

BRITISH MUSEUM EAST AFRICA EXPEDITION.

Account of the work done in 1930.

By F. W. H. MIGEOD, Leader.

THE 1930 programme was, firstly, to resume excavating at Tendaguru for a couple of months; then, when the country inland had dried up and the grass could be burnt, to prospect via Liwale along the old Kilwa to Songea road to the last-named town, and thence to Lake Nyasa. In Nyasaland the dinosaur beds on the north-west shore were to be examined for the purpose of a closer study of the relationship of the Nyasaland dinosaurs to those of Tendaguru. The expedition, which left England in March, consisted besides myself of Mr. F. R. Parrington, B.A., of the Museum of Zoology at Cambridge.

Tendaguru, 50 miles north-west from Lindi, has been the headquarters of the expedition from the first; and the particular spot that I had selected the year before for this season's work was about $2\frac{1}{2}$ miles west of north of Tendaguru Hill, and about 300 feet lower. It was near where in pre-War days the German expedition found their celebrated *Kentrurosaurus*, a spiked dinosaur allied to *Stegosaurus*. A piece of ground of about a quarter of a mile each way at the foot of the scarp was intensively examined, and in a short time M 23 became the designation of the site of a dinosaur of the *Brachiosaurus* type.

M 23; General position.

The position of M 23 was between two marine beds, the upper known as the *Trigonia smeei* zone, the lower about a hundred feet below it as the *Nerinea* zone. In altitude M 23 was considerably nearer the upper marine bed than the lower.

The rock on which lay the skeleton was a grey clay like the Kimmeridge and containing boulders of the same material. Above were alternating red and grey clays in thin layers. When viewed in a vertical wall these layers were in a waving line. A fault was visible. It crossed the ground a little below the ventral side of the skeleton.

Immediately below the upper marine bed was a thick bed of brown clay like that at the upper "Ng" digging, and also apparently without fossils. In one place on the east side was a little green clay with small chalk pockets in it. This was lying on the Kimmeridge.

It might be assumed that the carcase came to rest in the

backwater of a river. Some of it sank into the mud, and the upper part was gradually and somewhat rapidly buried by currents of water bearing alternately red and grey clay. It might be assumed that the "Kimmeridge" clay had been partly exposed when this dinosaur of presumably Jurassic age

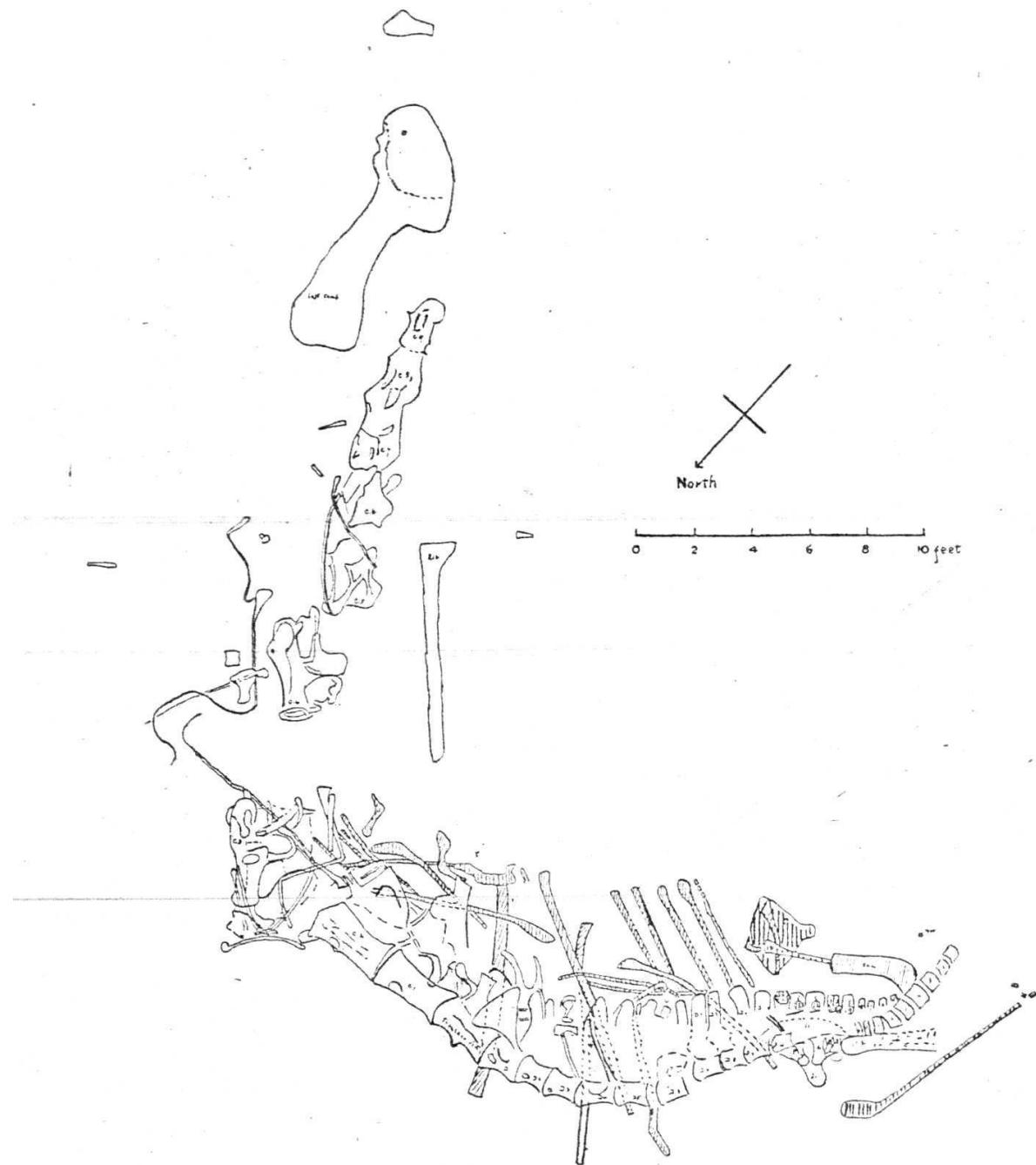


FIG. 1.—M 23, GROUND PLAN.

came to rest finally on it, and the surface was swept by currents of water bearing alternately scoured out Kimmeridge and the brown clay above it.

All parts of the skeleton were not equally well preserved. The roots of present-day trees had done some damage, principally at the sacral region. In one place there was a damp layer, so

that while the highest and the lowest bones were hard, the intermediate section was powdery. Further, there was a strong and corroding impregnation of iron here and there, which had done considerable damage.

Marine beds.

A few notes must be made on the two marine beds mentioned. There is a low scarp not more than 50 feet high at its edge about a hundred yards from M 23. At its top is the end of the *Trigonia smeei* marine bed. The total thickness of the bed cannot be estimated from its terminal exposure, as it is already thinned down. Here its thickness is about 20 feet. Possibly its greatest thickness anywhere is about 50 feet. Among invertebrates found on or near its edge, where some cutting in was done, were *Trigonia smeei*, *Ostrea* sp., *Placunopsis* sp., *Lima* sp., *Lithophaga* sp., also some *Nautilus* and crinoid fragments, the last only found on the surface. The topmost part of this bed is sandstone. The bottom rests on the brown clay above mentioned at M 23. The height above sea-level of the edge of this bed is between 520 and 500 feet.

The lower marine bed, 400 to 300 feet, known as the *Nerinea* zone, can be viewed well less than a mile from the upper bed. This was about the distance at which I studied it, but there must be nearer exposures. There are several steep gullies where the whole of the marine bed can be viewed almost vertically for a height of ninety feet or so. The sequence of invertebrates found in the Kindope lower marine bed, the *Nerinea* zone of the Germans, is as follows* :—

<i>Belemnopsis</i> sp., scattered, from 370 ft. down.			
<i>Ostrea</i> (<i>Lopha</i>) cf. <i>marshii</i> , J. de C. Sowerby, surface.			
<i>Nautilus sattleri</i> , Krenkel, 350 ft.			
<i>Aulacosphinctoides</i> sp., 340 feet.			
<i>Trigonia smeei</i> , J. de C. Sowerby, 340 feet.			
<i>Gervillia</i> cf. <i>aviculoides</i> , J. de C. Sowerby, about 340 feet.			
<i>Pteria tschingira</i> (Krenkel)	"	"	"
<i>Syncyclonema</i> cf. <i>solida</i> (Roemer)	"	"	"
<i>Lima</i> cf. <i>monsbeliardensis</i> , Contejean	"	"	"
<i>Lima</i> sp. of group of <i>L. duplicata</i> , Deshayes	"	"	"
<i>Protocardia</i> sp.	"	"	"
<i>Pinna</i> cf. <i>suprajurensis</i> d'Orbigny, 330 feet.			
<i>Nerinella credneri</i> (Müller) 320 feet.			
<i>Pinna</i> (<i>Trichites</i>) g.-mülleri, Krenkel, 300 feet.			

Some fossil wood was found at 320 feet, and part of the pubis of a big dinosaur embedded in sandstone lay low down a gully, but it was not possible to find its original position.

* The identification of the Ammonites is by Dr. L. F. Spath, of the others by Mr. L. R. Cox.

In M 23 no derived invertebrates were found, nor any in position.

Before giving some notes on the measurements of the bones, a description must be given of the general appearance of this dinosaur, together with a reproduction of the ground plan. It may be assumed that it was giraffe-like in shape, but of course on a far bigger scale, and its hide would have been like a lizard's. Of this no impress was found in the clay. Presumably the creature was cold-blooded, though whether the dinosaurs were actually so is a point that has been debated. At the shoulder it must have stood 18 feet in height with its head on a long flexible neck towering 25 feet higher. At its hind-quarters it was probably not more than 12 feet high.

The neck was deep rather than broad, and the vertebræ found give a 20-foot length. The lower ones, however, would have been in a sloping rather than an erect position. To this the four, or perhaps five missing vertebræ near the head would have added well over five feet more.

Of the skull no fragments have so far been identified, and this, the most interesting part of the body, as is so commonly the case with the dinosaurs, is lost. A large tooth was, however, found, measuring $6\frac{1}{2}$ inches in length with a maximum circumference of $5\frac{3}{4}$ inches, which would indicate that the head was large. This tooth, which is pointed, has a slightly serrated inner edge. Two other teeth, small ones, were also found in different places. Their dissimilarity in size would not be unusual if this dinosaur were a theropod, a flesh-eater, for this type had teeth of very varying sizes; but it is rather disconcerting in this case, the presumption being that the dinosaur was a sauropod, a vegetation-eater. It is therefore open to suspicion that the big tooth may be an intrusion.

The length of the back including the sacral region was about 15 feet. The eight or nine caudal vertebræ cover about 6 feet. From their size it may be assumed that the length of the tail cannot have been less than 20 feet, and much more if a whiplash end existed, a point that is examined later.

This specimen, therefore, from nose to tip of tail may well have been over 70 feet in length.

The cervical vertebræ.

Comparing the cervical vertebræ of M 23 with those of the well-known skeleton of *Diplodocus*, the vertebræ of the latter seem quite dwarfed.

The first cervical (C 1) is 33 inches long, compared with about two feet in *Diplodocus*, and on it and running its full length, and connecting with preceding and succeeding vertebræ, is a great superstructure. This, built up of "girders," plates and "buttresses," a construction found, of course, in the other cervicals as well, is of great intricacy, and though the whole as a living structure would have been of great strength, each part is delicate, and all the more so in its present-day condition. This superstructure was 44 inches high in C 1. This vertebra was firmly adhering to the succeeding "shoulder" vertebra, and to C 2, and could not be separated without cutting.

The neck had a break at C 2, the main part of the vertebra being left adhering to C 1, but drooping considerably, and the smaller part was fixed to C 3, which was twisted round to the right and depressed into a hole. The break was sharp and the gap left measured about a foot. C 3 was turned almost at a right angle to the main line of the backbone, and separated by a gap from the next anterior vertebra. This was the longest cervical, measuring 41 inches. Its great superstructure, in which appeared large sheets of the thinnest bone, was of a crumbly nature and could only be got out in pieces. The more solid portions also had to be plastered separately. Several processes on the under side as it lay on the ground were very friable.

After C 3 the vertebræ rapidly dwindle in size. C 4, 5, and 6 were separated by short intervals, but 7, 8, and 9 were adhering to one another. All of these were in very good condition, and were plastered separately without cutting to reduce size. C 4 was 39 inches by 23 high, and about a foot in thickness. The interior of the centra, as with the dorsal centra, are of a light cellular nature, the hollows being filled with the varying clays of the upper stratum which permeated into it.

Numerous short neck ribs were lying near the lower cervicals. In addition was the interesting preservation of a number of tendons of great length. One of them extending backwards from C 5 measures $97\frac{1}{2}$ inches, and is completely ossified and fossilized. It is about an eighth of an inch in diameter throughout its entire length, but has an elongated triangular head 10 inches long and with a terminal width of 6 inches.

Dorsal vertebræ.

It was difficult to number the dorsal vertebræ, Nos. 1 to 11 from the sacrum, for the reason that there was considerable damage in that region, and it was impossible at an early stage

in the excavation to decide which was the first dorsal vertebra from the tail end. In the circumstances the "shoulder" vertebra was taken as the zero, the next to it on either side being C 1 or D 1. In this skeleton the "shoulder" vertebra was readily distinguishable. Its length was 24 inches, and so shorter than the next cervicals, but very much longer than the first true dorsal.

Owing to this reptile's enormous neck and shoulder development, and to its tapering away behind like a giraffe, the dorsal vertebræ are remarkably small as regards their centra for such a big dinosaur. Dinosaurs of the *Brontosaurus* type, on the contrary, have dorsal vertebræ with very large centra. What, however, is lacking in the centra is made up for as regards the more anterior vertebræ by the neural arch and spines.

The length of some of the dorsals is as follows :—Shoulder 23 inches; D 1, 14 inches; D 2, 11 inches; D 3, $10\frac{1}{2}$ inches; D 5, 11 inches; D 10, 9 inches; the others being about the same. The evolution of the ventral surface groove running through all the cervicals is thus shown in the dorsals. On D 4 there is no indication of it. On the next one, D 3, there are signs of flattening on the lower face of the centrum. D 2 has a distinct hollow at the anterior end. D 1 has a bigger groove at the anterior end. In the shoulder vertebra the groove runs the full length of the lower surface, and in cervical 1 the deep trough is fully developed. There is a solid process or butt at the anterior end of the centrum. This is its development as observed on the left side: D 4 nil; D 3 slight; D 2 larger; D 1 larger still; shoulder vertebra, very large and on the edge of the groove. In C 1 it was flattened out and nearly gone; and in C 2 transformed.

All the dorsal centra, which are opisthocelous, were with one exception adhering very firmly to each other, especially the more anterior ones, so that some of them could only be separated by cutting, the rather elongated convex fore-end holding firmly into the posterior hollow of the preceding vertebra. The exception was a break between D 6 and D 7. The centrum of D 6 was in two parts, and whether there was a centrum that had slipped down here I was unable to determine while the vertebral column was *in situ*, when it was necessary for reference purposes that all the vertebræ should be numbered. After extracting D 7, however, together with D 8 (which were plastered together so that there might be no disturbance of the interlocking neural arches) there was found below D 6 part of a centrum not in the line of the other centra, but pushed up under the neural arches. It lay with its concave end correctly turned posteriorly. In all

—probability it belongs to the skeleton and will thus add one more vertebra to the back. The additional number of neural spines rather supports this view, as there are more than can normally be assigned to their proper centra.

On coming to the sacrum, D 11 is doubtfully claimed as a dorsal vertebra, when perhaps it is a sacral vertebra. The sacral region was badly crushed, and a re-examination of the material is necessary.

The centra, though solid to outward appearance, were of very thin cellular structure inside, and filled with the grey and red clays in which the greater part of the vertebral column lay.

With regard to the neural spines: the anterior dorsal vertebræ apparently had their neural spines in two parts, which led me at first to the opinion that this dinosaur was a *Dicraeosaurus*. This view proved on further excavation to be untenable, and indeed the bifurcate spines were similar to neither species of *Dicraeosaurus* found at Tendaguru by the Germans. Owing to the skeleton being on its right side the spines were pressed together, and only in the case of one dorsal, No. 4, and doubtfully D 3, could it be seen, as they lay in the ground, that the bifurcate spines stood in the living animal side by side. D 5, for instance, had two knob-ended spines lying side by side and in the fore-and-aft line. These might have been displaced. Ends of all the anterior spines were knob-like rather than of an oval section, while those from about D 10, the sacral ones, and those of the tail were as usual flattened. D 10 first indicated a distinctly circular section. There are more of these flattened spines than would furnish one for each centrum, and their allocation requires further study of the material. Already in D 10 the length of the neural spine was considerable. From Nos. 5 to 1 all the neural spines and processes are inclined forward, indicating a rise of the anterior part of the body. Of the two neural spines of D 4, which lay in the ground one over the other, and so were in their correct position, the upper one, *i.e.* the left, connected with D 5 and the under one with D 3.

In D 4 to D 1 a new development occurs. That is, the spines have great "wings" consisting of thin bone with thicker edges, and running to some two feet in diameter. They were in position on the lower side of the vertebra, but I was unable to decide whether there were two, the upper one having broken away, or whether the wing was a single one and standing somewhat like a sail. Why I was doubtful was because there lay partly on D 1 and partly on the shoulder vertebra a triangular flat bone of much the same shape, and I could not determine

whether it was a broken-down wing, or whether it was the head of one of the larger ribs. I was indisposed to disturb it, and it was plastered in position.

The following are the lengths of some of the spines of the dorsal vertebræ measured from the middle of the centrum on the ventral side. D 3, 39 inches; D 5, 38 inches; D 9, 34 inches; shoulder vertebra, 39 inches.

Tail.

Only a part of the tail was recovered. This was the proximal end, with one or two other stray vertebræ. There were eight caudal vertebræ in their proper position. They were amphicœlous, but inclining to have deeper cavities on the anterior surface. The upper, that is, the left-side surfaces were much worn down, especially as they neared the sacrum, where only about half of each vertebra was left intact. The neural spines were rectangular and generally good. It was difficult to decide whether the nearest vertebra was caudal or sacral, but it was probably the former, and so would raise the number of caudals in line to nine.

In addition to the part of the tail lying in line, a small vertebra 2 to 3 inches long was found near the humeri, and later still another only $13/16$ ths of an inch long in the tail region, but about 8 feet down. This last, if belonging to the same skeleton, and there is no great reason to presume otherwise in view of the depth at which the ribs and other bones were found, might indicate a whiplash end to the tail, a feature that would add very materially to the total length of the skeleton.

— Another equally small vertebra was found above the general level of the skeleton just beyond the humeri. Its association with the skeleton is therefore doubtful.

Limb bones and shoulder girdle.

Of the fore limbs there were found the scapula lying in the line of the neck and at its extreme end the two humeri. Of the lower limbs only the doubtful head of a radius was found.

The scapula was the left one, and though of great size was a very thin bone. The coracoid was completely fused with it. The total length was 87 inches measured on the curve; the arm and shaft were 26 inches across, and the end which was splayed was 27 inches across. Of the right scapula there was no trace.

The two humeri lay about 9 feet distant from their normal position. They measured $57\frac{1}{2}$ inches long and 20 inches wide,

and whilst one was sound, half of the other powdered away. These two were on the same level as the very highest part of the backbone. Though somewhat small for such a skeleton, from their position it was not possible seriously to doubt their association, until, just before closing down finally at the end of the season, another scapula was found close by and at a slightly higher level still. This measured 48 inches by 18 inches wide, but the edges and ends were worn off, and even allowing for this loss it cannot be regarded as the pair of the other scapula. Its proximity, therefore, to the humeri might almost seem to throw doubt on the two latter, a point that can only be settled when the bones are prepared and the articulations studied. In addition, it is possible that some uncertain fragments may be part of a sternum.

Of the hind limbs, one femur was found, measuring about 4 feet. Being in bad condition its exact length could not be ascertained. It lay some 3 feet below the pelvis. Of the other femur only parts were recovered. The tibiae and fibulae were not recognizable, nor was any part of the feet found, except a calcaneum.

Sacral region and pelvic girdle.

This part of the body, which was the first discovered, lay nearer the surface than any other part of the vertebral column, and had therefore suffered most damage.

The only bone recognizable in the first instance was an ischium of large size, but broken into segments of an inch or two each way. The joining up of these pieces occupied a considerable time. Only parts of a pubis were found: they were the ends, and were 10 and $8\frac{1}{2}$ inches wide respectively. Of the other ischium and pubis only uncertain fragments were found.

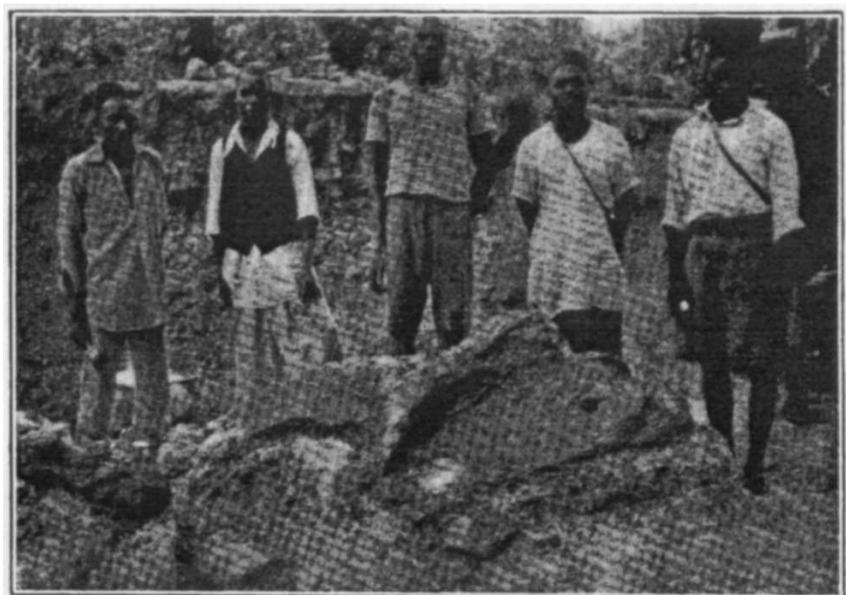


FIG. 2.—M 23, BIG SCAPULA.

After the sacral vertebræ had been extracted the right ilium was found lying underneath and in excellent condition. It measured $38\frac{1}{2}$ by 31 inches, and was distinctly the type of ilium of a Sauropod, more particularly of *Apatosaurus* (or *Brontosaurus*). Before this ilium was uncovered a flat bone had been found lying just below and in close proximity to the sacral area. It measured $26\frac{1}{2}$ by 25 inches before plastering, and was assumed to be one of the ilia. The discovery later of the real ilium made a revision of the identification of the other desirable, but it had already been plastered and packed.

The sacral vertebræ seem to be five in number, but there is a sixth of doubtful classification. The lower-lying processes were more or less in position and in good condition, but the left-side ones were fragmentary or lost.

Ribs.

The excavation had been carried on for some time and but few ribs were noticeable. This was puzzling, as pieces of rib are generally common in all excavations. The skeleton being on its right side, the dispersal of the left ones was not unnatural, and some were recovered later. Why none of the right ribs was found at first was because they were deep in the ground. As soon as one of them was discovered all the rest were found close by and lying more or less in their correct positions, the whole flank of the reptile having evidently come away in one piece. The heads of the ribs became detached from the vertebræ, but apart from that there was no shifting of position, and the side of the dinosaur complete, held together by the then undecayed skin, was pressed down in the mud by the weight of the body. The depth in the mud of the foremost big rib was 4 feet, and others averaged $3\frac{1}{2}$ feet below the spinal column. This gives some clue to the thickness of the body, making it between 7 and 8 feet broad at the breast. One of the heaviest ribs measured 82 inches, but a thinner one was as much as $92\frac{1}{2}$ inches long. The former had a slightly triangular section, and the majority of the thinner ribs an oval section, but one big rib under the fore-part was very flat and was about 6 inches wide.

It was scarcely to be expected that all parts of the skeleton should be equally well preserved. The roots of trees do most damage. In one place there was a damp layer, so that whilst the uppermost and the lowest bones were hard, the intermediary bones were powdery. Further, there was a strong and corroding impregnation of iron here and there, which had done considerable damage. One region in particular I should like to have found

perfect was the base of the spine. Here is lodged the larger of the two brains which most dinosaurs possessed. One can speculate freely on the relative functions of these two masses of nervous matter. If the head brain, which may be less than a quarter of the size of the posterior brain, merely served for vision, hearing and scent, etc., one can imagine it, on coming to something new, telephoning to the base to ask for instructions, failure immediately to respond being likely to cause disaster. Still, speculation and imagination have many pitfalls. When one part of mankind cannot grasp the mentality of another part, to grasp that of a dinosaur sixty million years ago is not less difficult.

TENDAGURU.

Feet above sea level.	Vertical plan of diggings, etc.	
800 (about). Top Tendaguru Hill. Marine Bed, <i>Trigonia schwarzi</i> zone.		
747. Tendaguru House datum point. (Former estimate 827 ft., less 80 ft. correction, = 747.)		
700. —		
675. M 4, M 8, M 18 (about).		
670 to 665. Ng. marine bed. Belemnites.		
665. M 3 (sand), M 3a (sand). Bone-store.		
660. M 7 (plants).		
645. Ng. upper.		
635. M 1 (laminated grey grit on sand).		
630. M 9, M 11.		
620. M 6, M 21 (about). Both containing derived belemnites. Ng. lower.		
610. M 10.		
605. M 19.		
600. —		
580. M 20.		
565. M 2 (sand, sandstone).		
555. M 5 (contorted coloured clays).		
550. Kingutinguti waterhole in ravine.		
520. Upper Kindope marine bed at edge of scarp (<i>Trigonia smeei</i> zone). Crinoids, <i>Trigonia</i> , <i>Nautilus</i> .		
500. Bottom of Upper Kindope marine bed. Brown clay begins.		
472. M 23. On "Kimmeridge" clay. Above, alternate thin streaks red and grey clay. No invertebrates.		
400. Sandstone. Top of lower Kindope marine bed (<i>Nerinea</i> zone). Zone contains <i>Trigonia</i> , <i>Belemnites</i> , <i>Ammonites</i> , <i>Nerinella</i> , Fossil wood, etc.		
300. Bottom valley, and about bottom of marine bed.		
0. Sea level.		

? Same marine bed.
Existence only traceable between Ng. and Kindope by occasional derived invertebrates. Dip about 1 in 140.

Notes.—(1) Heights assessed by aneroid.

Estimates given in earlier printed papers now revised.

- (2) The relative position of M 4 and M 8, etc. in regard to Ng. Marine Bed requires accurate levelling.
- (3) Invertebrates mentioned are this year's finds.

Towards the end of August work had to cease at Tendaguru to enable the Nyasaland part of the programme to be carried out. The bones still unremoved were therefore covered up, and at the end of the month the expedition, taking several of its old trained

natives, left Lindi for Songea in motor lorries, the distance of 380 miles taking four days. The original plan had been to travel on foot direct from Tendaguru to Songea in order to prospect for more bones on the way, but this part had to be cut out. The only part of the journey, therefore, on

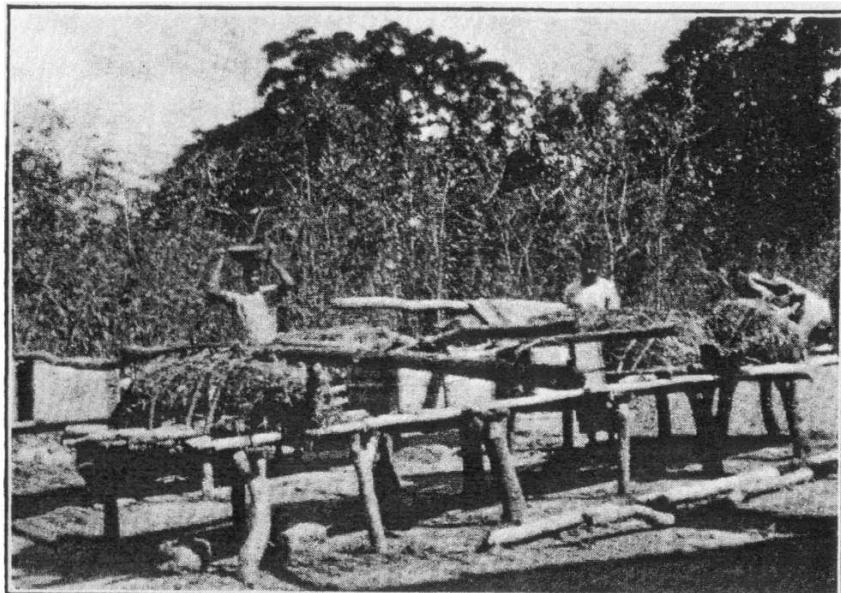


FIG. 3.—BIG BONES PACKED READY FOR TRANSPORT FROM TENDAGURU.

which carriers were required for the baggage was between Songea and Manda on Lake Nyasa, a matter of about seven days. On this section I broke the journey a few days at Likuyu to make a botanical collection, and at Munya maji, two marches on, a patch of Karroo formation was passed over. A small surface collection of reptilian bones was made here. They had become a hard chert, and lay in a soft sort of marl. On the 10th of September the Lake was crossed to Ngara in the Nyasaland Government steamer "Guendolen."

The Nyasaland Government had very kindly made all necessary arrangements in advance, so that no time was lost in beginning work. Mr. W. A. Maxwell, a planter living at Nyungwe, a few miles from where it was proposed to work, very greatly assisted by inviting us to make his house our headquarters whilst in the neighbourhood, which welcome assistance, measured in terms of time, added quite a week to our stay in the country. Dr. F. Dixey, O.B.E., Director of Geological Survey, also met us, and his advice was of the greatest value, as he had earlier prospected all this part of the country.

The north-west shore of Lake Nyasa was first examined between 1906 and 1909 by Dr. A. R. Andrew and Mr. T. E. G. Bailey, and since 1924 has been very thoroughly gone over again

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by Dr. Dixey. As a preliminary I give a table of the rocks and their appearance based on Dr. Dixey's reports.

North-west shore of Lake Nyasa.

The Tertiary and post-Tertiary Lacustrine Sediments.

	Beds.	Maximum observed thickness.	Appearance.
Recent.	6. Recent deposits.	—	—
Pleistocene.	5. Dwangwa Gravels. 4. Songwe Volcanic Rocks. 3. Chitimwe Beds.	250 ft. 270 ft.	— Red conglomerates with red gravels above.
Pliocene.	2. Chiwondo Beds.	200 ft.	Unconsolidated calcareous marls, silt and sands associated with bands of shelly limestone. Pale grey, greenish-grey, pale buff, more rarely light red.
Pre-Pliocene, Miocene or earlier.	1. Sungwa Beds.	160 ft.	Buff-coloured grits and sandstones with locally large pebbles and small concretions.
Lower Cretaceous to Jurassic.	Dinosaur Beds.	?1200 ft.	Friable sandstones, sandy marls and clays. In lower part, red, mauve and purple tints; in upper, red marls alternate with white sandstones. Bones rare in lower part. Dip 10 to 30 deg. N.E.
Triassic.	Karoo Beds.	—	(Deposit at Chiweta a very hard shale tilted northerly.)
? Pre-Cambrian.	Crystalline Rocks.	—	Include Schists and Gneisses with intrusions of Syenite and related rocks.

It was the dinosaur beds with which the expedition was principally concerned. They lie within the Nyasan Rift Valley at an average distance of about eight miles from the north-west shore of Lake Nyasa. They extend for about 78 miles, for the greater part of which they rest on crystalline rocks. In one or two places Karroo beds are recognizable below them.

The upper beds are characterized by strong current bedding and contemporaneous erosion and marked alternation of red and white colouring. The red bands are usually of a marly, clayey or shaly nature, whereas the white are sandy, gritty and occasionally pebbly. In general they are soft, friable and easily weathered.

This occurrence of dinosaur bones in positions indicating current bedding is also common to Tendaguru.

In the lower beds, according to Dixey, remains are rare, a point I was not able to go into, as, being desirous of finding bones, I examined first the ground they were most likely to occur in.

Although the dinosaur beds extend a considerable distance north and south in a long thin line, it was only in the neighbourhood of Mwaka Syunguti that excavation was done this year, as this was proved bone-bearing ground.

This name is given to the upper part of a valley that runs down to Nyungwe, which is six miles from Ngara, a calling-place for steamers on the Lake. It is so called from a chief who has two villages some four or five miles up the valley. The river down it runs all the year through. Above Mwaka Syunguti village the valley is very eroded, with precipitous hills a hundred or more feet high, which are strewn with large pebbles, chiefly of quartz. The width of the valley might be about two miles at the upper Mwaka Syunguti village, which is rather over a mile from the first village of that name, and digging was begun a mile up beyond village No. 2.

The east and west sides of the valley are bounded by crystalline hills. The eastern ridge shuts off the Lake. The western ones are the foot-hills of the Nyika plateau.

The dinosaur beds occupy the middle of the valley. On these at the sides are the Chiwondo beds (Pliocene). A good section of these beds may be followed for several miles along the bold scarp following the eastern side of the valley. They are of a variable thickness with a maximum of about 100 feet as observed by Dr. Dixey. On the Chiwondo beds are the Chitimwe beds (Pleistocene) which form a conspicuous battlemented capping to the east scarp. The thickness of the Chitimwe bed is according to Dixey about 20 feet for conglomerates, on which lie to a depth of 60 feet red gravels.

There would seem to be Pliocene beds resting immediately on dinosaur beds in this valley. It is, however, the Sungwa beds which in other places are found to intervene, and further examination of this valley may reveal their existence here too. The first dinosaur bones discovered in Nyasaland were collected by Mr. E. C. Holt in 1924 according to Dixey.

The first few days in the valley were given to prospecting from the camp which was established at village No. 2. It was difficult owing to the steepness of the hillsides, the valley being deeply intersected with gullies. Very few of the surface bones found were worth removing. Subsequently digging was carried on in four localities.

Site A was about a mile straight up the valley from the camp.

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It was on a hill-top, and excavation was easy, as it was only necessary to throw the earth down the hillside. Here a number of bones were found belonging to at least two Sauropods, most being in good condition. To give some idea of the size:—one scapula was 45 by 17 inches; (?) tibia 27 by 8; a pair of scapulæ $31\frac{1}{2}$; humerus 32; femur 46; (?) radius $28\frac{1}{2}$; two thin plates, (?) sternal, 17 by 11 and $15\frac{1}{2}$ by $11\frac{1}{2}$. There were also incomplete ribs, a pubis and ischium, and some vertebræ, mostly centra only. There were also a humerus of unusual shape and other uncertain bones, among which were what might be external spines. A part of a large bone, perhaps a femur, lying somewhat apart, was found to be completely impregnated with a cobalt blue coloration.

Site B. This was about a mile farther up the valley. Not many bones were found here and they were scattered as much as ten yards apart. They were on the surface or immediately below it. Digging did not reveal other bones in proximity to the ones found.

The finds were a humerus 32 inches long, the centra of two caudal vertebræ, and a femur 46 inches. In addition were some small fragments of bones about a millimetre in diameter; a very small vertebra; two shells (*Unio, sp.*); a part of a big bone in three pieces completely calcified; and specimens were also taken of a rippled brown clay.

Site C. This site lay to the right going up the valley, and about the same distance from the camp as A. Some of the bones from here were distinctly puzzling.

Among the finds were a femur $34\frac{1}{2}$ inches; tibia $18\frac{1}{2}$; (?) metatarsal $7\frac{1}{2}$; several centra, a sacral vertebra; and a vertebra with a neural spine which was cup-like and which must be that of a dinosaur, if dinosaur it be, of unusual type.

Site D was another hill peak only about a hundred yards from A. It produced a group of bones all belonging to a single small Sauropod. On the surface close by were found amongst the quartz gravel several pieces of fossil wood, which were probably of derived origin, the same as the gravel.

The bones included both humeri 27 inches; ulna; femur 34 inches; both radii; both scapulæ; ribs; ilium, very curved; pubis; (?) coracoid; and numerous vertebræ, some with spines complete. Their preservation was good.

Bones were also reported from lower down the valley below the two Mwaka Syunguti villages, but after examining them I did not consider it worth while digging there in view of the shortness of the time available. One enterprising native, on

finding old bones to be sought after, made a collection of all he could find on his farm, and put them in his house, and then offered to sell them to me. He received sixpence for his report, but a sale was not effected.

Uraha is a small flat-topped and wooded hill seen to the south over the flats from Nyungwe house. It is about six miles distant by road. It rises 250 feet above the Recent alluvial plain, and constitutes one of the best exposures, according to Dixey, of the Chiwondo beds. The Chitimwe beds topping these are 15 feet in thickness according to Dixey.

A small village lies about half a mile from the rise of the hill, and here a camp was made, a stream of water being close by.

No excavation was done on the top, but from the slope some pieces of a *Mastodon* jaw were recovered, together with several elephantine and other teeth, a small (?) metacarpal, small astragalus, etc., also a lamellibranch shell. An extensive examination of this hill would be of interest.

After Uraha and Mwaka Syunguti had been done, the expedition moved south beyond Florence Bay to Chiweta.

The small area of Karroo formation to which this name is given is comprised within about one square mile, lying between the southern spurs of Mt. Waller and the Lake. Mt. Waller is a conspicuous eminence with well-defined stratification at the top, visible from a great distance. The deposit is bounded on the south by the rocky and swift Rumpi river, while on the north edge of its valley and at the base of the 250 feet high ridge that separates it from the Karroo area are hot sulphur springs. Up the Zindiri valley, the next gorge to the south is a coal deposit about 700 feet above the Lake.

The Chiweta beds dip north easterly, so that the oldest reptilian remains are exposed on the S.W. side at a height of over 200 feet, and here some were found under a rocky cap. The ground is mostly a hard shale, which is difficult to break up.

Surface finds were made over the whole of the ground, and in the fortnight that was given to this locality probably most of the exposed fragments were examined, and not much is left worth removing. Owing to the hardness of the ground, excavation is a matter of the greatest difficulty. *Dicynodon* bones were the most common, but there are others which have still to be identified.

The Nyasaland part of the programme was now completed, and on the 5th November I recrossed the Lake to Manda on my return journey to Tendaguru, Mr. Parrington leaving the expedition in order to return home via South Africa. I extracted

the bones I had left behind, and though digging was carried on for five weeks more, not much of any value was found, and the missing bones I had hoped to find were still elusive. They had probably drifted away when the carcase of M 23 rested finally on its right side in a shallow backwater.

Now Tendaguru is abandoned. I disposed of the equipment in accordance with instructions and left for England in January.

EARTHQUAKES IN BRITAIN.

By W. E. SWINTON, B.Sc., Ph.D., Assistant Keeper, Department of Geology.

AT 1.26 a.m., Summer Time, on Sunday, June 7, 1931, Great Britain was visited by "the worst earthquake ever known in England." However true this description may be, the event was seized upon with enthusiasm by certain sections of the Sunday Press, and we were informed that thousands of people rushed from their homes or telephoned to the police or the exchanges. What solace they thus obtained was not divulged by the more sober week-day publications. Days after the first excitement had subsided, energetic persons were still describing their experiences in letters to editors. Some had the unhappiness of observing a sort of wave traversing the floor of their rooms, others described the feeling as akin to sailing in a rough sea. Fortunately the majority of the public, less sensitive perhaps or maybe better sailors, slept peacefully without any such maritime discomforts.

Against the over-sensitive class of observers may be placed that section which treated the event with undisguised levity. Of such is a lady journalist who remarks delightfully : "When I felt my bed shake under me I supposed it was merely the man-under-the-bed, for whom for many years I had neglected to look, and who now, waxed bold from my long tolerance, was heaving under me."

The sensational view of the earthquake was long ago belaboured by Dr. Johnson : "Sir," said he, "it will be much exaggerated in popular talk. People do not mean to lie, but taking no pains to be exact they give you very false accounts. If anything rocks at all, they say it rocks like a cradle."

The views of those like the lady journalist only show what a charming field of literary speculation the phenomenon is.