seem referable to a period in which the world was inhabited by land animals, bearing a general resemblance to those now existing, before the last inundation of the earth; but so completely has the violence of that tremendous convulsion destroyed and remodelled the form of its antediluvian surface, that it is only in caverns that have been protected from its ravages, that we may hope to find undisturbed evidence of events in the period immediately preceding it. The bones already described, and the stalagmite formed before the introduction of the diluvial mud, are what I consider to be the products of the period in question. It was indeed probable, before the discovery of this cave, from the abundance in which the remains of similar species occur in superficial gravel beds, which cannot be referred to any other than a diluvial origin, that such animals were the antediluvian inhabitants of this country; but the proof was imperfect, as it has been said they might have been drifted or floated hither by the waters, from warmer latitudes: but the facts developed in this charnel house of the antediluvian forests of Yorkshire, show that there was a long succession of years in which these animals had been the prey of the hyænas, which like themselves at that time, must have inhabited these regions of the earth; and it is in the diluvial wreck occurring in such latitudes, that similar bones have been

found buried, in the state of grave bones, over great part of northern Europe, as well as North America and Siberia. The catastrophe producing this gravel, appears to have been the last event that has operated generally to modify the surface of the earth, and the few local and partial changes that have succeeded it, such as the formation of deltas, terraces, tufa, torrent-gravel and peat-bogs, all conspire to show, that the period of their commencement was subsequent to that at which the diluvium was formed.*

* It was stated in describing the locality of the cave at Kirkdale, and on comparing it with the fact of its containing the remains of large and small aquatic animals, that there was probably a lake in this part of the country at the period when they inhabited it; and this hypothesis is rendered probable by the form and disposition of the hills that still encircle the Vale of Pickering. (See Map, Plate XV.)

Inclosed on the south, the west, north-west, and north, by the lofty ranges of the Wolds, the Howardian hills, the Hambleton hills, and Eastern Moorlands, the waters of this vale must either run eastward to Filey Bay, or inland towards York; and such is the superior elevation of the strata along the coast, that the sources of the Derwent, rising almost close to the sea, near Scarborough and Filey, are forced to run west and southward fifty miles inland away from the sea, till falling into the Ouse, they finally reach it by turning again eastward through the Humber. The only outlet by which this drainage is accomplished, is the gorge at New Malton; and though it is not possible to ascertain what was the precise extent of this antediluvian lake, or how much of the low districts, now constituting the Vale of Pickering, may have been excavated by the same diluvian waters that produced the gorge; it is obvious, that without the existence of this gorge, much of the district within it would be laid under water; and it is equally obvious, that the gorge is referable to the agency of diluvian denudation, the ravages of which have not, perhaps, left a single portion of the antediluvian surface of the whole earth, which is not torn and re-modelled, so as to have lost all traces of the exact features it bore antecedently to the operations of the deluge.

It is probable, that inland lakes were much more numerous than they are at present, before the excavation of the many gorges by which our modern rivers make their escape; and this is consistent with the frequent occurrence of the remains of the hippopotamus in the diluvian gravel of England, and of various parts of Europe.

It is in the highest degree curious to observe, that four of the genera of animals whose bones are thus widely diffused over the temperate, and even polar regions of the northern hemisphere, should at present exist only in tropical climates, and chiefly south of the equator ; and that the only country in which the elephant, rhinoceros, hippopotamus and hyæna are now associated, is Southern Africa. In the immediate neighbourhood of the Cape they all live and die together, as they formerly did in Britain ; whilst the hippopotamus is now confined exclusively to Africa, and the elephant, rhinoceros and hyæna are also diffused widely over the continent of Asia.

Such are the principal facts I observed in the interior of the cave at Kirkdale, and such the leading conclusions that seem to arise from them ; and I cannot sufficiently lament that I was not present at its first opening, to witness the exact state in which it appeared, before any part of the surface of the mud had been disturbed.

From the description given of the state of the bones, and of the mud and stalactite that accompany them, we may extract the following detailed history of the operations that have successively been going on within the cave.

1st. There appears to have been a period (and if we may form an estimate from the small quantity of stalagmite now found on the actual floor of the cave, a very short one,) during which this aperture in the rock existed, but was not

It is not unlikely that, in this antediluvian period, England was connected with the Continent, and that the excavation of the shallow channel of the Straits of Dover, and of a considerable portion of that part of the German ocean which lies between the east coast of England and the mouths of the Elbe and Rhine, may have been the effect of diluvial denudation. The average depth of all this tract of water is said to be less than thirty fathoms.

tenanted by the hyænas. The removal of the mud, which now entirely covers the floor, would be necessary to ascertain the exact quantity of stalagmite referable to this period ; but it cannot be very great, and can only be expected to exist where there is much stalactite also upon the roof and sides.

The 2d period was that during which the cave was inhabited by the hyænas, and the stalactite and stalagmite were still forming. The constant passage of the hyænas in so low a cave, would much interrupt this formation ; as they would strike off the former from the roof and sides by their constant ingress and egress ; and accordingly in some specimens of the breccia, we find mixt with the bones, fragments of stalactite, that seem to have been thus knocked off from the roof and sides of the cave, whilst it was inhabited by hyænas before the introduction of the mud ; I have one example of a hollow stalactitic tube that lay in an horizontal position in the midst of, and parallel to, some long splinters of bone and the unbroken ulna of a rat : all these are united by stalagmite ; and it is impossible that this stalactitic pipe could have been formed in any other than a vertical position, hanging from the roof or sides. In other specimens of the breccia, I have split fragments of the teeth of deer and hyæna ; and in almost every portion I have seen, either of this breccia or of the antediluvian stalagmite, there are teeth of the water rat. Mr. GIBSON possesses a mass exceeding a foot in diameter, composed of fragments of many large bones, mixed with some teeth of rhinoceros and several of the larger animals, and also of rats, all adhering firmly together in a matrix of stalagmite. It did not occur to me, whilst on the spot, to examine whether the bottom of the

cave is any where polished (like the tiger's den before alluded to), in those parts which must have been the constant gangway of the hyænas; but the universal cover of mud by which it is buried, renders it necessary that this should be removed, in order to the observation I suggest. During the formation of this stalactitic matter, no mud appears to have been introduced; and had there been any in the cave at the time whilst the osseous breccia was forming, it would either have excluded all access of the stalagmite to the bones, or have been mixed and entangled with it in very large proportions, forming a spongy mass, such as it does at the root of the stalagmites that lie on its surface.

The 3rd period is that at which the mud was introduced and the animals extirpated, viz. the period of the deluge. I have already stated that the animal remains are found principally in the lower regions of this sediment of mud, which appears to have been introduced in a fluid state, so as to envelope the bony fragments then lying on the bottom of the cave: and the power of water to introduce such sediments is shown by the state of Wokey Hole, and similar caverns in the Mendip Hills, and Derbyshire, which are subject to be filled with water occasionally by heavy land floods. The effect of these floods being to leave on the floor, a sediment of mud precisely similar to that which covers the bones and osseous breccia in the cave of Kirkdale. I have also mentioned that there is no alternation of this mud with beds of bone or of stalagmite, such as would have occurred had it been produced by land floods often repeated; once, and once only it appears to have been introduced; and we may probably consider its vehicle to have been the turbid

waters of the same inundation that produced the diluvial gravel: these would enter and fill the cave, and there becoming quiescent, would deposit the mud suspended in them (as we see daily silt and warp deposited in quiet spots by waters of muddy rivers) along the whole bottom of the den, where it has remained undisturbed ever since. We cannot refer this mud to a land flood, or a succession of land floods, partly for the reasons before stated, and partly from the general dryness of the cave; had it been liable to be filled with muddy water, it would have been so at the time I visited it in December, 1821, at the end of one of the most rainy seasons ever remembered; but even then there were not the slightest symptoms of any such occurrence, and a few scanty droppings from the roof were the only traces of water within the area of the cavern.

The 4th period is that during which the stalagmite was deposited which invests the upper surface of the mud. The quantity of this stalagmite appears to be much greater than that formed in the two periods during, and before which, the cave was tenanted by hyænas. In the whole of this 4th period no creature appears to have entered the cave, with the exception possibly of mice, weasels, rabbits, and foxes, until it was opened last summer, and no other process of any kind appears to have been going on in it except the formation of stalactitic infiltrations; the stratum of diluvial sediment marks the point of time at which the latter state of things began and the former ceased. As there is no mud at all on the top or sides of the cave, we have no mark to distinguish the relative quantities of stalactite formed on these parts during the periods we have been speaking of: should it however contain in any

part a fragment of bone or tooth of any of the extinct animals, it will follow that this part was antediluvial. A farther argument may be drawn from the limited quantity of post-diluvian stalactite, as well as from the undecayed condition of the bones, to show that the time elapsed since the introduction of the diluvian mud, has not been one of excessive length.

The arguments arising from the detail of facts we have been describing, are applicable to the illustration of analogous phenomena, where the evidence of their history is less complete. In our own country there are five other instances of bones similarly deposited in caverns, the origin of some of which, though not before satisfactorily made out, becomes evident as a corollary from the proofs afforded by the cave at Kirkdale: these are in Glamorganshire, Somersetshire, Derbyshire, and Devonshire.

1. The first is in the parish of Nicholaston, on the coast of Glamorganshire, at a spot called Crawley Rocks, in Oxwich Bay, about twelve miles S.W. of Swansea; it was discovered in the year 1792, in a quarry of lime-stone, on the property of T. M. TALBOT, Esq. of Penrice Castle, and no account of it has, I believe, been ever published; some of the bones however are preserved in the collection of Miss TALBOT, at Penrice; they are as follows:

Elephant—Three portions of large molar teeth.

Rhinoceros—Right and left ossa humeri.

One atlas bone.

Two molar teeth of upper jaw.

Ox—First phalangeal bone of left fore foot.

Stag—Lower extremity of the horn.

Stag—————Three molar teeth.

One first phalangeal bone, right leg.

Hyæna—————Two canine teeth, much worn.

These bones were found in a cavity of mountain limestone, which was accidentally intersected, like the cave at Kirkdale, in working a quarry : they have a slight ochreous incrustation, and a little earthy matter adhering to them ; but are not in the least degree rolled ; and the condyles of the two humeri of the rhinoceros, belonging to different individuals, have in each case been entirely broken off, as if by gnawing. The two canine teeth of hyæna (worn down to the stumps), that were found in the same cave with them, afford ground for probable conjecture as to the means by which those bones were thus broken, as well as introduced to this cave in Glamorganshire.*

2. The next case I shall mention is that of teeth and bones of elephants and other animals discovered in the Mendip Hills in cavities of mountain limestone, which were lined, and nearly filled with ochreous clay. These are preserved in the collection of the Rev. Mr. CATCOTT, in the City Library at Bristol. The following account of them is extracted by my friend the Rev. W. D. CONYBEARE, from Mr. CATCOTT'S MS. notes ; he has added also a few explanatory observations.

“ The ochre pits were worked about the middle of the last century, near the summit of the Mendip Hills, on the S. of

* On comparing one of these humeri of the rhinoceros with a similar bone from the cave at Kirkdale, I found in each case both extremities of the bone broken or gnawed off exactly to the same point, i. e. just so far as was sufficient to extract the marrow and take off the most spongy portions of the extremities, whilst the parts remaining were only the hardest and most compact cylindrical portions of the centre of the bones in question.

the village of Hutton, near Banwell, at an elevation of from three hundred to four hundred feet above the level of the sea : they are now abandoned.

“ The ochre was pursued through fissures in the mountain lime-stone, occasionally expanding into larger cavernous chambers, their range being in a steep descent, and almost perpendicular. Thus, in opening the pits, the workmen, after removing eighteen inches of vegetable mould, and four feet of rubbly ochre, came to a fissure in the lime-stone rock, about eighteen inches broad, and four feet long. This was filled with good ochre, but as yet no bones were discovered ; it continued to the depth of eight yards, and then opened into a cavern about twenty feet square, and four high ; the floor of this cave consisted of good ochre, strewed on the surface of which were multitudes of white bones, which were also found dispersed through the interior of the ochreous mass. In the centre of this chamber, a large stalactite depended from the roof ; and beneath, a similar mass rose from the floor, almost touching it : in one of the side walls was an opening about three feet square, which conducted through a passage eighteen yards in length, to a second cavern, ten yards in length, and five in breadth, both the passage and cavern being filled with ochre and bones ; another passage, about six feet square, branched off laterally from this chamber about four yards below its entrance ; this continued nearly on the same level for eighteen yards ; it was filled with rubbly ochre, fragments of lime-stone rounded by attrition, and lead ore confusedly mixed together ; many large bones occurring in the mass ; among which four magnificent teeth of an elephant (the whole number belonging to a single skull) were found ; another shaft was sunk from the surface perpendicularly into

his branch, and appears to have followed the course of a fissure, since it is said that all the way nothing appeared but rubble, large stones, ochre, and bones: in the second chamber, immediately beyond the entrance of the branch just described, there appeared a large deep opening, tending perpendicularly downwards, filled with the same congeries of rubble, ochre, bones, &c.; this was cleared to the depth of five yards; this point, being the deepest part of the workings, was estimated at about thirty-six yards beneath the surface of the hill; a few yards to the west of this another similar hole occurred, in which was found a large head, which we shall have occasion presently to notice."

The bones from this cavern, preserved in Mr. CATCOTT'S cabinet in the Bristol library, are the teeth and fragments of some bones of the elephant; and similar remains of horses, oxen, and two species of stag, besides the skeleton, nearly complete, of a fox. There are also molar teeth of the hog, and a large tusk of the upper jaw; (see Pl. XXV. fig. 30, 31, 32, 33.) This tusk probably belonged to the head mentioned in his MS. as having been found in the pit above described, and of which the following particulars are specified:—"The head was stated by the workmen to have been about three or four feet long, fourteen inches broad at the top, or head part, and three inches at the snout. It had all the teeth perfect, and four tusks, the larger tusks about four inches long out of the head, and the lesser about three inches."* The tusk now

* The head here described, is evidently that of a hog; the account of its length being exaggerated by the workmen, from whose report alone Mr. CATCOTT gives the measures of it. The head itself was lost or destroyed before he had seen it.

preserved is about three inches long, its enamel is fine, it is longitudinally striated, and on one side of the apex truncated and worn flat by use.

On the summit of Sandford Hill, on the east of Hutton, bones of the elephant were also, according to Mr. CATCOTT'S MSS., discovered four fathoms deep among loose rubble. Some farther detail of the bones found in the cave at Hutton are given as a note in Mr. CATCOTT'S *Treatise on the Deluge* (page 361, 1st. edition), in which he specifies six molar teeth of the elephant, one of them lying in the jaw, part of a tusk, part of a head, four thigh bones, three ribs, with a multitude of lesser bones, belonging probably to the same animal. " Besides these (he adds), we picked up part of a large deer's horn very flat, and the slough of a horn (or the spongy porous substance that occupies the inside of the horns of oxen), of an extraordinary size, together with a great variety of teeth and small bones belonging to different species of land animals. The bones and teeth were extremely well preserved, all retaining their native whiteness, and, as they projected from the sides and top of the cavity, exhibited an appearance not unlike the inside of a charnel-house."

It appears to me most probable, from the description given of these bones and horns, that they were not all dragged in by beasts of prey, but some of them, at least, drifted in by water, and the presence of pebbles seems to add credibility to this conjecture.

3. Another case of fossil fragments of bone has been discovered by Mr. MILLER, of Bristol, in a cavity of mountain lime-stone, near Clifton, by the turnpike gate on Derdham

Down: these are not rolled, but have evidently been fractured by violence: they are partially incrustated with stalactitic matter, and the broken surfaces have also an external coating of thin ochreous stalactite, showing the fracture to have been ancient; one specimen, the property of Mr. MILLER, displays the curious circumstance of a fossil joint of the horse; it is the tarsus joint, in which the astragalus retains its natural position between the tibia and os calcis; these are held together by a stalactitic cement, and were probably left in this position by some beast of prey that had gnawed off the deficient portions of the tibia and os calcis.

4. A fourth case is that of some bones and molar teeth of the elephant, found in another cavity of mountain limestone at Balleye, near Wirksworth, in Derbyshire, in the year 1663; one of these teeth is now in the collection of Mr. WHITE WATSON, of Bakewell. There is, I believe, no detailed account of the circumstances under which these remains were found, farther than that the cavity was intersected in working a lead mine; they might possibly have been introduced in the same manner as those at Kirkdale and Crawley Rocks.

5. The fifth and last example which I am acquainted with, is that described by Sir EVERARD HOME and J. WHIDBY, Esq. in the Philosophical Transactions for 1817, as discovered at Oreston, near Plymouth, by Mr. WHIDBY, in removing the entire mass of a hill of transition limestone for the construction of the Breakwater. This limestone is full of caverns and fissures, such as may be seen at Stonehouse and elsewhere along the edge of the cliffs; that in which the bones were found was fifteen feet wide, twelve high, and

forty-five long, and about four feet above high water mark; it was filled with solid clay (probably diluvian mud) in which the teeth and bones were imbedded, and was intersected in blasting away the body of the rock to make the Breakwater. The state of the teeth and bones was precisely the same with that of those found at Crawley rocks, they were much broken, but not in the slightest degree rounded by attrition, and Sir EVERARD HOME has ascertained them to belong exclusively to a species of rhinoceros. A similar discovery of teeth and bones was made in 1820, in a smaller cavern, distant one hundred and twenty yards from the former, being one foot high, eighteen wide and twenty long, and eight feet above the high water mark; a description of its contents is given in the Philosophical Transactions for 1821, by the same Gentlemen. It contained no stalactite, which abounds in many of the adjacent caverns. Sir EVERARD HOME describes these teeth and bones as belonging to the rhinoceros, deer, and a species of bear.

Mr. WHIDBY is of opinion, that neither of these caverns had the appearance of ever having had any opening to the surface, or communication with it whatever; an opinion in which I can by no means acquiesce; though I think it probable that the openings had, as at Kirkdale, been long ago filled up with rubbish, mud, stalactite, or fragments of rock re-united, as sometimes happens, into a breccia as solid as the original rock, and overgrown with grass. It is now too late to appeal to the evidence of facts, as the rock in which the cave existed is entirely removed; but the circumstances of similar caverns that have communication with the surface, either open or concealed, both in this neighbourhood, and in compact lime-stone rocks of all ages and formations, and in all

countries, added to the identity of species and undecayed state of the animal remains which they contain, render the argument from analogy perfect, to show that the bones at Oreston are not coeval, and have only an accidental connection with the rock in the cavities of which they were found.

It by no means follows, from the certainty of the bones having been dragged in by beasts of prey to the small cavern at Kirkdale, that those of similar animals must have been introduced in all other cases in the same manner; for, as these animals were the antediluvian inhabitants of the countries in which the caves occur, it is possible, that some may have retired into them to die, others have fallen into the fissures by accident and there perished, and others have been washed in by the diluvial waters. By some one or more of these three latter hypotheses, we may explain those cases in which the bones are few in number and unbroken, the caverns large and the fissures extending upwards to the surface; but where they bear marks of having been lacerated by beasts of prey, and where the cavern is small, and the number of bones and teeth so great, and so disproportionate to each other as in the cave at Kirkdale, the only adequate explanation is, that they were collected by the agency of wild beasts. We shall show hereafter, that in the case of the German caves, where the quantity of bones is greater than could have been supplied by ten times the number of carcasses which the caves, if crammed to the full, could ever have contained, they were the bones of bears that lived and died in them during successive generations.

WE may now proceed to consider how far the circum-

stances of the caves we have been examining in England, appear consistent with those of analogous caverns in other parts of the world. The history of the diluvian gravel of the Continent, and of the animal remains contained in it, appears altogether identical with that of our own; and with respect to the bones that occur in caverns, the chief difference seems to be, that on the Continent some of the caves have their mouths open, and have been inhabited in the *post-diluvial* period by animals of now existing species. Thus at Gailenreuth the great extinct bear (*Ursus spelæus*) occurs, together with the Yorkshire species of extinct hyæna, in a cave, the mouth of which has no appearance of having ever been closed, and which at this moment would, probably, have been tenanted by wild beasts, had not the progress of human population extirpated them from that part of Germany.

For a description of the cavern at Gailenreuth, (which I visited in 1816) of which, in Plate XXVI. I have given a sectional representation, I must refer to the work of ROSENMULLER, published at Weimar in 1804, in folio, with engravings of nearly all the bones composing the skeleton of the extinct bear, the size of which approached nearly to that of a horse; and for a description of the caves at Blankenburg, to an account by ESPER and LEIBNITZ, published at Brunswick.

M. ROSENMULLER says, he has never seen the remains of the elephant and rhinoceros in the same cavern with those of bears; and that he has found the bones of wolves, foxes, horses, mules, oxen, sheep, stags, roebucks, badgers, dogs, and men;* and that the number of all these is in no propor-

* M. ESPER has found in one of the caverns containing bears' bones, fragments of urns, which from their form were probably made at least 800 years ago.

tion to that of the bears. The bones of all kinds occur in scattered fragments. One entire skeleton only of the *Ursus spelæus* is said to have been found by BRUCKMANN, in a cave in the Carpathians, and to have been sent to Dresden. He adds, that the different state of these bones shows that they were introduced at different periods, and that those of all the animals last enumerated, including man, are in much higher preservation than those of the bears and hyænas.

Thus it appears that the bones which are in most perfect preservation, and belong to existing species, have been introduced during the *post-diluvian* period; whilst the extinct bears and hyæna are referable to the antediluvian state of the earth. In corroboration of this, I found in 1820, in the collection of the Monastery of Kremsminster, near Steyer, in Upper Austria, skulls and bones of the *Ursus spelæus* in consolidated beds of diluvial gravel, forming a pudding-stone, and dug for building near the monastery; from which it appears that this species of bear lived in the period immediately preceding the formation of that diluvium; and the same thing has been already shown of the extinct hyæna in the gravel of France and Germany.

M. ROSENMULLER states that in all the caverns he has examined, the bones are disposed nearly after the same manner; sometimes scattered separately, and sometimes accumulated in beds and heaps of many feet in thickness; they are found every where from the entrance to the deepest and most secret recesses; never in entire skeletons, but single bones mixed confusedly from all parts of the body, and animals of all ages. The skulls are generally in the lowest part of the beds of bone, having from their form and weight sunk

or rolled downwards, as the longer and lighter bones were moved and disturbed continually by the living animals passing over them; the lower jaws are rarely found in contact with, or near to the upper ones, as would follow from the fact last mentioned.* They are often buried in a brown argillaceous or marly earth, as in the cases of Gailenreuth, Zahnloch, and in the Hartz, which earth, from an analysis by M. FRISCHMAN, seems to contain a large proportion of animal matter derived from the decay of the fleshy parts of the bears.

In the caves of Gailenreuth and Mockas, a large proportion of the bones is invested with stalactite. Even entire beds, and heaps of them many feet thick, are sometimes cemented together by it, so as to form a compact breccia. Occasionally they adhere by stalactite to the sides of the cavern, but are never found in the substance of the rock itself. At Sharzfelden, and in the Carpathians, they have been found enveloped with agaric mineral (*lac lunæ*); they have undergone no alteration of form, but the larger bones are generally separated from their epiphyses. Their usual colour is yellowish white, but brown where they have lain in dark coloured earth, as at Lichtenstein. At Mockas their degree of decay is by far the greatest. Even the enamel of the teeth is far gone, and the bones are perfectly white, having lost all their animal

* At Kirkdale, not one skull, and few, if any, of the larger bones are found entire; for these had all been broken up by the hyænas to extract the brains and marrow; and in their strong and worn out teeth we see the instruments by which they were thus destroyed. The bears, on the other hand, not being exclusively carnivorous, nor having teeth fitted for the cracking of large bones, have left untouched the osseous remains of their own species.

gluten, and acquired the softness and spongy appearance, as well as colour, of calcined bones; still their form is perfect, and substance inflexible, and when struck, they ring like metallic bodies falling to the ground. These retain simply their phosphate of lime. In other caverns they are usually less decayed, but they sometimes exfoliate and crack on exposure to air, and the teeth, particularly, are apt to split and fall to pieces, as are also those at Kirkdale.*

M. ROSENMULLER is decidedly of opinion with M. CUVIER, that the bears' bones are the remains of animals which lived and died through successive generations in the caves in which we find them; nay, even that they were also born in the same caves. In proof of which he has found some bones of a bear, that must have died immediately after birth, and other bones of individuals that must have died young. This is analogous to the case of numerous teeth of young hyænas with fangs not formed; and the jaws of two that had not shed their first teeth, which I found at Kirkdale.

Most of the arguments which I have used to show that the bones in Yorkshire cannot have been accumulated by the action of one, or of a succession of floods, apply with equal force to the cave at Gailenreuth, and it is unnecessary to repeat them.

The above description of the cave at Gailenreuth, extracted from ROSENMULLER, and confirmed by my own observations

* It is a curious fact, that of the numerous caves in the calcareous hills near Muggendorf, that flank the valley of the Weisent-stream, those on the north chain contain not a fragment of the bones of the *Ursus spelæus*, while those on the south side are full of them. This may probably be explained by supposing the mouths of the former to have been closed in the antediluvian period, and afterwards laid open by denudation.

on the spot, may be taken as an example of the state of the other caves on the Continent, of which it is superfluous here to say any thing farther, than to subjoin a list given by M. CUVIER of the most important of them, and to refer to the fourth Volume of his *Animaux fossiles*, for farther details taken from the authors by whom these caves have been described.

The caves alluded to are as follows :

1. That of Bauman, in the county of Blankenberg, in Brunswick, on the east border of the Hartz forest, and described by LEIBNITZ.

2. That of Sharzfels, in Hanover, in the south border of the Hartz, described by LEIBNITZ, DELUC, and BRUCKMANN.

BEHRENS, in his *Hercynia Curiosa*, speaks of several more in the neighbourhood of the Hartz ; from most of these the bones were collected during a long course of years, and sold for their imaginary medicinal virtues under the name of Licorne.

3. The caves that next attracted attention were those of the Carpathians, and the bones found in them were at first known by the name of dragons' bones, and have been described by HAYNE and BRUCKMANN.

4. But the most richly furnished are the caves of Franconia, described by ESPER and ROSENMULLER, near the sources of the Mayn, in the vicinity of Bamberg and Bayreuth, at the villages of Gailenreuth, Mockas, Rabenstein, Kirch-a-horn, Zahnloch, Zewig, and Hohen Mirchfeld.

5. A fifth locality occurs at Glücksbrun, near Meinungen, on the south border of the Thuringerwald.

6. And a sixth in Westphalia, at Kluterhoehle and Sund-

wich, in the country of Mark. M. CUVIER states, that the bones found in these caverns are identical over an extent of more than 200 leagues; that three-fourths of the whole belong to two species of bear, both extinct; the *Ursus spelæus* and *Ursus arctoides*, and two-thirds of the remainder to extinct hyænas. A very few to a species of the cat family, being neither a lion, tiger, panther, or leopard, but most resembling the jaguar, or spotted panther of South America. There is also a wolf or dog (not distinguishable from a recent species), a fox and polecat. He adds that, in the caves thus occupied, there occur no remains of the elephant, rhinoceros, horse, ox, tapir, or any of the ruminantia or rodentia. In this respect they differ materially from that of Yorkshire; but such variation is consistent with the different habits of bears and hyænas, arising from the different structure of their teeth and general organization; from which it follows, that bears prefer vegetable food to that of animals, and, when driven to the latter, prefer sucking the blood to eating the flesh, whilst hyænas are beyond all other beasts addicted to gnawing bones.

From this circumstance it is rendered probable, that in the caves inhabited chiefly by bears, the bones of other animals should be extremely rare. But unless there be an error in the statement of M. DELUC (*Lettres*, vol. iv. p. 588), that a tooth found in the cave at Scharzfels was ascertained by M. HOLLMAN to be that of a rhinoceros; and of ESPER, that large cervical vertebræ of an elephant were found by M. FRISCHMAN in the cave of Schneiderloch; it follows, that these two animals occur, though very rarely, in the caves of Germany, and they may have been introduced by the few hyænas that

occasionally inhabited them; that they lived in the neighbourhood of these caves, in the period immediately preceding the formation of the diluvium, is probable, from the occurrence in it of the bones of the elephant and rhinoceros near the caves of Scharzfels and Alterstein, mentioned by BLUMENBACH. (*Archaeologia Telluris*, p. 15.)

The fact mentioned by M. CUVIER, of the same hyæna being common to the caves and gravel of France and Germany, and that ascertained by myself, of the *Ursus spelæus* occurring in the gravel of Upper Austria, proves both these extinct species to have been the antediluvian contemporaries of the extinct elephant and rhinoceros; there is therefore no anachronism in finding the remains of the two latter in a den that was occasionally inhabited by such hyænas and bears.

With respect to the analogies of the diluvian sediment and the stalactite in Germany and Yorkshire, in the case of the open caves that have been disturbed and ransacked for centuries, it is hopeless to expect evidence of what was the precise state of these deposits in each individual cavern at the time it was first entered. Still there is information respecting some that have been recently discovered, which is to our purpose. It is stated, that a sediment of this kind was found on the sides and floor of the cave at Glucksbrun, near Meinungen, when it was newly opened in cutting a road in 1799, and that in all the other caverns also there is mud, but no rounded pebbles. M. DELUC, in describing the matrix in which the bones are lodged in the cave at Scharzfels, says, “le fait est donc simplement, que le sol de ces cavernes est d’une terre calcaire,” “qu’en creusant cette couche molle, on en tire quantité de fragmens d’os; et qu’il s’y trouve aussi des concrétions pier-

reuses qui renferment des os." DELUC, *Lettres*, vol. iv. p. 590. These concretions with bones appear analogous to the stalagmitic concretions at Kirkdale, and the soft calcareous earth by which they are covered, resembles its stratum of mud. Again, the resemblance holds also in the existence both of bones and soft mud in the smallest recesses of the caverns. He says, p. 589, " Il faut en quelques endroits se trainer sur le ventre, par dessous la pierre dure pour continuer a y creuser." This is an exact description of the state of the extremities of the cave at Kirkdale at the present moment.

LEIBNITZ, in his description of this same cavern, has the following words to the same purpose, " Limo nigricante vel fusco infectum est solum." LEIBNITZ, *Protogaea*, p. 65.

ESPER thus describes the state of the floor near the entrance of one of the largest caverns at Gailenreuth. " Dans toute la contrée le terrain est marneux, mêlé avec du limon, et tire sur le jaune, mais ici on trouve une terre moins limoneuse dans une profondeur considérable. Je ne prétends pas encore la prendre absolument pour une terre animale telle qu'est sans contredit la terre qui se trouve plus bas, mais probablement elle doit y être rapportée, p. 9. This again is consistent with the circumstances of the cave at Kirkdale, the mud, thus dubiously spoken of, being probably of diluvial origin, and reposing on, and being mixed with, the animal earth that had been formed before its introduction. The absence of black animal earth at Kirkdale, results from the fact of the flesh, and great part even of the bones of the animals introduced to it, having been eaten by the hyænas.

The identity of time and circumstances which I am endeavouring to establish between the German and English

caverns, does not, however, depend so much on comparisons between the stalactitic matter and earthy sediments which they contain, as on the agreement in species of the animals entombed in them, viz. in the agreement of the animals of the English caves, with those of the diluvian gravel of the greater part of Europe; and, in the case of the German caves, on the identity of the extinct bear with that of the diluvian gravel of Upper Austria, and the extinct hyæna with that of the gravel at Canstadt, in the valley of the Necker; and at Eichstadt, in Bavaria; to these may be added the extinct rhinoceros, elephant, and hippopotamus, which are common to gravel beds as well as caves. And hence it follows, that the period at which all these caverns were inhabited by the animals in question, was antecedent to the formation of that deposit of gravel, which it seems to me impossible to ascribe to any other origin than a transient deluge, affecting universally, simultaneously, and at no very distant period, the entire surface of our planet.

The bones found in these caverns are considered by M. CUVIER, to be of older date than those of the osseous breccia, which, at Gibraltar and various places along the coast of the Mediterranean and Adriatic, occur in vertical fissures of limestone. This breccia contains fragments of bones and teeth of various ruminating and gnawing animals; that is, of ox, deer, antelope, sheep, rabbits, rats, mice; also of the horse and ass, of snakes and birds, mixed with land shells, and angular fragments of the adjacent rock; all united into a solid breccia by ochreous stalactite. The greater number of these animals agree with species that now exist, and are supposed by M. CUVIER to have fallen into the fissures in

the period succeeding the last retreat of the waters. I do not see why some of them may not also have fallen in during that earlier period in which the bears occupied the caves of Germany, and the hyænas that in Yorkshire; for some of the animals found at Kirkdale seem to agree in species with those that occur in the fissures; but as they are at the same time not distinguishable from existing species, the argument arising from this resemblance is imperfect. The discovery of the extinct elephant, rhinoceros, hippopotamus, bear, and hyæna in this breccia, should it ever be made, would be decisive of the question.

For an account of the bones accumulated in these fissures, I must again refer to the works of M. CUVIER, which contain more sound and clear philosophical reasoning on the early state of habitation on our planet, and a more valuable collection of authentic facts relating to the history of its fossil animals of the higher orders, than can be found in all the books that have ever yet been written on the subject.

APPENDIX.

It was mentioned, when speaking of Gailenreuth, that human remains had been discovered there in the same cave with the bones of antediluvian animals, but that they are of comparatively low antiquity.

Three analogous cases have been noticed in this country in cavities of mountain lime-stone, at Burringdon, in Somersetshire, and in Glamorganshire and Caermarthenshire; and these also are attended by circumstances which indicate them to be of post-diluvian origin.

1. The discovery of human bones incrustated with stalactite, in a cave of mountain lime-stone at Burringdon, in the

Mendip-hills, is explained, by this cave having either been used as a place of sepulture in early times, or been resorted to for refuge by wretches that perished in it, when the country was suffering under one of the numerous military operations which, in different periods of our early history, have been conducted in that quarter. The mouth of this cave was nearly closed by stalactite, and many of the bones were incrustated with it. In the instance of a skull, it had covered the inside as well as the outside of the bone; and I have a fragment from the inside, which bears in relief casts of the channel of the veins along the interior of the skull. The state of these bones affords indications of very high antiquity; but there is no reason for not considering them post-diluvian. Mr. SKINNER, on examination of this cave, found the bones disposed chiefly in a recess on one side, as in a sepulchral catacomb; and in the same neighbourhood, at Wellow, there is a large artificial catacomb of high antiquity, covered by a barrow, and constructed after the manner of that at New-Grange, near Slane, in the county of Meath, of stones successively overlapping each other till they meet in the roof. In this were found the remains of many human bodies. A description of it may be seen in the *Archæologia* for 1820.

2. Mr. DILLWYN has observed two analogous cases in the mountain lime-stone of South Wales; one of these was discovered, in 1805, near Swansea, in a quarry of lime-stone at the Mumbles, where the workmen cut across a wedge-shaped fissure, diminishing downwards, and filled with loose rubbish, composed of fragments of the adjacent lime-stone, mixed with mould. In this loose breccia lay, confusedly, a large number of human bones, that appear to be the remains of bodies thrown in after a battle, with no indications of regular

burial; they were about 90 feet below the present upper surface of the lime-stone rock.

3. The other case occurred, in 1810, at Llandebie, in Caermarthenshire, where a square cave was suddenly broken into, in working a quarry of solid mountain lime-stone on the north border of the great coal basin. In this cave lay about a dozen human skeletons in two rows at right angles to each other. The passage leading to this cave had been entirely closed up with stones for the purpose of concealment, and its mouth was completely grown over with grass.

It is obvious, that in neither of these cases, are the bones referable to so high an era as those of the wild beasts that occur in the caves at Kirkdale, and elsewhere.

P. S. As this paper was going to the press, I have been gratified to hear that my conjecture, as to the abundance of such caverns as that at Kirkdale, has been verified by the discovery of another cave (containing chambers lined with stalactite, and having on its bottom mud, and bones imbedded in the mud), in a quarry close to the town of Kirby Moorside, on the property of C. DUNCOMBE, Esq., who has judiciously taken every precaution to secure it from injury, till some qualified person shall be present to observe, and record the undisturbed appearance presented by its interior. Should it be in my power, as I hope it may, to assist at its farther opening, I shall communicate the result to the Royal Society.

It is recollected also, that about 20 years ago, another cavity, containing bones, was discovered on the north of Kirby Moorside, but none of them have been preserved.

Though it is probable, as I have stated, that such caverns are not uncommon, we shall cease to wonder that they are

so rarely brought to light, when we consider the number of accidental circumstances that must concur to lead to such an event. 1st, The existence of caverns is an accidental circumstance in the interior of the rock, of which the external surface affords no indication, when the mouth is filled with rubbish and overgrown with grass. 2d, The presence of bones is another accidental circumstance, though probably not an uncommon one in the case of those caves, the mouths of which were accessible to the wild beasts that inhabited this country in the period immediately preceding the deluge. 3d, A farther requisite is, the intersection of one of these caves in which there happen to be bones, by a third accident, viz. the working of a stone quarry by workmen who have sufficient curiosity or intelligence to notice and speak of what they find, and this to persons who may be willing or able to appreciate, and give publicity to the discovery. The necessary concurrence of all these contingencies renders it probable, that however great may be the number of subterraneous caverns, in an inland country, very few of them will ever be discovered, or if discovered, be duly appreciated. Those I have mentioned in Devon, Somerset, Derby and Glamorganshire, were all laid open by the accidental operations of a quarry or mine.

May 24, 1822. I have this day received the entire lower jaw of an hyæna from Lawford, near Rugby, in Warwickshire. It was found by ANDREW BLOXAM, Esq. in the same diluvial clay and gravel with the bones of elephant and rhinoceros. This is the first instance of the remains of hyæna being noticed in the diluvium of England. The animal must have perished by the same catastrophe which extirpated the hyænas, and closed the den at Kirkdale, and which swept together the remains of elephant, rhinoceros and hyæna in the diluvian gravel of the Continent. The support which this recent discovery gives to my arguments on the cave in Yorkshire, is too obvious to require pointing out.

EXPLANATION OF THE PLATES.

All the Drawings are of the natural size, unless where it is expressed to the contrary.

PLATE XV.

Map of the country adjacent to the cave at Kirkdale, showing the entire drainage of the vale of Pickering to be effected through the gorge at Malton, the stoppage of which would at once convert it into an inland lake.

PLATE XVI.

Fig. 1. View of the mouth of the cave at Kirkdale, in the face of a quarry, near the brow of a low hill.

Fig. 2. Section of the cave before the mud had been disturbed.

A. Stratum of mud covering the floor of the cave to the depth of one foot, and concealing the bones.

B. Stalagmite incrusting some of the bones, and formed before the mud was introduced.

C. C. Stalagmite formed since the introduction of the mud, and spreading horizontally over its surface.

D. Insulated stalagmite on the surface of the mud.

E. E. Stalactites hanging from the roof above the stalagmites.

Fig. 3. Ground plan of the cave, by W. SALMOND, Esq. showing its extent, ramifications, and the fissures by which it is intersected.

PLATE XVII.

1. Portion of the left upper jaw of the modern hyæna from the Cape.
2. Inside view of No. 1.
3. Analogous portion of the left upper jaw of the fossil hyæna from Kirkdale.
4. Inside view of No. 3, with the tooth of a water-rat adhering by stalagmite to a broken portion of the palate.
5. Fragment from Kirkdale, showing five incisor teeth of the upper jaw, much worn down, and the inside of the palate.

PLATE XVIII.

1. Outside view of the right lower jaw of the modern Cape hyæna.
2. Analogous portion of lower jaw of the Kirkdale hyæna, being nearly one-third larger.
3. Inside view of No. 2.

PLATE XIX.

1. Fragment of the right lower jaw of an hyæna, showing the convex surface of the jaw and its teeth, that lay uppermost in the den, to be deeply worn by friction, and to have received a polish. The enamel, and one-third of the substance of the teeth and bone on this side have been worn away.
2. Concave surface of No. 1, having no marks of friction, polish, or decay: the enamel on this side of the teeth is perfect and unchanged.
3. Fragment of the right lower jaw of a young hyæna, having the convex surface only polished as in No. 1; and showing the cavities in which the second set of teeth were rising to succeed the first set; one of which, the posterior

molar tooth, still remains in its place, having its enamel on this side worn away, as in the teeth of No. 1.

4. Inside or concave surface of No. 3, has suffered no friction or polish, and the enamel of the tooth is perfect and fresh as in No. 2.

5. Metatarsal bone of hyæna.

6, 7. Phalanges of the toe of an animal not ascertained.

8. Claw bone of the toe of an hyæna.

9, 10, 11. Metacarpal bone and two phalanges of the toe of hyæna.

12. Claw bone of the toe of an hyæna.

PLATE XX.

1. Canine tooth or tusk of a bear (*Ursus spelæus*).

2. Inside view of posterior molar tooth of the lower jaw on the left side of hyæna.

3. Outside view to No. 2.

4. Largest canine tooth or tusk of hyæna found at Kirkdale.

5. Tusk of an animal of the tiger kind.

6. Outside view of right posterior molar tooth of the lower jaw of a tiger.

7. Inside view of No. 6. On comparing 6 and 7 with 2 and 3, it will be observed that in 6 and 7, the angle near the middle part of the crown is less obtuse than in 2 and 3, and that the two lobes which project at the base of the crown of 2 and 3 are wanting in 6 and 7.

8. Tusk of fox.

9. Incisor tooth of fox.

10. Inside view of No. 9.

11. Small molar tooth of fox.

12. Great molar tooth of the right lower jaw of fox; outside view.

13. Inside view of No. 12.
14. Penultima of upper jaw, right side, of fox.
15. }
16. } Molar teeth of wolf.
17. } Inside view.
18. } Outside view of No. 17.
19. Tooth of an animal not ascertained.
- 20, 21, 22, 23, 24, 25, 26, 27. Outside and inside views of four molar teeth of an animal not ascertained: they are all extremely thin, and have deep furrows worn on them.
- 28, 29. Posterior tooth and penultima of a weasel, left upper jaw (twice the natural size).
- 30, 31. Two views of the same tooth of an animal not ascertained, perhaps a seal.

PLATE XXI.

1. Small molar tooth of a very young elephant, being the average size of those found in the den.
2. Fragment of a still younger elephant's tooth.
3. Molar tooth of upper jaw of rhinoceros.
4. Inside view of molar tooth of lower jaw of rhinoceros.
5. Crown of No. 4, as seen from above.
6. Outside view of No. 4.
7. Molar tooth of the upper jaw of a horse.
8. } Two views of a molar tooth of hippopotamus not yet
9. } worn down.
10. Molar tooth of hippopotamus, having the summits of the crown worn down.

PLATE XXII.

1. Posterior molar tooth of the lower jaw of an ox,
2. Crown of No. 1.

3. Posterior molar tooth of the right lower jaw of a species of deer.
4. Molar tooth of the upper jaw of an ox.
5. Molar tooth of the lower jaw of a calf.
6. Side view of No. 5.
7. Molar tooth of the upper jaw of an ox.
8. Outside view of No. 7.
9. Molar tooth of the upper jaw of a very large species of deer, equalling in size the largest elk, but differing in form.
10. Outside view of No. 9.
11. Molar tooth of the upper jaw of a second species of deer, equalling in size the largest red deer.
12. Outside view of No. 11.
13. } Inside and outside views of a rising molar tooth of a
14. } third species of deer, of the size of a large fallow deer.

PLATE XXIII.

1. Outside view of a molar tooth of the lower jaw of a large species of deer.
2. Inside view of No. 1.
3. Base of the horn of a large deer, measuring nine inches and three quarters in circumference, which corresponds exactly in size with that of a very large English red deer in the Anatomy School at Oxford.
4. Base of a horn similar to No. 1, having two antlers near its lower extremity, and measuring seven inches and three quarters in circumference.
5. Base of a deer's horn, having the lowest antler at the distance of three inches and a half from the lower extremity, and measuring eight inches in circumference.

PLATE XXIV.

1. Coronary bone of a horse.
2. First phalangeal bone of a very large ox; side view.
3. Under side of No. 2.
- 4, 5. Astragalus of a large ox: two different sides of the same bone.
6. Album græcum, showing a small sphere adhering to the larger one, and an indentation of the sides of both by pressure from a third sphere.
7. Astragalus of hyæna.
8. Side view of No. 7.
9. Astragalus of fox.
10. Side view of No. 9.
11. Astragalus of water-rat.
12. Os calcis of water-rat.
13. Os calcis of fox.
14. Os calcis of rabbit.
- 15, 16. Internal metatarsal bone of rabbit, having lost the epiphysis.
- 17, 18. Metatarsal bone of rabbit, retaining the epiphysis at the lower extremity.

PLATE XXV.

1. Lower jaw of a water-rat.
2. Lower incisor tooth of No. 1.
3. Upper incisor of water-rat.
4. Anterior molar tooth of lower jaw of water-rat.
5. No. 4, magnified.
6. Crown of No. 4, magnified.
7. Jaw of a mouse.
- 8 and 9. Teeth of No. 7, magnified four times.

10. Anterior molar tooth of the upper jaw of a rabbit.
11. Os innominatum of a young water-rat.
12. Tibia of a water-rat.
13. Lower epiphysis of femur of water-rat, twice magnified.
14. Femur of water-rat, twice magnified.
15. Ulna of water-rat.
16. Tail vertebra of water-rat.
17. Anterior extremity of No. 16.
18. Posterior extremity of No. 16.
19. Right ulna of a raven; anterior extremity.
20. Outside view of No. 19, showing the points of attachment of the quill feathers.
21. Right ulna of a raven, showing the other extremity of No. 19.
- 22, 23. Other views of No. 20, showing the cavity to be nearly filled with stalagmite.
24. Right ulna of a lark, showing the attachments of the quill feathers.
25. Inside view of No. 24.
26. Left ulna of a very large species of pigeon.
27. Inside view of No. 26.
28. Right coracoid process of the scapula of a small species of duck or widgeon.
29. Inside view of No. 28.
30. Tusk of the upper jaw of a large hog, polished obliquely near its apex, and having a molar tooth of hog adhering to it, near its base, by an ochreous crust.
31. View of the opposite side of No. 30.
32. Large molar tooth of hog in a fragment of the lower jaw, slightly incrustated with ochre.
33. Small molar tooth of hog.

PLATE XXVI.

Vertical section of the great cave at Gailenreuth, near Bamberg, in Franconia ; drawn from a sketch made on the spot by Professor Buckland, A. D. 1816.

A. Entrance passage, varying from five to eight feet in height, terminated externally by an open mouth in the steep side of a hill, and internally expanding into the cavern B. : a few bones are scattered irregularly along the floor.

B. First large chamber, having stalactites of all sizes hanging from its roof, and numerous bones of bears scattered on its floor.

C. Second chamber, separated from B by a perpendicular precipice, but having, probably, other lateral communications with it. On its floor the bones lie scattered more abundantly than in B.

D. Large aperture, descending obliquely downwards from C, and having cart loads of loose bones in it.

E. Mass composed chiefly of bones cemented by stalagmite, and forming a compact breccia.

F. Very long and low passage, connecting the chamber C with the vertical fissure G. The length of this passage is not expressed, for want of room ; it can be traversed only by crawling on the hands and knees.

G. Vertical fissure of considerable depth, and about three feet in breadth ; the only mode of descent is by supporting the hands and feet on niches cut in the opposite sides of the fissure.

H. Oven-shaped cavity, which has been produced artificially by extracting bones and skulls from the osseous breccia.

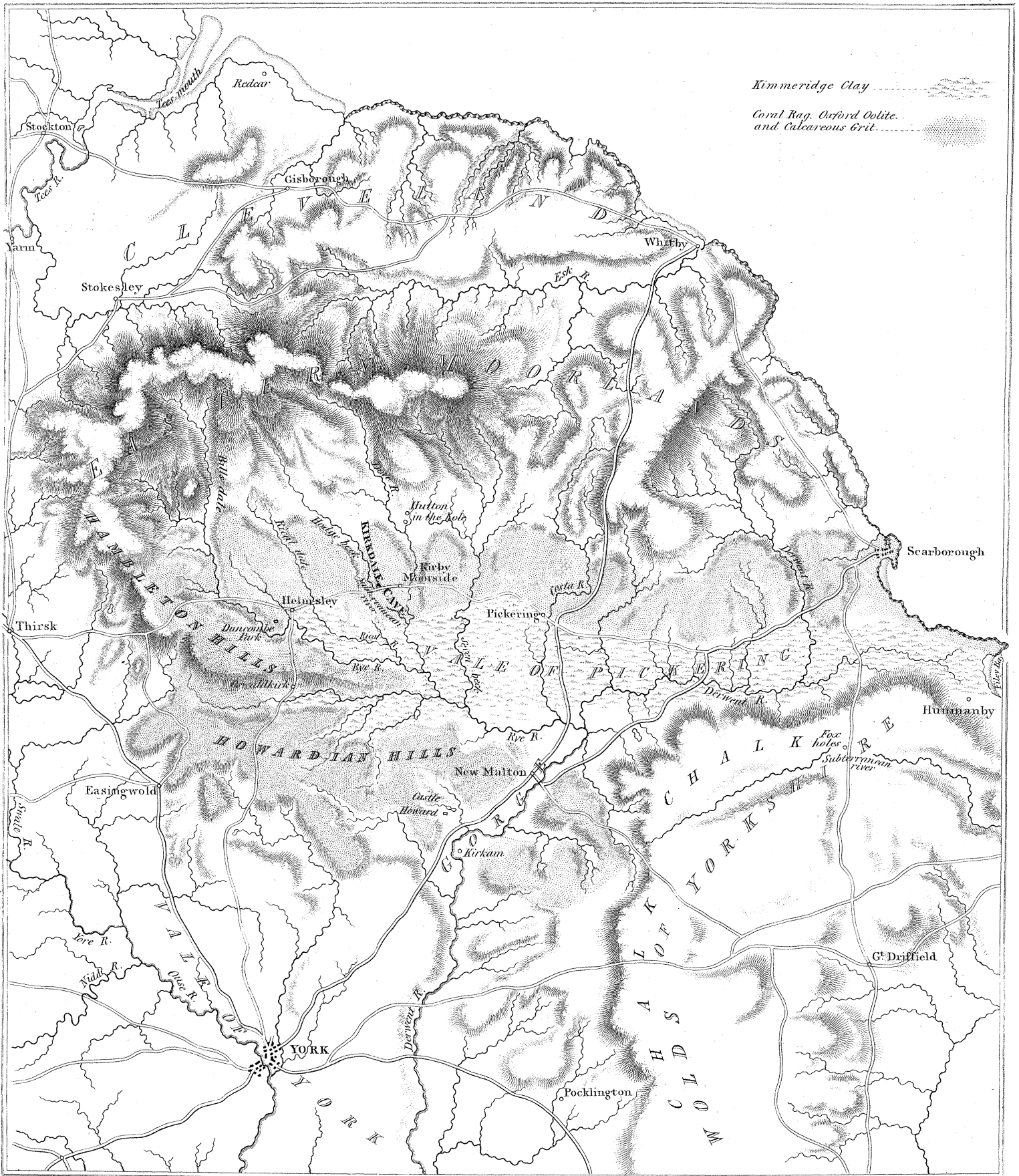


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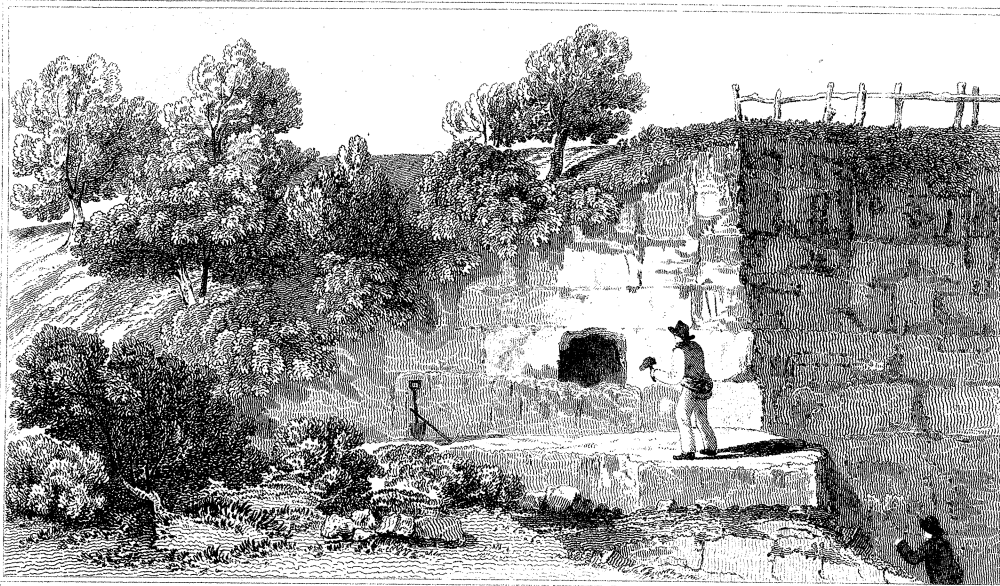


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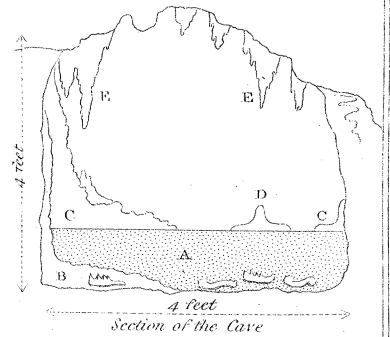
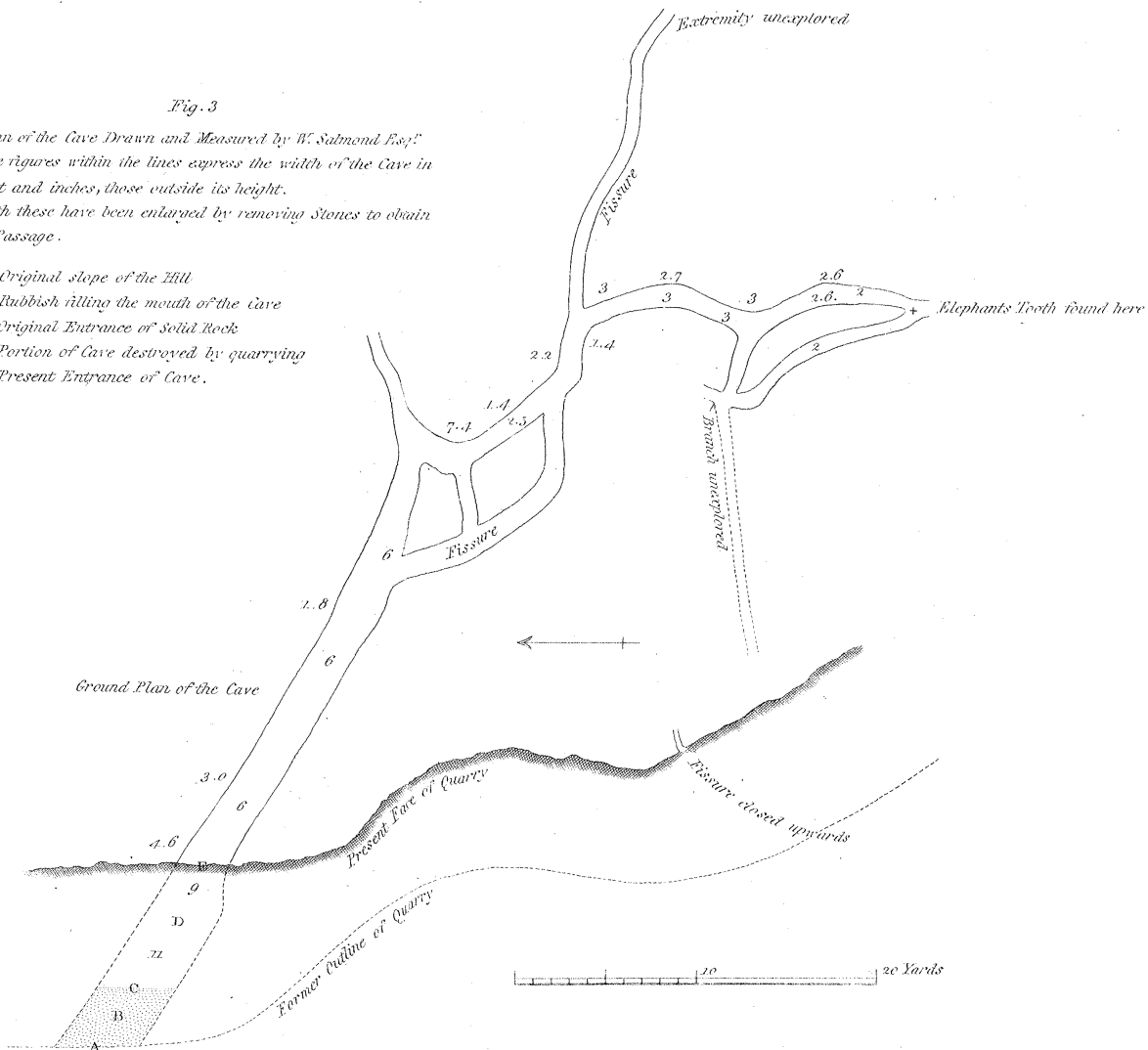


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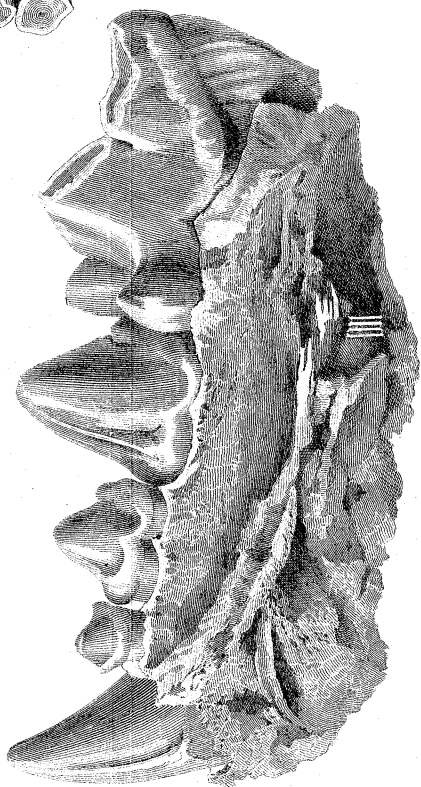
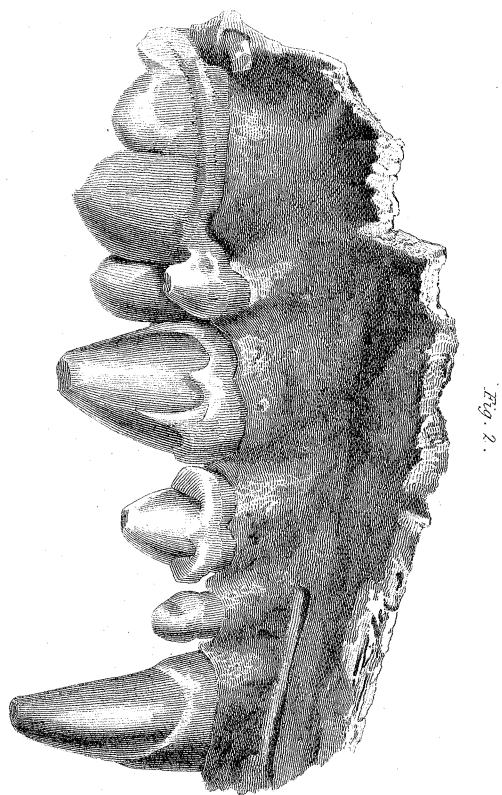
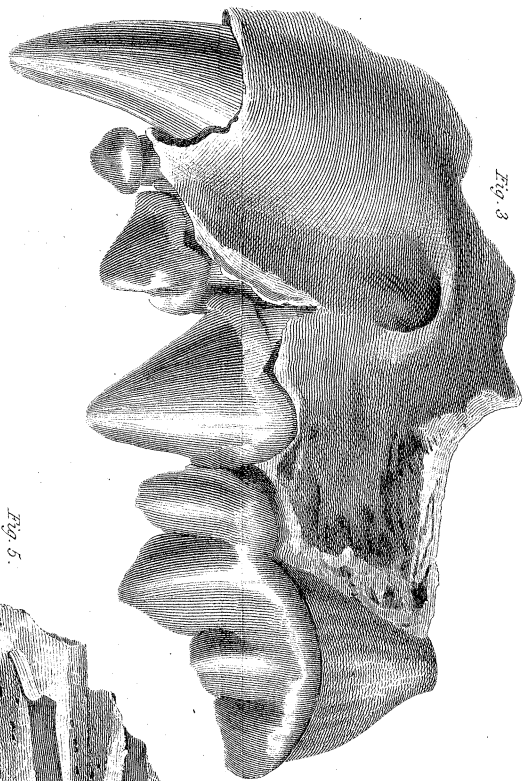
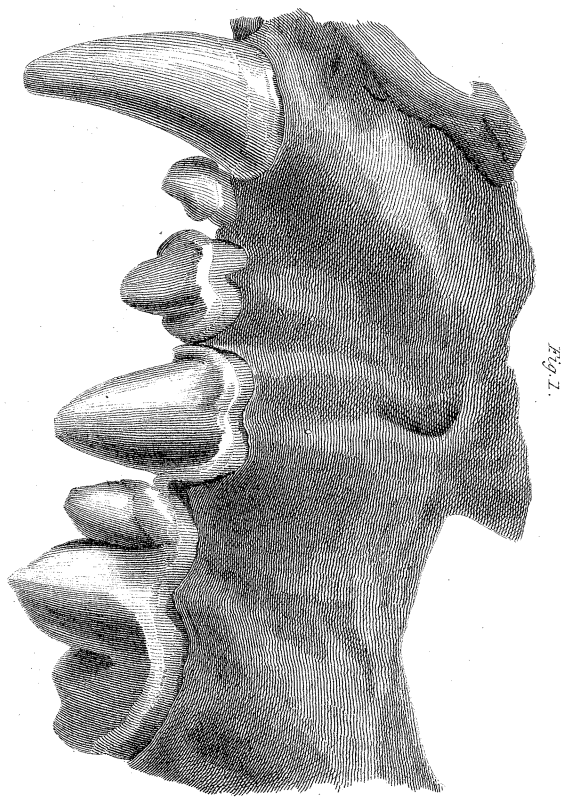
Plan of the Cave Drawn and Measured by W. Salmon Esq.
 The figures within the lines express the width of the Cave in feet and inches, those outside its height.
 Both these have been enlarged by removing Stones to obtain a Passage.

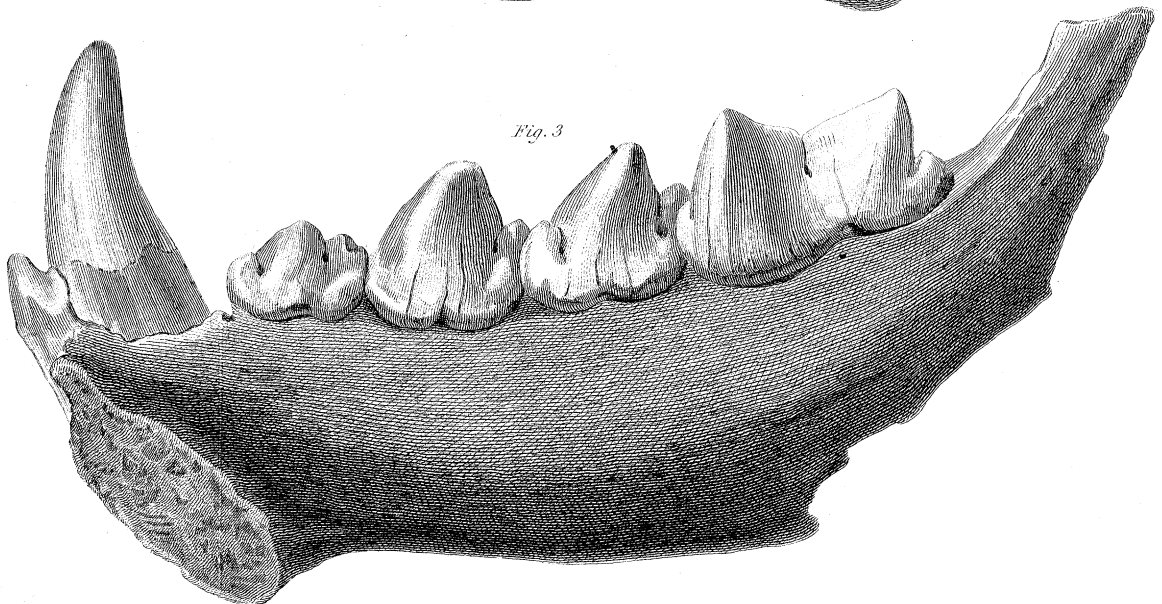
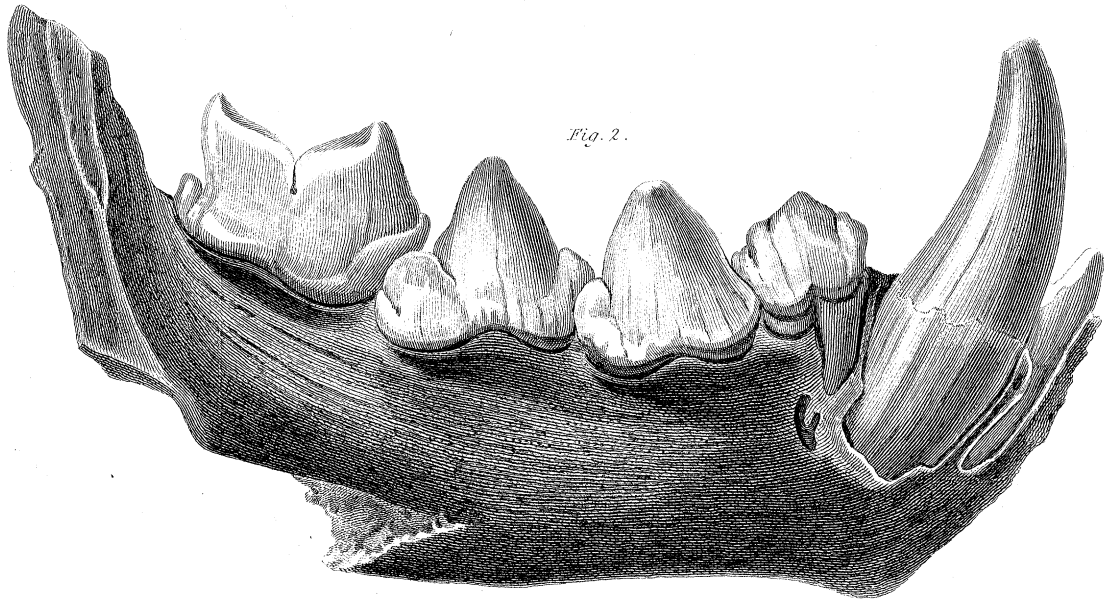
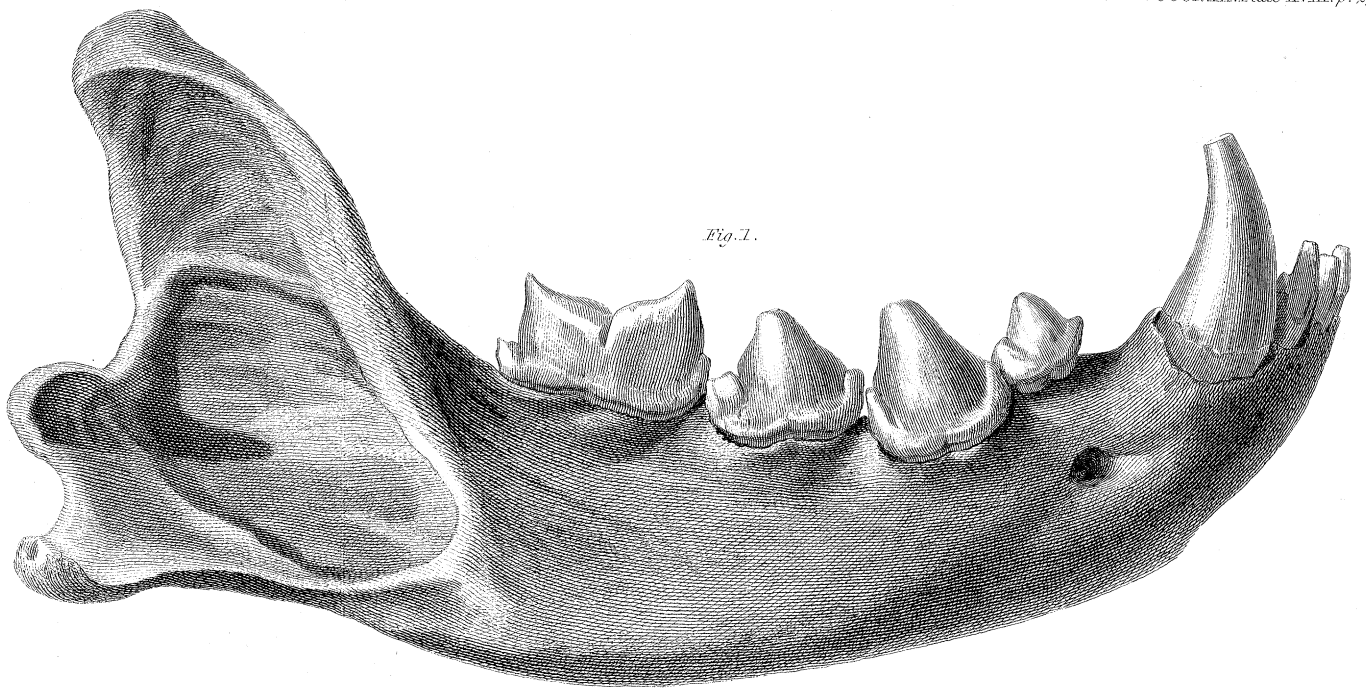
- A. Original slope of the Hill
- B. Rubbish filling the mouth of the cave
- C. Original Entrance of Solid Rock
- D. Portion of Cave destroyed by quarrying
- E. Present Entrance of Cave.



W. Duckland del.
 T. W. Peeler

J. Baird sc.





*T. Webster
W. Clift &
M. Merland } del.*

J. Basse sc.

Fig. 1.

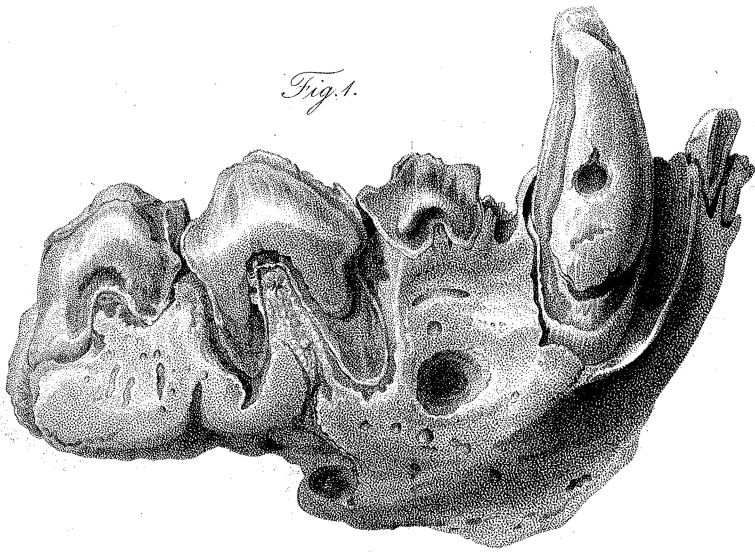


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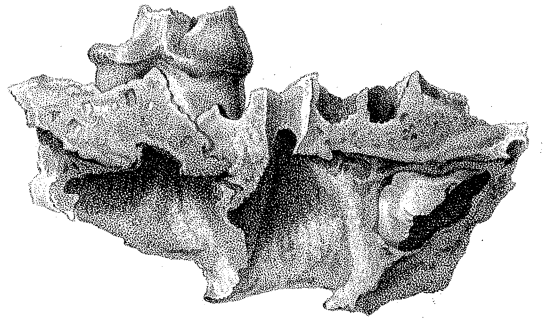


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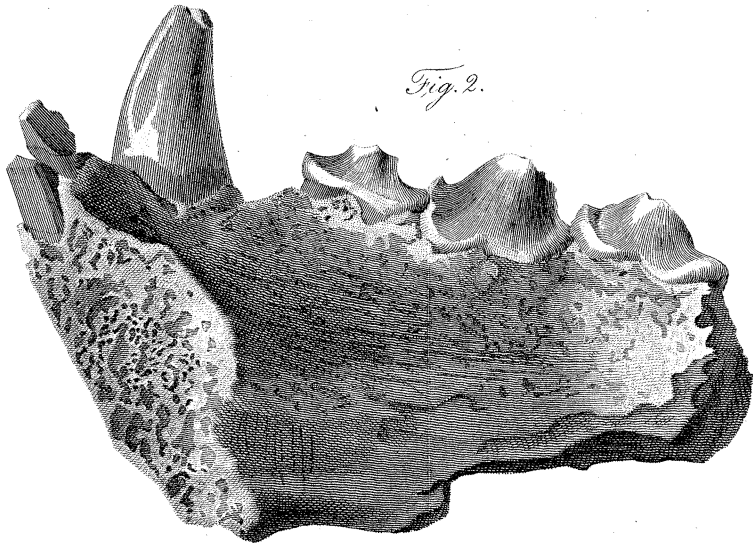


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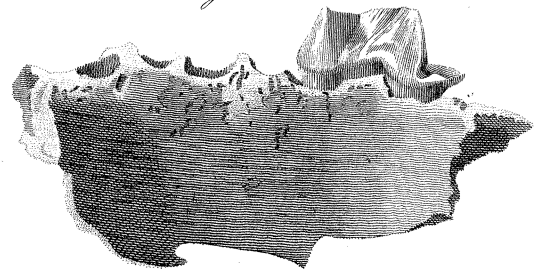


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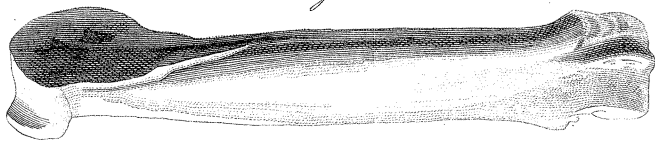


Fig. 6.



Fig. 8.



Fig. 7.



Fig. 9.

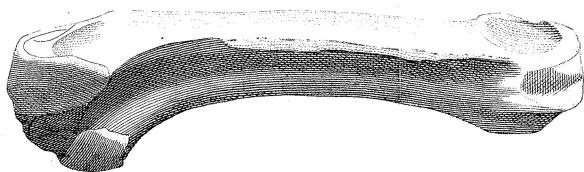


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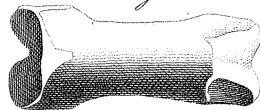


Fig. 11.



Fig. 12.



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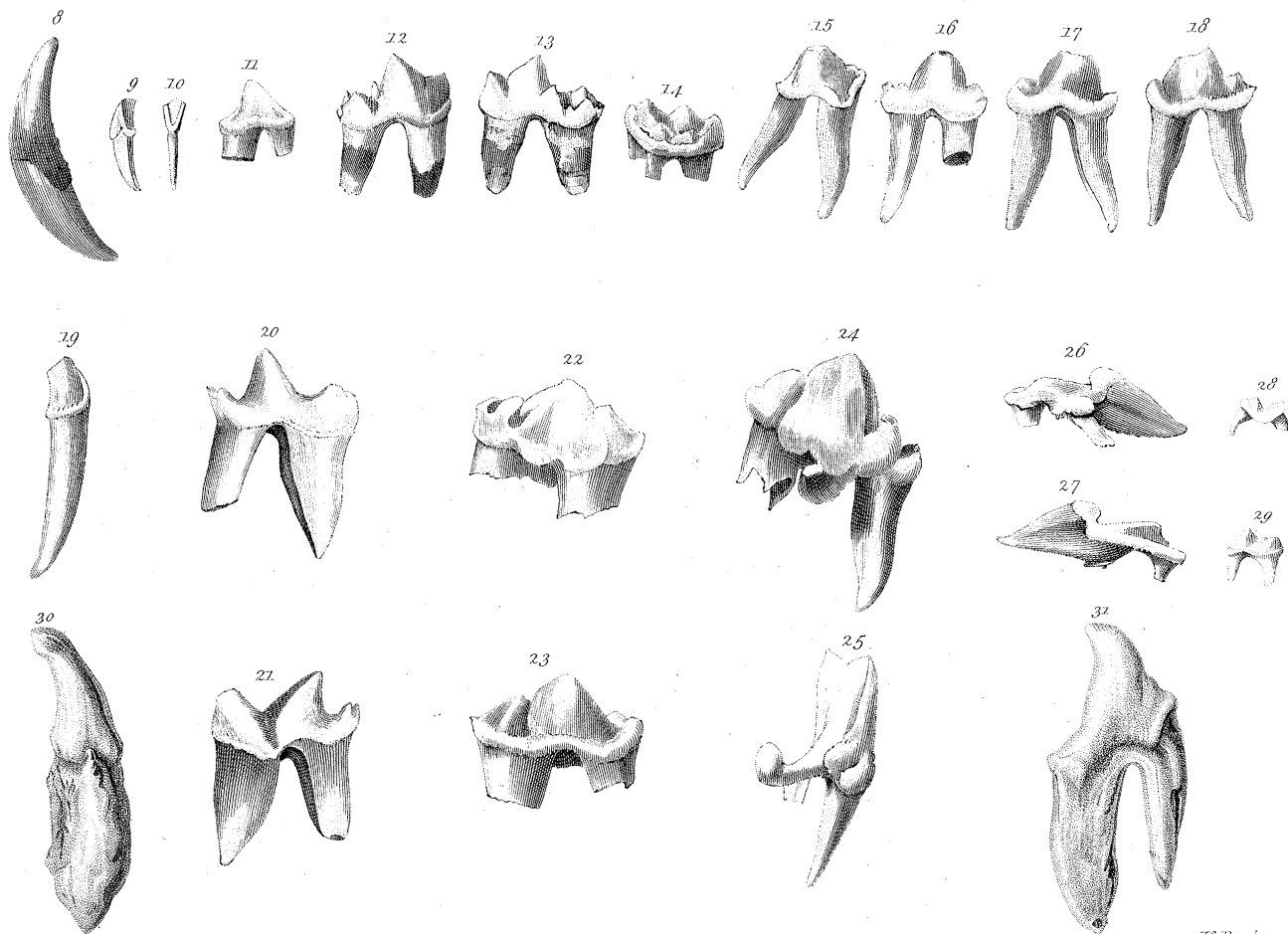
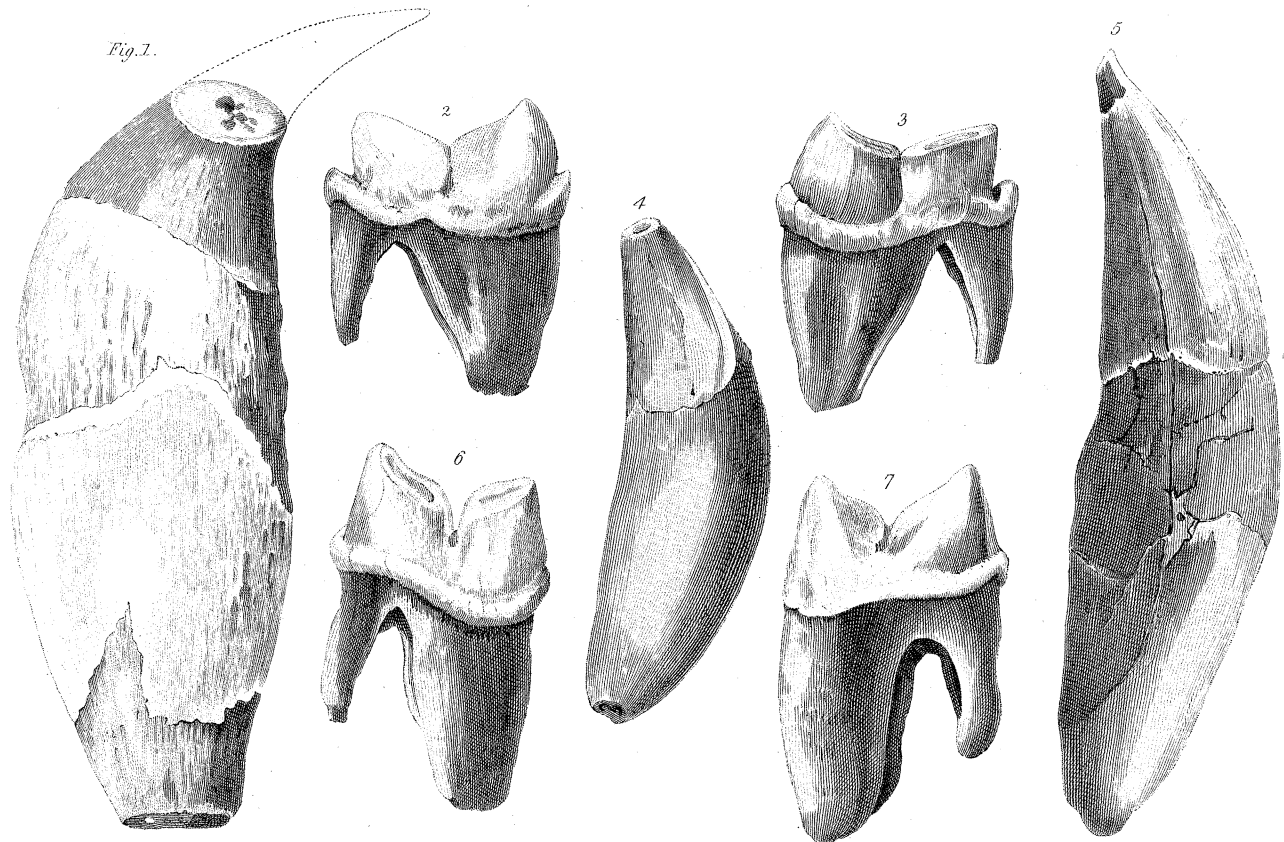


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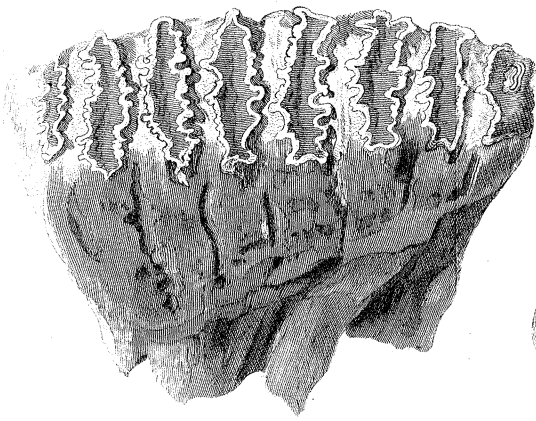


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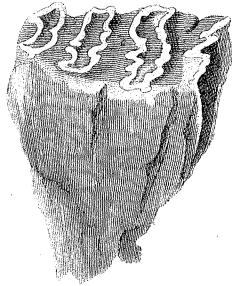


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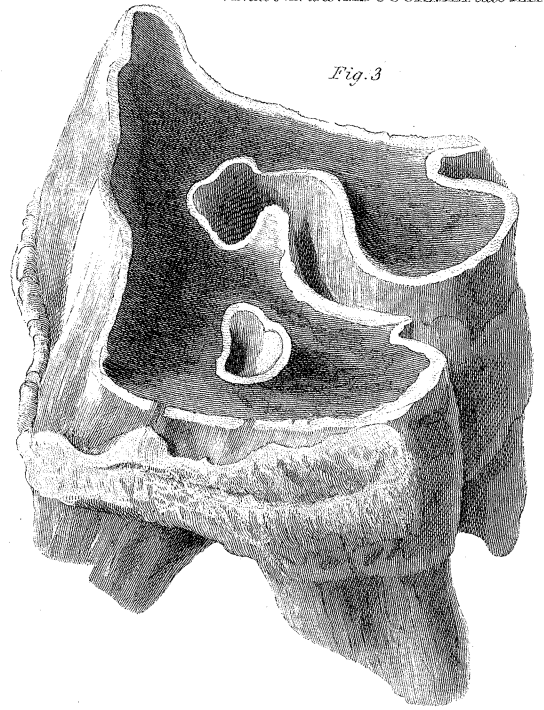


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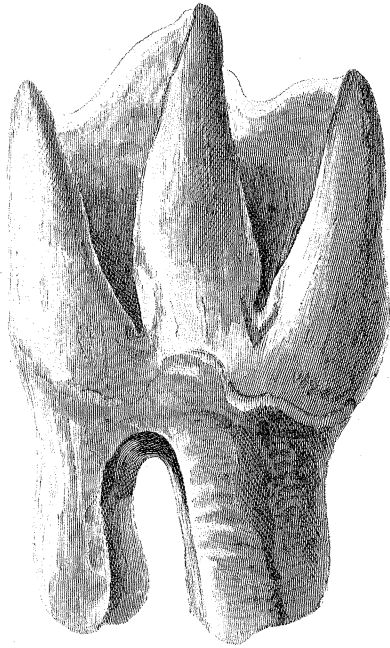


Fig. 5.



Fig. 6.

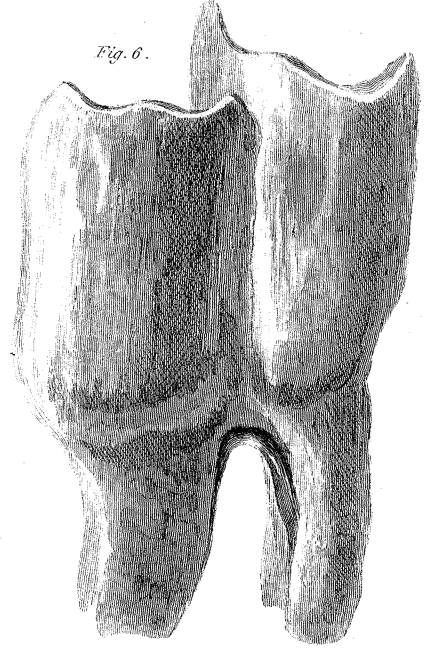


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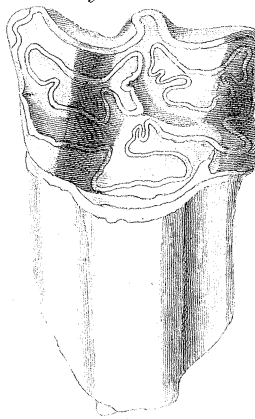


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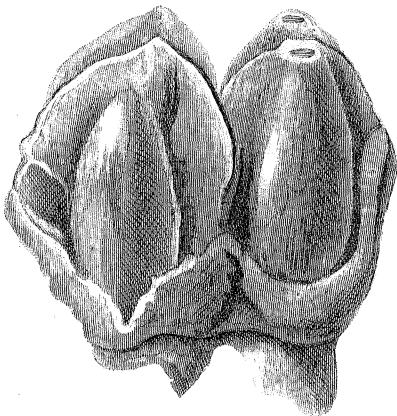


Fig. 9.



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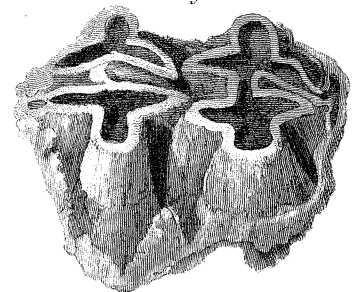


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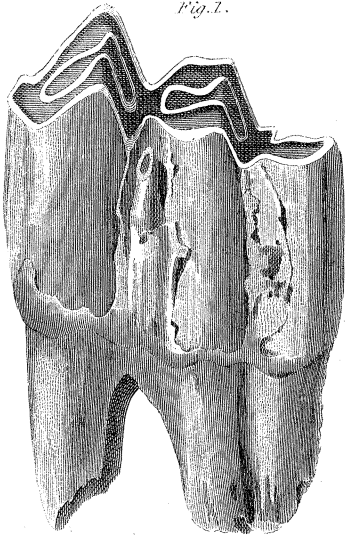


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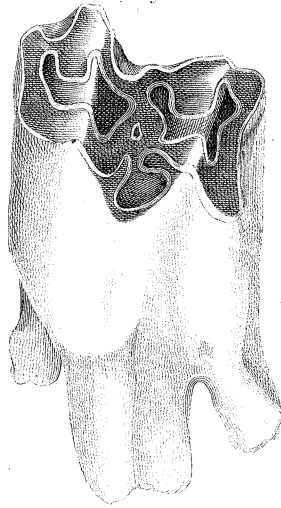


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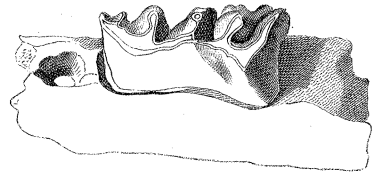


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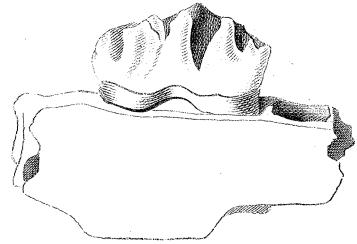


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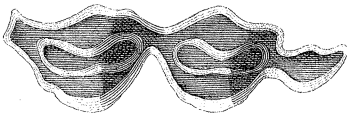


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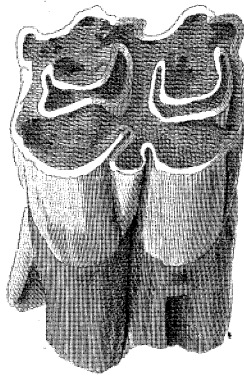


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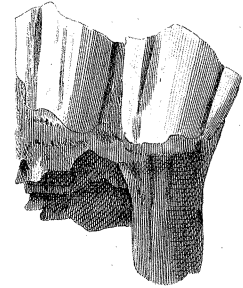


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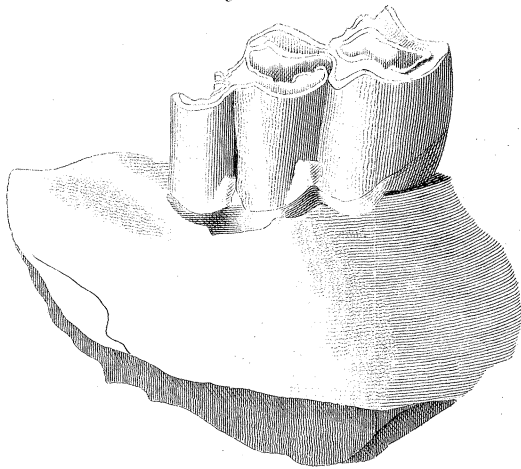


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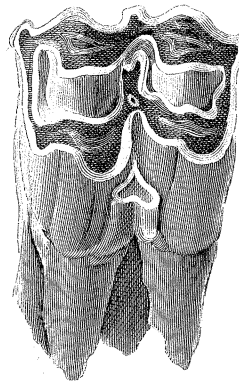


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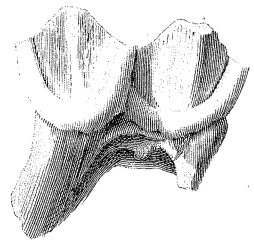


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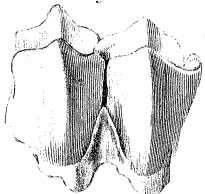


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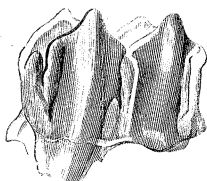


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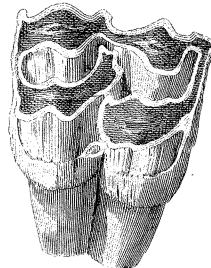


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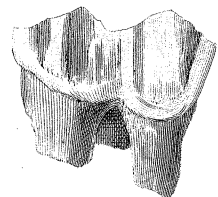


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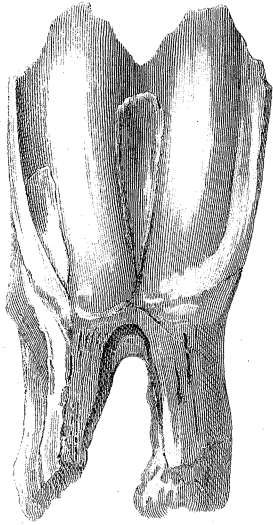


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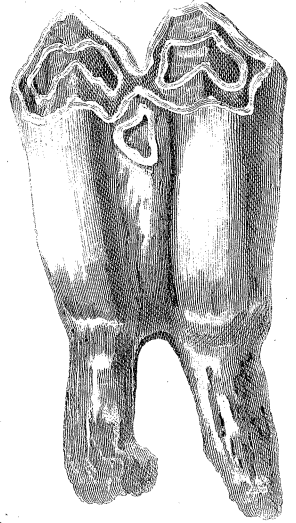


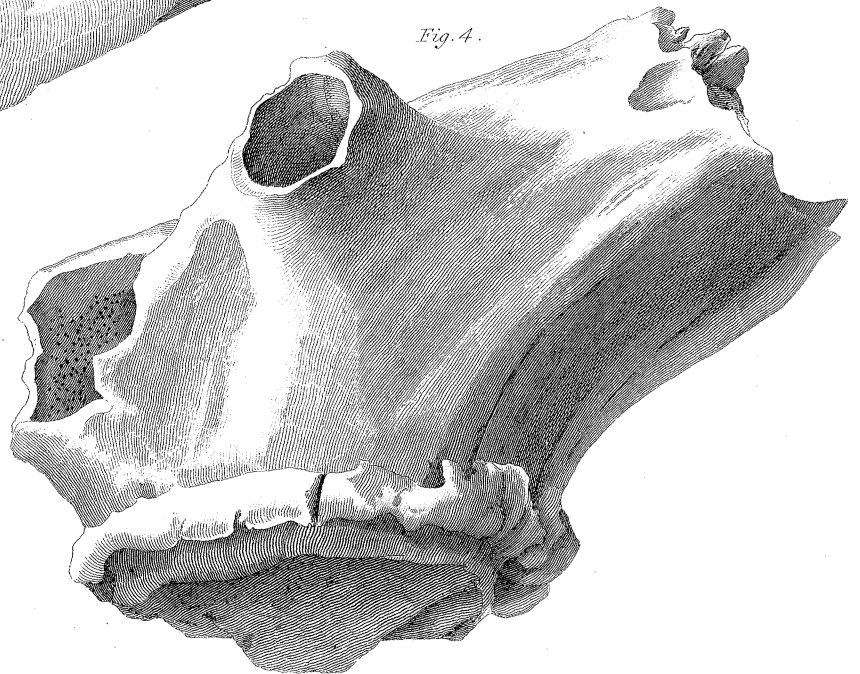
Fig. 3.



Fig. 5.



Fig. 4.



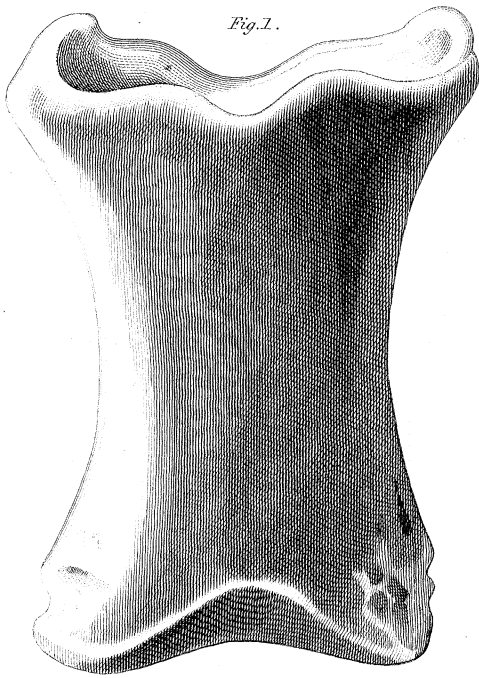


Fig. 1.



Fig. 2.



Fig. 3.

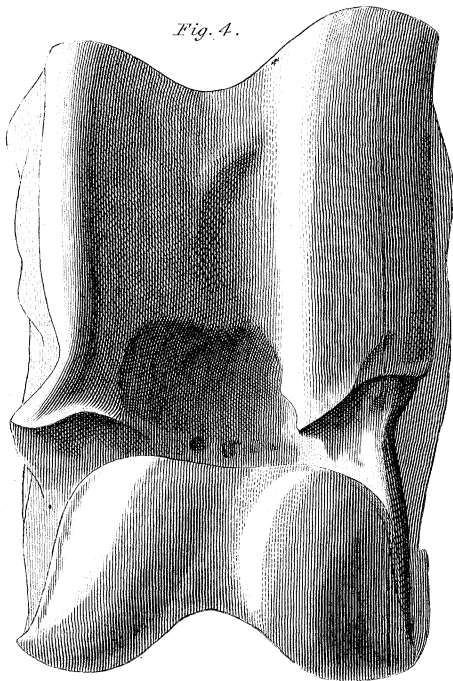


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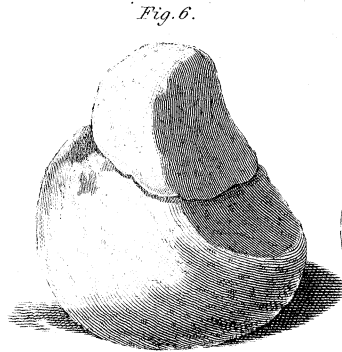


Fig. 6.



Fig. 5.

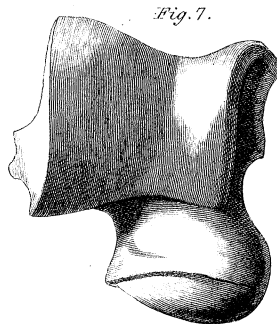


Fig. 7.



Fig. 9.



Fig. 10.



Fig. 11.



Fig. 12.

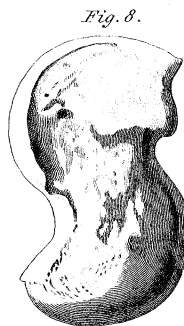


Fig. 8.



Fig. 15.



Fig. 16.



Fig. 17.



Fig. 18.

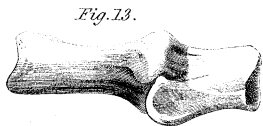


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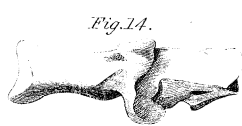
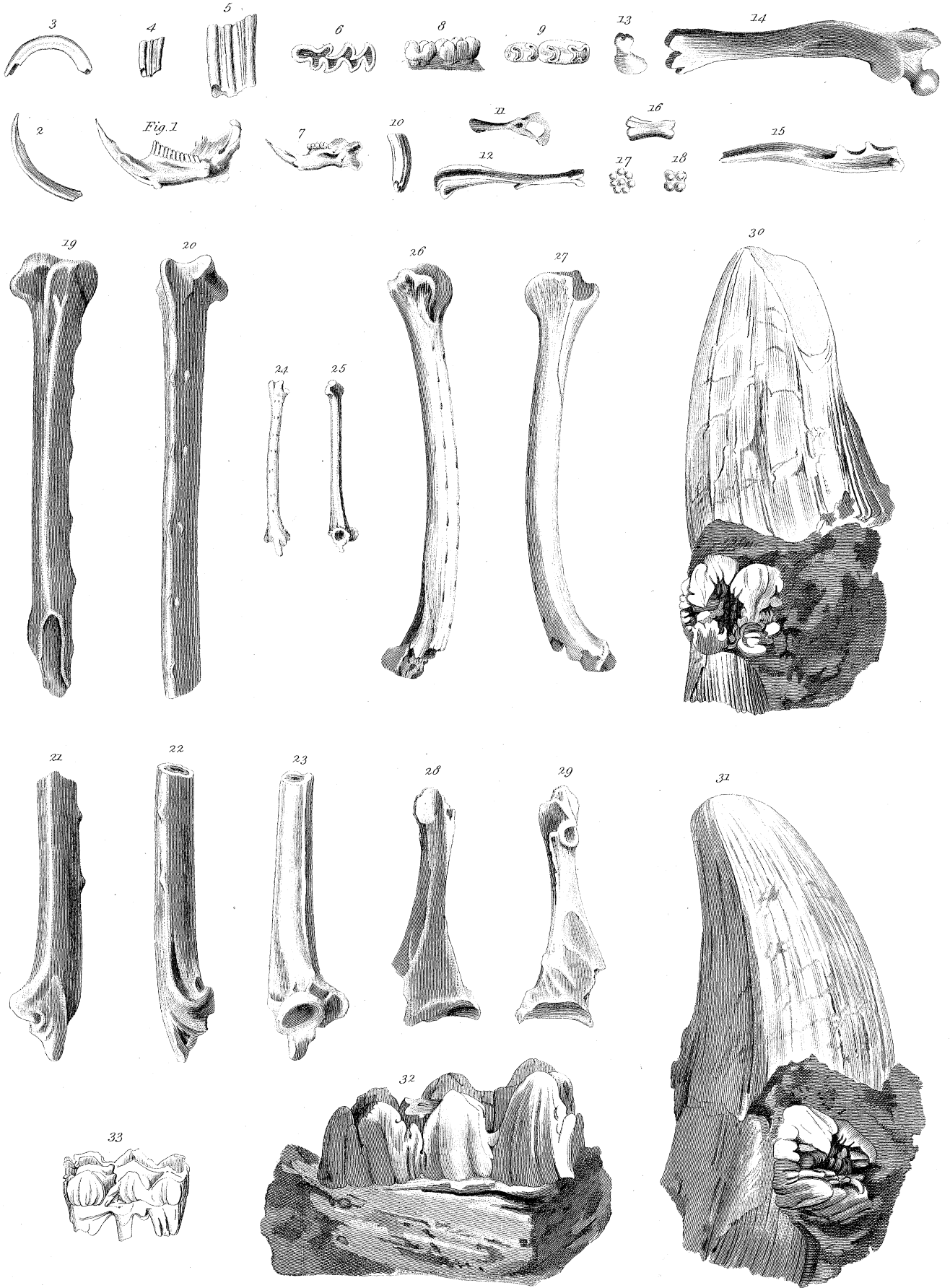


Fig. 14.



M. Morland,
 T. Webster, del.
 H. C. Neil.

J. Basire sc.



W. Buckland } del.
T. Webster }

J. Baire sc.