

traversers, and the inventor even proposes to apply it to the performance of various kinds of work on board ships.

In reply to some questions by Mr. LIDDLE, of Lindholme, Mr. BROADRICK said the hydrostatic crane was no more than the multiplying power of the engine.

Mr. LIDDLE said he thought that it might be made available, and would save much wear and tear of engines, on the works on the moors.

Mr. BROADRICK said in that case it might be useful, because when the engine was not at work they might be filling the accumulator. They would in that case diminish the first cost of the engine, but they would have the accumulator to pay for; and although that was a simple thing in itself, yet it was not economical unless there was a large use of cranes. It would reduce the cost of craning in some instances to one-half.

ON THE DISCOVERY OF HIPPOPOTAMIC AND OTHER REMAINS IN THE NEIGHBOURHOOD OF LEEDS. BY MR. H. DENNY, A.L.S., &C., LEEDS.

The superficial deposits which are so prominent in every quarter of the globe,—on the vast plains of South America, the swamps of North America, the flats and gorges of New Zealand and Australia, the ridges of the Himalayas, the shores of Siberia, the Steppes of Russia, and, lastly, on extensive districts in the British Isles,—must of necessity be invested with great interest, from the circumstance that such accumulations are the relics of the last physical changes which have taken place on the surface of the earth, and are, therefore, (geologically speaking,) of comparatively modern date, and, in some instances, probably, approaching to, if not during, historic times. These accu-

mulations, known as beds of gravel, boulder clay, &c., are of varying character and nature, and also derived from different sources. They are, further, either extensive in their distribution, or limited and local.

The Rev. Wm. Thorp, in an able paper read before this Society, has demonstrated four such gravel beds as occurring in Yorkshire, of different geological ages and derived from different sources, each possessing peculiar and well marked characters. The *first* of these, which covers vast districts in other counties, and is known as the Great Northern Drift, has transported boulders of rocks from Cumberland and Westmoreland for 110 miles, over the plains of York, from the Tees to the Humber, and up to Flamborough Head. The *second* is a range of gravel which touches the former, and varies from one to two miles in breadth, and passes down the rivers Aire and Calder, from Leeds by Ferrybridge, to Goole, consisting of pebbles derived from an entirely different series of rocks,—those of the coal formation, consisting of the carboniferous sandstone, and, occasionally, mountain and magnesian limestone, which proves the direction of the currents to have been from west to east. The *third* is a range which has an east and west course down the river Don, to the south bank of the Humber, the pebbles of which are also derived from the coal formation, but of the harder sandstone rocks of Rotherham, and the mountain limestone of Derbyshire. A *fourth* range of diluvium is that which extends from near Bawtry, to one of the highest points in Nottinghamshire, and is composed exclusively of magnesian limestone pebbles. Hence, while the former and most extensive, which consists of boulders of granite, &c., is supposed to have been the result of a great current from the north, these smaller, almost wholly composed of the rocks of the coal district or its neighbourhood, are conjectured to have been derived from the

materials of the coal field by the waters which were driven eastward during the time of emergence, and down the lines of the valleys, as the Aire, Calder, Don, &c.

Now, from the distance of transport and overwhelming force of the former, the geological date of which is known, the remains of animals and plants might be transported into regions in which they were previously unknown, and there deposited beneath vast masses of gravel and other accumulations; but in the case of the latter, which are of limited extent, this could not occur, and we may trace an interesting distinction in the state of their organic remains, inasmuch as the animals appear to have been living in the districts at the period when they were inundated by the torrents of water, alluvial mud, and gravel, in which they are entombed, and this consequently proves the aboriginal character of the quadrupeds whose remains are now found in such situations, which generally follow the course of valleys, either excavated at the period by the force of the water, or the former beds of rivers since diverted. In instances where animals not natives are transported from remote districts, their bones are scattered, fragmentary, frequently water-worn, and associated with rocks from distant localities and of varying kinds; while in cases like these, of animals submerged in their native haunts, their remains are generally in close connexion, present a very recent and unbroken appearance, and have not those distant materials buried with them which serve the purpose of medals, if I may so speak, or references to the districts from whence they were derived.

From the summary just given, and from the circumstance that my communication owes its origin to a local deposit, it will readily be perceived that the one to which I have now to call your attention is the second enumerated by Mr. Thorp, which extends down the valleys of the Aire and Calder, and, consequently, passes though Leeds and the

adjacent neighbourhood, on the S., S.W., and S.E., and whose materials have recently been so fully developed during the sewerage excavations through Kirkstall Road, Wellington Street, Wilson Street, and Hunslet Lane, on which line numerous boulders of grit stone occurred with the gravel. Here also the remains of various ruminant and pachydermous animals have been found at different periods, viz., in the last locality, several heads, horns, and bones of the Short-horned Ox; jaws, teeth, and bones of the Horse, Swine, and Goat, and a magnificent horn, three feet in length, the jaw, and metacarpal bones, of the Red Deer; the latter associated with large trunks of trees, upwards of 22 feet in length and 52 inches in circumference, which were at the depth of 20 feet from the surface. In excavating for the docks at Crown Point, the skull of the Red Deer was found 10 feet below the surface. At St. Peter's Hill and on Kirkstall Road, two horns and bones of the same animal, with hazel nuts and branches of trees, were also found 6 feet 6 inches below the surface. At the Monk Pits, when excavating for the Railway Station, numerous bones of the Short-horned Ox and Deer, human bones, and fragments of pottery, were exhumed 12 feet below the surface. In all the instances just named, the remains were in gravel, or, apparently, lacustrine deposits, and, therefore, comparatively recent, belonging to the Post-glacial period of Phillips, or that immediately succeeding the last subsidence of this portion of the British Isles,—when animals mostly resembling those of the present day were inhabitants of Yorkshire, such, for instance, as the Giant Deer, Red Deer, Fallow Deer, Short-horned Ox, Horse, Swine, Goat, &c.

At a period, however, antecedent to that just mentioned, the fauna of the Yorkshire hills and plains is generally supposed to have been of a totally different and more tropical

character, viz.,—the Pre-glacial period, when Yorkshire was inhabited by the Lion, Tiger, Hyæna, Bear, Wolf, Elephant, Rhinoceros, Hippopotamus, Giant Deer, Urus, and also other animals similar to those of the present day.

An accidental, though highly interesting discovery, however, having been recently made in the neighbourhood of Leeds, which militates against the latter supposition, or, at least, that part of it which teaches that the larger pachyderms ceased to exist with the Pre-glacial period; and as the placing on record any fact regarding the discovery in a fresh locality of remains of the former inhabitants of this island is of great importance, either in confirmation of, or disproving the accuracy of existing theories, I am induced to occupy the attention of this Society for a few minutes, in order to lay before them a short notice of the exhumation of a considerable number of bones of the Great Northern Hippopotamus in the township of Wortley, and parish of Leeds. On the 3rd of April, last year (1852), as some workmen in the employ of the Messrs. Longley, of Leeds, were digging clay for the purpose of making bricks, they discovered, at the depth of 10 feet, in a dark blue sedimentary clay, almost approaching mud, several large bones, some of which attracting their attention more than the others, were brought to me, and, from the situation in which they were found, it was highly probable that the animals to which they belonged had lived and died in the immediate vicinity, and were subsequently drifted, together with fragments of trees, to the bottom or lower part of a swamp, for not only is this particular bed of clay confined to one portion of the field, but the whole series of beds of clay become much thicker as they approach this spot, thus clearly indicating it to have been lower than the remainder. I was much surprised in observing that, although the field is very limited in extent, the variation in the strata or deposits in those parts which

can be observed is very considerable. Towards the S.E. no clay is found, the sandstone reaching the surface; but towards the centre, in a westerly direction, where the bones were deposited, in one section is a bed of clay from five to six feet thick; next a bed of grayish sand, of about two feet, which runs out a little further to the south-west to two inches in thickness; this is succeeded by a bed of yellow sand two feet thick; and fourthly, by another bed of white sand, in which are a vast number of boulders, perfectly rounded by attrition. These are, with few exceptions, all grit or sandstone, with an occasional fragment of limestone or chert. In another direction is a bed of dark red gravel; while in the particular spot where the Hippopotamic remains were deposited no sand or gravel appears, but a series of beds of clay, of variable quality, with occasionally large boulders, some of which contain impressions of *Stigmaria*, and fragments of trees, to the depth of ten feet, where it becomes valueless for the purpose of brickmaking, consisting of so large a proportion of sediment or mud, and is consequently not worked.

It is much to be regretted that the attention of the labourers was not earlier directed to the preservation of these interesting remains, of which a number had been neglected and destroyed before their curiosity was excited by the discovery of one of the massive thigh bones and the fore arm, whose unusual size, to use their own words, "made them think they could not be Christians' bones," and, therefore, to solve this important problem, they determined to bring them to the Philosophical Hall. Upon ascertaining their identity, I visited the field daily, and sometimes twice a day, and ascertained that two scapulæ, six molar teeth, three incisors, and various small bones, had been found and destroyed. I was also informed that in the adjoining brick-field, in the same bed of clay, several large bones had been

found during the previous year. Having now stimulated the men by the promise of pecuniary reward to increased care and search, in the course of a few weeks I was in possession of the other femur, the right and left humerus, the left radius and ulna, two scapulæ, the tibia and fibula, the pelvis, three specimens of the astragalus, the right os-calcis, one carpal, and five entire meta-tarsal bones, a large portion of the cranium, and part of the lower jaw, with the two straight incisors, fragments of the upper and lower jaws, with the molar teeth, together with examples of nearly all the incisive and canine tusks and teeth, two cervical, seven dorsal, and nine lumber vertebræ, the sacrum, numerous fragments of ribs, and a large quantity of fractured bones from various parts of the skeleton.

From an examination of the teeth alone, thus obtained, without taking into account those which were destroyed, (of which fact I had undoubted evidence), I found that there had been two adult individuals,* one considerably larger than the other; but whether this difference in size was owing to age, or merely a sexual distinction, I am not aware, but I presume the latter is the cause, as we always find the males provided with defensive weapons of greater magnitude than the females. That both were adult I have no doubt, and one I believe to have been a very old animal, from the surface of the molar teeth being so much worn down, as well as the extremities of the great incisors. Besides these, I found fragments of canine teeth evidently belonging to a young animal, the extremities of which are perfectly smooth and pointed; also some meta-tarsal bones and vertebræ, of which the epiphyses had been separated and lost, and also a portion of a scapula was obtained, with the

* Since this paper was read, a much larger example of the canine tusk has been found, belonging to a third and more aged individual, as also some other bones.

glenoid cavity, which, from its much smaller size, is indicative of its having belonged to a young individual.

These bones were not, as is usually the case, dispersed and fractured, but confined to the limited space of a few yards; thus affording presumptive evidence that the animals had not been drifted from a distance in detached portions and separately embedded in the sedimentary deposit; for, on the contrary, I observed that the vertebral column of one individual extended in a line across the trench, the ribs appeared to have been *in situ*, the pelvic bones and head were contiguous, as well as some of the bones of the extremities, and from their position, I should conjecture the animal to have been lying upon its side. The bones of the feet are comparatively few, and the caudal vertebræ are entirely missing. This, however, may have arisen from their size not being sufficient to attract the attention of the workmen in the first instance; and subsequently, upon re-tempering the clay, only a few meta-tarsal bones have been detected, and some of these only within the last three weeks. When it is borne in mind, however, that nearly a year and a half has elapsed since the clay was first dug, and that it has since laid exposed in the brick-yard, it is only surprising that any of the bones have been preserved to this day, to attest the fact that the Hippopotamus was once an inhabitant of the valleys and plains of the West Riding of Yorkshire.

That the extinct Hippopotamus was equal, if not superior, in size to the species now inhabiting the rivers of Africa, is evident from a comparison of some of the bones and teeth in the two species. The great median incisor, or canine tusk, found at Wortley, measures 18 inches in length by $2\frac{1}{4}$ inches in breadth; and the straight incisor of the lower jaw, 12 inches by $1\frac{3}{4}$ inches; while the former tusk in a fine recent skull of a mature animal in the Museum of the Leeds Philosophical Society, measures only 15 inches in

omit

length. The extremities of the straight incisors are very peculiar in form in the fossil species, to which I do not find any allusion by Professor Owen, in his valuable History of British Fossil Mammalia.

Besides the Hippopotamic remains, I have discovered, amongst the numerous bones obtained from the brick-field at Wortley, the following belonging to the Elephant: The glenoid cavity of the scapula, portions of the femur and tibia; the articular surfaces of the humerus and left femur; left os-calcis; part of the ischium, with the acetabulum, and fragments of the tusks; also a large portion of the jaw with teeth; a molar tooth, and fragments of the radius, &c., belonging to some large ruminant, which I believe to be the Urus, *Bos primigenius*. It is somewhat singular, however, that there is a marked difference in the state of perfection and the number of the bones of these different animals. For, while those of the Hippopotamus are the most perfect as well as most numerous, and lie in such immediate proximity as to warrant the supposition that the animals had lived on the spot or in its immediate vicinity, those of the Elephant are few, from different parts of the body, much fractured, and apparently weatherworn; and those again of the Urus still fewer in number, more broken, and in some parts rounded as if by attrition; from which fact I should infer that these latter have been washed down from the more elevated districts.

The remains of the Hippopotamus, which are by no means so common as those of the Rhinoceros, have been found in various parts of Britain, as Gloucestershire, Somersetshire, Worcestershire, Lancashire, Yorkshire, Huntingdon, Essex, Devonshire, Norfolk, and Middlesex, and in every instance in fluviatile deposits; and there is no evidence, according to Professor Owen, that it existed on our planet prior to the deposition of the *Pliocene* division of the *Tertiary* epoch. That is the last great deposit before the superficial accu-

mulations of gravel, clay, sand, &c. Associated with the remains discovered in the parish of Burfield, in Worcestershire, my friend Mr. Strickland found a number of shells, of which he determined twenty-four species (five terrestrial and nineteen fresh water); of these only three appeared to be extinct species; all the others are now existing, and indigenous to Britain, a proof sufficient, if no others could be cited, that this quadruped was associated with them in life as well as after death, and not brought from tropical regions, as also of the comparatively recent date of the animal's destruction. Sir C. Lyell, in alluding to this discovery, observes,—“The Hippopotamus is now only met with in rivers where the temperature of the water is warm and nearly uniform; but the great fossil species certainly inhabited England when the testacea of our country were nearly the same as those now existing, and when the climate cannot be supposed to have been very hot.”

In Yorkshire, the bones of the Hippopotamus have been found in only *three* localities,—in the cave at Kirkdale, near Pickering, where six molar teeth and a few fragments of incisors and canine teeth were discovered; at Overton, near York, a single molar tooth; and in the present instance, which is the first on record in the West Riding; and it is an interesting circumstance, as I have already stated, that these remains indicate the quadrupeds to have been of different ages—both mature and immature, and especially when taken in connexion with those from the Kirkdale Cave, afford presumptive evidence of the aboriginal nature of the animals, which would not have been so satisfactory if only a fragment or two of a single individual had been discovered, as these might have been drifted from a neighbouring county or distant region, which is not so probable when both old and young individuals are found associated in different parts of the same county, and under different circumstances. Dr. Buckland figures two permanent molar teeth of a young

Hippopotamus from the above cave, which had just cut the gum and had not had the fangs completed when the animal perished; which proves, as Professor Owen observes, that, like the remains of the mammoth associated with them, they were of young inexperienced individuals, that had fallen into the clutches of the co-existing predatory carnivora, which made that cave their lurking place, and perfectly coincides with the conclusions which Dr. Buckland thus enunciates,—“ That the facts developed in this charnel-house of the antediluvian forests of Yorkshire, demonstrate that there was a long succession of years in which the Elephant, Rhinoceros, and Hippopotamus had been the prey of the Hyænas, which, like themselves, inhabited England in the period immediately preceding the formation of the diluvial gravel.”

That the above-mentioned large pachyderms, and other extinct animals, were cotemporary with the Hippopotamus in England, is also a fact clearly proved, as at Brentford, in Essex, at Durdam Down, near Bristol, as well as at Kirkdale, the bones of the Elephant, Rhinoceros, Auroch, Bear, and Hyæna, were found associated with those of the Hippopotamus.

As regards the geological age of these remains, I shall venture but few remarks. It is generally supposed that the larger pachyderms, as well as the more ferocious carnivora, were inhabitants of the Yorkshire hills during the Pre-glacial period, that is, prior to the deposit of the diluvial gravel, &c., when they ceased to exist, leaving only the more peaceful and domestic animals, as the Bovine and Deer tribe, to represent its former fauna. Such is the opinion of Professors Buckland and Phillips. It appears, however, very difficult to draw a satisfactory line of demarcation between these different periods, or, more correctly speaking, perhaps, to fix the life periods of the former inhabitants of this portion of our island; inasmuch as if the Pre-glacial

and Pliocene are equivalent, then many of the large pachyderms were also existing at subsequent periods, as the Glacial, if not Post-glacial, and the evidence appears very strong in favour of the latter, for had they been destroyed by the Glacial detritus, it would naturally have consisted of boulders, &c., derived from distant regions, which is not the case. They must, consequently, have inhabited this locality after the deposit of the Great Northern drift, and been suddenly submerged by some local lacustrine flood from the Yorkshire hills, as the gravel beds and clay clearly testify, which are, as I have already stated, almost entirely derived from the rocks of the coal formation.

It is not a little remarkable that the Hippopotamus should have been the first which suggested itself as the quadruped to which several large fossil bones belonged, as early as 1669, though the difficulty then presented itself as to how an animal inhabiting the Nile should be found in Kent. Still the conclusions to which one of the early writers came were perfectly in accordance with those of the leading geologists of the present day. The Rev. J. Douglas, in a dissertation on the Antiquity of the Earth, observes,—“When we consider the great distance of the Medway from the Nile and other rivers near the tropics, where those kinds of animals are known to inhabit, and when we have no authority from the Pentateuch to conclude that any extraordinary convulsion of nature had impelled animals at that period from their native regions to countries so remote, so we have no natural inference for concluding that the deluge was the cause of this phenomenon. Taking, then, into consideration the geological features of the stratum of the river soil, and that as the Hippopotamus is known to be the inhabitant of muddy rivers like the Nile and Medway, it should, therefore, argue that this animal was the inhabitant of these regions when in a state of climature to have admitted of its existence.”

I consider that great praise is due to the Messrs. Longley for the facilities they afforded in order to rescue as perfect a collection of the bones as possible, as soon as it was ascertained they were of so interesting a nature; as, without their sanction and direct interference in causing special excavations to be made, it is most probable very few specimens would have been preserved; and thus one of the most important geological discoveries ever made in this neighbourhood would have been lost to science, and the Society's Museum deprived of the most valuable series of British Hippopotamic remains in the kingdom. I believe I am correct in this assertion; for in the British Museum the specimens are very few and unimportant. The majority therein deposited are from the magnificent collection of fossils discovered in the Sivalik Hills, in India, by Capt. Cautley and Dr. Falconer; and in provincial collections we find only a molar tooth in one, a canine tooth in another, or fragments of the jaw and teeth in a third; and although Mr. Trimmer, in describing those disinterred in the brick-field at Brentford, remarks,—“The remains of the Hippopotamus are so extremely abundant, that, in turning over an area of 120 yards in the present season (1812), parts of six tusks have been found,” yet, as he does not specify the exact kind of tusk, whether incisor or canine, or both, we cannot determine with certainty to what number of individuals these tusks may have belonged, or whether to more than one, as each animal has six larger tusks, besides others of an intermediate size; so that, in reality, only one specimen might have been deposited at Brentford, and the bones subsequently much dispersed.

From the few remarks I have thus thrown together concerning the discovery at Wortley of these mammalian relics, the importance of depositing even a single bone of an unknown animal in a public Museum will be evident, as it is by the accumulation of a mass of materials of local interest

like the above, though apparently useless in themselves, that a vast amount of information is to be derived, throwing light upon the past history of the district, which cannot be obtained from any other source;—a chronicle of events of a far distant date; a page of history, concerning which no record of man reveals a glimpse, and which, but for such medals of creation, would be wholly unknown to us or disbelieved. For to what book, but that of nature, can we turn to gain a retrospect of the past and compare it with the present state of our island, or even this county? Where can we find traces of the mighty changes to which Yorkshire has been subject, but to the evidence which geology alone supplies? Who, on looking at the busy and crowded population of some of our neighbouring towns, with the din of machinery and commerce, or the more quiet and retired villages, would see any indication of these same spots having been, at a comparatively recent period, the sites of interminable forests or swamps, tenanted by the Elephant, Rhinoceros, Hippopotamus, Auroch, Urus, Wolf, Gigantic Deer, &c., or that our more elevated limestone tracts afforded caves for the Lion, Tiger, Bear, and hordes of Hyænas, and numerous other quadrupeds no longer inhabitants of Britain? Yet such are the facts, the indisputable facts, which geology alone teaches us in such legible characters,—"That he who runs may read!"

Having alluded in the early part of this communication to the effects of currents in transporting materials to great distances, I would beg to say a word in conclusion.

As, to persons unacquainted with geological phenomena, it may appear a startling assertion to hear of large boulders travelling from Cumberland over the plains of Lancashire and Cheshire, or even to Bridgenorth, by the mere action of water, or of the continuous streams of boulders in Forfarshire, between three and four miles broad, and in a straight line for thirty miles, yet by no other agent than water has all

this been accomplished. If, however, we still want actual evidence of what a comparatively small current can produce in one hour, we have only to refer to the effects of the Holmfirth flood, in February, 1852. The materials swept from the reservoir when it burst were supposed to weigh about 50,000 tons. The reservoir was not more than a quarter of a mile in length, with a surface of eleven acres, and contained about 86,248,000 gallons of water, yet the torrent tore up the sides of the valley in some places to a depth of 10 to 20 feet, and covered the meadows with fragments of rock, sand, and gravel for a considerable distance. Amongst the comparatively small masses, however, scattered about, there were three or four blocks of stone which deserve to be recorded,—the first, a mass 7 feet in length by 5 feet in breadth and 2 feet in depth, and weighing 5 or 6 tons, was transported half-a-mile; another, 12 feet by $6\frac{1}{2}$ feet, and 2 feet deep, and weighing 7 or 8 tons; and lastly, in the middle of the valley, near Upper Digley Mill, about one-third of a mile from the parent rock, was a block 22 feet long, 6 feet broad, and $3\frac{1}{2}$ feet thick, and weighing about 20 tons. If, then, such were the effects of a temporary flood, caused by a body of water comparatively so small, and along a valley where its force could not be maintained, we may easily form some conception of the enormous power which a more continuous flood, with more sustained action, would possess. But what are all these, however large we may consider them, compared with many which are still lying on the precipitous sides of the mountains in Switzerland? One block of granite behind Neufchatel, 850 feet above the lake, measures between 50 and 60 feet in length, by 20 feet in breadth, and 40 feet in height. Another, in the Canton of Berne, measures 61,000 cubic feet. The largest boulder I have seen turned up during the recent excavations, is one lying near Larchfield Foundry, in Hunslet-lane, about a yard long and nearly two feet broad.

In order to exhibit more clearly the Bones obtained, I subjoin the following list, exclusive of numerous fragments, and also of those destroyed, which are enumerated as far as their identity could be made out in a previous page:—

GREAT NORTHERN HIPPOPOTAMUS. (*Hippopotamus Major.*)

Upper portion of the skull, with the occipital foramen.
Two portions of the upper jaw, with the molar teeth.
Portion of the lower, with molar teeth.
Symphysis of lower jaw, with straight incisors in situ.
Three of the great canine tusks of the lower jaw and fragment of a fourth.
Two of the second incisive tusks of ditto.
Three of the great canine tusks of the upper jaw.
Two of the median incisors of upper jaw.
Two of the second incisors of upper jaw.
One superior pre-molar.
Right and left scapulæ of an adult.
Glenoid cavity of an immature scapula.
Right and left humerus, with portion of a third.
Right and left radius and ulna.
Right and left femur.
Right and left patella.
Right and left tibia and fibula.
Four specimens of the astragulus.
Nearly entire pelvis.
The entire right side of the pelvis.
The ilium and portion of the os-pubis of the left side.
The right and left os-calcis.
Four of the carpal bones.
Six of the metacarpal bones.
Eight of the metatarsal bones.
One of the first phalanges.
One of the second phalanges.
Three cervical vertebræ.
Seven dorsal vertebræ.
Nine lumbar vertebræ and sacrum.
Seven ribs, and numerous fragments.

MAMMOTH OR FOSSIL ELEPHANT. (*Elephas Primigenius.*)

Glenoid cavity of the scapula.
Fragments of the femur and tibia.
Portions of the articular surfaces of femur and humerus.
Left os-calcis.
Part of the ischium, with the acetabulum.
Fragments of tusks.

URUS. (*Bos Primigenius.*)

Jaw, molar tooth, fragments of tibia, and astragulus.