17. — *The fauna and Stratigraphy of the Stormberg Series.* — By S. H. Haughton, B.A., D.Sc., F.G.S., Hon. Curator of the Palaeontological Collections, formerly Assistant Director, S. A. Museum. (With 55 Text-figures.)

INTRODUCTION.

In the following pages an attempt is made to bring together facts, previously scattered through a number of publications, bearing upon the stratigraphy and palaeontology of the Stormberg Series and to incorporate among them the results of three collecting expeditions made by the author mainly in the districts of Herschel and Wodehouse. The whole of the fossil collection of the South African Museum has been reviewed — the animals by the author, the plants by Dr. A. L. du Toit. The work of the latter is not yet ready for publication; but Dr. du Toit has kindly forwarded a provisional list of his identifications, which is incorporated below. To him I am also indebted for constant critical advice and, as will be seen, I have drawn largely upon his published descriptions of the stratigraphy of the beds.

Mr. Macgregor, of the Rhodesian Geological Survey, has been good enough to supply me with notes and specimens from Southern Rhodesia. Rock-sections have been cut in the Geological Department of the University of Cape Town, where Professor A. Young has critically examined the petrological work, besides discussing the many interesting points of palaeogeography which arose. Thanks are due to the Royal Society of South Africa for a grant which resulted in the discovery of the skeleton of *Massospondylus harriesi*; and, among others, I am indebted for help to Dr. L. Péringuey for examination of the insect-remains and to Mr. K. H. Barnard for inspection of the crustacea.

FAUNA AND FLORA.

The following list shows the forms found in the Stormberg Series.

PLANTS.

(List supplied by Dr. A. L. du Toit.)

Neocalamites (*Schizoneura*) *Carrerei*, (Zeill.).
Neocalamites sp. Sew.

Danaeopsis hughesi, (Feist.).
Thinnfeldia odontopteroides, (Morr.).
Thinnfeldia lancifolia, (Morr.).
Thinnfeldia Feistmanteli, Johnston.
Thinnfeldia aquilina, Shirley.
Thinnfeldia trilobita, Johnston.
Taeniopteris Carruthersi, (Ten.—Woods).
Taeniopteris Tenison—Woodsi, Eth. jun.
Taeniopteris crassinervis, (Feist.).
Chiropteris Zeilleri, Sew.
Chiropteris cuneata, (Carr.).
Chiropteris copiapensis, Stein. et Solms.
Gingkoites (Ginkgo) digitata, (Brongn.).
Ginkgoites antarctica (Sap.).
Ginkgoites, nov. sp.
Baiera Schenki, Feist.
Baiera stormbergensis, Sew.
Baiera moltenensis, Sew.
Sagenopteris longicaulis, du Toit.
Cladophlebis (*Todites*) *Roesserti*, (Presl.).
Cladophlebis nebbensis, (Brongn.).
Callipteridium stormbergense, Sew.
Stenopteris elongata, (Carr.).
Stenopteris rigida, Dun.
Stormbergia Gardneri, Sew.
Sphenopteris alata, Brongn.
Sphenopteris lobifolia, Morr.
Pterophyllum natalense, du Toit.
Pterophyllum cf. *Footeanum*, Feist.
Phoenicopsis (*Desmiophyllum*) *elongata*, (Morr.).
Pachypteris acuta, du Toit.
Pachypteris lanceolata, Brongn.
Zamites sp.
Marattiopsis munsteri, (Goepp.).
Glossopteris browniana, Brongn.
Glossopteris conspicua, Feist.
Stachopitys sp.
Strobilites sp.
Rhexoxylon sp.

ANIMALS.

CRUSTACEA.

Cyzicus (*Euestheria*) *draperi* (Jones & Woodw.).
Cyzicus sp. Leriche.
Lepidurus stormbergensis, sp. nov.
Unnamed Ostracod.

INSECTA.

Coleopteron. Gen. et sp. indet.
Phthartus africanus, sp. nov.
Striatotegmen africanum, gen. et sp. nov.
Unnamed Blattid.
Archaegryllodes stormbergensis, gen. et sp. nov.
Eggs of Orthopteron?

PISCES.

Semionotus capensis, Sm.—Woodw.
Helichthys (?) sp.

REPTILIA.

Pachygenelus monus, Watson.
Tritheledon riconoi, Br.
Lycorhinus angustidens, gen. et sp. nov.
Sphenosuchus acutus, Htn.
Notochampsa istedana, Br.
Pedeticosaurus leviseuri, v. Hoep.
Erythrochampsa longipes, (Br.).
Thecodontosaurus browni, (Seeley).
Thecodontosaurus skirtopodus, (Seeley).
Thecodontosaurus minor, Htn.
Gyposaurus capensis, Br.
Aristosaurus erectus, v. Hoep.
Massospondylus carinatus, Owen.
Massospondylus harriesi, Br.
Massospondylus schwarzi, sp. nov.
Aetonyx palustris, Br.
Dromicosaurus gracilis, v. Hoep.
Plateosaurus stormbergensis, Br.
Plateosaurus cullingworthi, sp. nov.
Gryponyx africanus, Br.
Gryponyx transvaalensis, Br.
Gryponyx taylori, sp. nov.
Euskelesaurus browni, Huxley.
Euskelesaurus capensis, (Lyd.).
Euskelesaurus africanus, sp. nov.
Gigantoscelus molengraffi, v. Hoep.
Eucnemesaurus fortis, v. Hoep.
Melanorosaurus readi, sp. nov.
Geranosaurus atavus, Br.

PART I.

DESCRIPTION OF SPECIES.

CRUSTACEA.

ENTOMOSTRACA.

Family CYZICIDAE.

CYZICUS, Audouin.

Cyzicus (Euestheria) draperi (Jones & Woodw.)

1894. *Estheria Draperi* and *E. stowiana*, Jones & Woodward, Geol. Mag., N.S. Dec. IV, vol. I, p. 289. Pl. IX figs. 1*a*—*c*, 2.

The original description runs as follows: — "Size: Length of valve, 16 mm. Length of hinge-line, 11 mm. Height $10^1/_2$ mm. Valves suboblong, straight above, slightly curved below, rounded at the ends; anterior margin higher and less convex than the posterior. The interspaces on the surface are ornamented with coarse shallow pits, making an obscure reticulation. The umbo is just in front of the middle of the hinge-line."

I have examined a number of specimens from the shale-band at Siberia, Wodehouse. C. P. in the Cave Sandstone which belong to this species. None of them attain the dimensions recorded by Jones & Woodward: the largest valve seen by me is 12 mm. long, 8 mm. high and has a hinge-line of $8^1/_2$ mm. The corresponding dimensions on a number of the specimens are $7^1/_2$ mm., 5 mm. and 5 mm., while some have a length of not more than $2^1/_2$ mm.

Several of the specimens show the details of the external markings. The shape is somewhat variable, the smaller specimens approximating more to that figured by Jones & Woodward as *E. stowiana.* All agree, however, in the possession of the concentric ridges and, as far as can be seen, in the nature of the intercostal ornamentation.

In a valve having a height of 4 mm. there are 13–14 regularly spaced well-marked fine costae with broad interspaces. As the valves grow older and larger the costae increase rapidly in numbers and are crowded together near the ventral border in the larger specimens as in *C. mangaliensis.*

The intercostal ornamentation consists of shallow pits when viewed from without and pustules when viewed from within the valve. These are arranged in irregular rows and are set closely together so that there are 7 or 8 rows in each interspace. The pits are rounded rather than polygonal in outline. The older portion of the valve (that around the umbo) is smooth save for the concentric ridges. The pits are more prominent near the ventral, anterior and posterior borders of the valves. The abscence of pits near the umbo on the larger specimens is presumably due to wear or some other cause, as the small specimens occasionally show ornamentation over the whole valve.

Some of the valves show a considerably greater degree of ribbing than the more typical specimens. This variation in sculpture is paralleled in *C. murchisonae* in different valves of which Rupert Jones recorded variable ribbing.

The similarity of ornamentation between the valves of all sizes found at Siberia helps to prove the assumption here made that *C. stowiana* and *C. draperi* are but growth-stages of the one species. This possibility was mentioned by Jones & Woodward who had not, however, material for observing the intercostal ornamentation on the smaller forms nor intermediate valves showing the gradual changes in size. The variation in shape between specimens of the same size does not seem sufficient warrant for separating the specimens into several species. The species figured by Rupert Jones in his "Monograph of Fossil Estheriae" are variable in shape-characters; and the variations seen in *C. draperi* are no greater than those figured for his *Estheria ovata* or *E. minuta.*

In general form *C. draperi* seems to approach fairly closely to *C. mangaliensis* from the Rhaetic of India and from the Argentine.

Type. In the British Museum.

Locality. Harrismith, O. F. S.

Horizon. Shale-band in the Cave Sandstone.

CYZICUS sp.

1920. Leriche. *Estheria* sp. Rev. Zool. Afric. VIII p. 78. Pl. II, fig. 1.

Founded on specimens from the Lubilash Beds at Kitari, cañon of the Inzia, Belgian Congo.

"The valves are sub-oval; the beak is anterior and not prominent. The dorsal border is almost straight. The anterior border is rounded and passes insensibly into the ventral border, with which it forms a very regular curve. The ventral border is regularly convex; it joins the posterior border, which is oblique to the dorsal border, by a very obtuse angle. The valves carry about fourteen concentric ribs. The state of preservation does not permit of the presence of an intercostal ornamentation being stated."

Leriche states that these fossils belong to a group of "*Estheria*" characterised by a regular concentric ornamentation formed of prominent spaced ribs. This group has been called *Euestheria* by Deperet and Mazeran. The Congo form approaches most closely *E. mangalensis* but is distinguished by the slightly more elongate shape and the sharper demarcation of the posterior and ventral borders. *E. greyi* has a similar ornamentation but has a more oval and more inequilateral form.

Specific identification is not possible without a knowledge of the intercostal ornamentation.

Fam. APODIDAE.

LEPIDURUS, Leach.

Lepidurus stormbergensis sp. nov.

This form is represented in the South African Museum collection by a number of impressions on shale. Some represent isolated carapaces of immature animals; others more or less complete mature individuals. No specimen is perfect, and therefore several have been examined in the preparation of the following description. In some cases impressions of the appendages are fairly well-preserved, but detailed description of these is postponed.

The carapace is almost circular, slightly longer than broad, and deeply emarginate behind, the emarginate portion having an untoothed border. There is a strong median keel extending from the hinder border to a short distance behind the eyes.

Measurements of four carapaces of varying size are as follows:

Median length	Maximum length	Maximum breadth
9 mm.	10·3 mm.	10 mm.
9 mm.	11 mm.	10 mm.
11 mm.	13 mm.	12 mm.
	19 mm.	17·5 mm.

The smaller carapaces are isolated; the larger are attached in each case to the body.

The first antenna is short, single, possibly divided into two joints. As seen in specimen 5752 and possibly in 5751 it is similar in appearance to that of the recent *L. viridis.* The antenna is best seen in specimen 5758.

The second antenna cannot be distinguished.

The mandible is apparently an elongate plate (breadth greater than length) with a denticulate biting edge having 5 or 6 teeth. An impression is seen in no. 5758. In no. 5752 the maxilla is seen in juxtaposition with its neighbour of the other side.

The segments under the carapace are all provided with setose Phyllopod appendages.

In one specimen there are about 17 segments protruding beyond the carapace; of these at least 7 are longer than the others and may be regarded as true abdominal segments, although none of the segments are seen to possess feet. Each segment bears an encircling row of sharp spines which diminish in number posteriorly. The spines arise from near the middle of each segment and project well back behind the posterior border. Excluding the telson the body is about half the length of the carapace. (In another specimen the body is shorter, and the number of abdominal segments apparently six. This is possibly a female).

The telson is moderately short, spatulate, with a fairly well rounded posterior border and a pronounced longitudinal median keel. It carries no spines, and the edge is entire. In specimen 5763, however, the telson, instead of being spatulate, is somewhat pointed at the end, like a spear-head, and the lateral edges seem to be either serrate or provided with short spines. This may represent a variety; but the specimen is otherwise too incomplete for lengthy description.

The caudal filaments are fairly broad at the base, taper fairly rapidly and are covered with long fine hairs.

Specimen no. 5752 shows an oval body 2·5 mm. long situated in the neighbourhood of the 15th or 16th legs under the carapace, behind the mid-line of the carapace and to the side. The body is empty, but was probably an ovisac.

The form has been placed in the genus *Lepidurus* on account of the characteristic telson which distinguishes it at once from *Apus.* As far as can be discovered *Lepidurus* has not hitherto been described from Triassic deposits, although an allied form *Apudites* (or *Apus*) *antiquus* has been named by Schimper from the Lower Trias

(Voltzia Sandstone) of the Vosges. Unfortunately it has not been possible to consult the description of this form, which has been placed in the genus *Apus* by Ph. C. Bill (1914). The genus *Lepidurus* is not a member of the modern South African fauna although several species of *Apus* occur in the South African vleis, which habitually suffer periodic dessication.

Co-types. S. Af. Mus. Coll. Cat. Nos. 5751–5754, 5759–5761.

Locality. Siberia, Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Class INSECTA.

Order COLEOPTERA.

Text fig. 1.

A piece of shale in the collection of the South African Museum contains the impression of what seems part of a coleopterous elytron. The impression is that of the posterior half of a right elytron, the anterior portion being overlain by another impression which, according to Dr. L. Péringuey, cannot be coleopterous. The impression

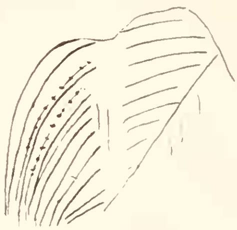


Fig. 1. *Coleopterous elytron.*

shows 8 main sub-parallel veins and a fairly broad fold. The sixth and seventh of the veins coalesce posteriorly. In addition there is a series of pustules (left in the impression as punctures) forming a fine line between the two outer veins, and another series between the next pair of veins.

The fragment (Cat. No. 5635) is too incomplete to justify naming. Triassic coleoptera have been described from Australia (families Hydrophilidae?, Elateridae?, Tenebrionidae? and Malacodermidae) and from the Keuper and Rhaetic of Europe. No Permian forms have hitherto been described.

Locality. Siberia, Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Order PLECTOPTERA.

Fam. EPHEMERIDAE.

Phthartus africanus, sp. nov.

Text fig. 2.

This is represented by several imperfect larvae of which the specimen figured (Cat. No. 5732) is nearly complete, lacking the head and lateral appendages. The cercal setae are faintly indicated — and have been drawn in on the evidence of a second specimen (No. 5733) consisting of the hinder portion of an abdomen in which the long setae are well-marked.

As preserved, the body without the cerci is 15 mm. long and 3·5 mm. broad in the middle.

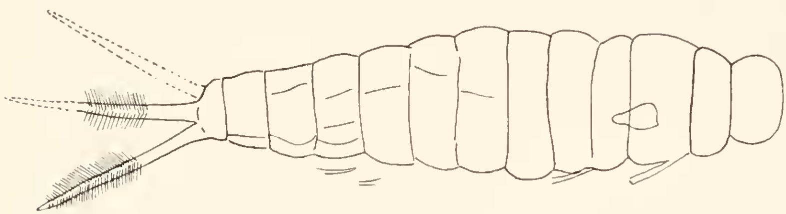


Fig. 2. *Phthartus africanus*, Htn.

The earliest Ephemerid larvae belong to the genus *Phthartus* Handl. from the Permian of Russia. The present form seems fairly similar to that genus, but the cerci are shorter and stouter. It may be grouped provisionally as *Phthartus africanus* sp. nov.

Type. Impression on shale — S. Afr. Mus. Cat. No. 5732.

Locality. Road-cutting, Siberia, Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Order ORTHOPTERA.

Fam. MESOBLATTINIDAE, Handl.

Striatotegmen africanum, gen. et sp. nov.

Text fig. 3.

Tillyard's emendation of the characters of this family runs as follows: — "Subcosta much reduced. Radial area extensive and strongly developed, sending numerous branches towards the anterior border, and reaching nearly to the apex. Media free, dividing into a variable large number of branches directed towards the apical border. Cubitus also free, branching variably, the branches directed towards the posterior border. Anal field large, well-defined, usually somewhat cultriform, with more or less curved veins running chiefly towards the posterior border. Intercalated veins and reticulation or cross-venation may or may not be present. Mostly small to medium-sized forms." (Proc. Linn. Soc. N. S. Wales, XLIV. 2, 1919, p. 366).

The fossil S. A. M. Cat. No. 5634 consists of a piece of shale and a partial counter-piece showing a nearly complete insect. One tegmen is folded back on the body; the other is spread out at right angles to the body and is preserved without the apex as an impression on slab 5634*a*.

The width of the tegmen is just over one-third of the probable length (which is about 9 mm.). The humeral area is narrow and distinctly less in length, from base to apex, than the anal area, and is bounded distally by a slightly double-curved sub-costa which is apparently unbranched. The humeral area is sharply pointed at the apex.

The radius is strongly double-curved. It gives off eight primary branches to the anterior border, excluding the forked distal end: of these, the first six are simple veins, the seventh and eighth forked. The median has four branches which apparently extend to the border below the apex. The cubitus has at least six branches.

In the area covered by R, M, and Cu strong raised ridges separate the veins. These are preserved as strong channels; but that they are not true veins is shown by the fact that they do not unite with one another basally, whereas the true veins do. There are faint indications of crossvenation on the proximal portions of the area covered by M and Cu.

The anal area has the ***vena dividens*** strongly marked. The first anal vein rises from the ***vena dividens*** but ends at the wing border just below the apex of the area. The third vein is forked at some distance from the border. The fourth vein is waved, as is the fifth — the latter being forked near its distal end. The sixth vein is also waved. In the anal area, there are indications of faint ridges between the veins. There is also a certain amount of irregular cross-venation.

Comparison of this wing with the forms from the Ipswich Beds of Australia gives the following results: — From ***Triassoblattina*** it differs in the narrower humeral area, the reduced nature of the subcosta, the stronger double-curving of the radius, and in the fact that none of the anal veins end distally on the ***vena dividens***. There are differences, too, from the genotype *T. typica* in the number of branches of R, M, and Cu.

From *Samaroblatta* it differs in the shorter and narrower humeral area, in that the distal portion of R probably reached the apex. In other points it approaches fairly closely to this genus, especially in the possession of intercalated ridges and a cross-venation. The difference in branching of R, M, and Cu is not of great moment; Tillyard has pointed out that not only different individuals of the same species of Cockroach, but also even the right and left tegmina of the same individual, show considerable differences in this respect.

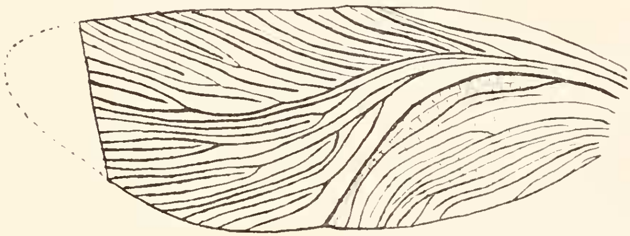


Fig. 3. *Striatotegmen africanum*, Htn.
Venation of tegmen.

From *Austroblatta*, with which it agrees in size, it differs in the smaller humeral area, the pronounced bending of R, and the presence of intercalated veins.

In general characters it agrees closely with *Mesoblattula* from the Lias of Mecklenburg. It shows the same reduced subcosta: the humeral area shorter than the anal, the same strongly double-curved radius, and the same general features of M and Cu As in *Mesoblattula* there are intercalated ridges, and evidence of occasional cross-venation (cf. *M. geinitziana*). Unfortunately the anal area is unknown in the genus *Mesoblattula*. Our form differs from this genus in that the anterior branch of the medial is apparently not forked; in this it differs also from *Mesoblattopsis*, *Liadoblattina*, *Rhipidoblattina* and *Caloblattina*, and apparently agrees with *Mesoblattina*. It agrees also with *Mesoblattina* in the reduced humeral area and the simple subcosta; but the area covered by the radius is larger in the South African form, the radius is more strongly curved, and there are fewer primary branches. The tegmen, too, is somewhat broader.

Two genera of this family have been described from the "Rhaetic" of Tonkin — *Rhaetoblattina* Handl. and *Hongaya* Handl. Both of these are larger than our form. In each the humeral area is short, the subcosta reduced to a single vein, the radius strongly double-bent so that it touches at its lowest point the middle line of the tegmen. *Hongaya* agrees with the South African form in that the upper branch of the median is not forked, in the general nature of the cubitus and median, in the fact that the first anal vein rises from the *vena subdividens* and ends distally on the wing border, and in the presence of intercalated ridges; but it differs in the number and nature of the radial branches and in the smaller size of the anal area. *Rhaetoblattina* has a larger anal area, comparable with that of our form, a small humeral area, and intercalated veins: but the median and cubitus are not so similar to our form as those of *Hongaya*. In neither of the Tonkin genera are cross-veins described; and Handlirsch was unable to discern them.

As was to be expected, this form shows close relationships with the Triassic, Rhaetic and Liassic forms of the Mesoblattinidae, and is more advanced than the Carboniferous and Permian members of the family. It does not seem to fall readily into any one of the described genera and for that reason the new generic name *Striatotegmen* is proposed for it, founded upon the following generic characters: —

Striatotegmen gen. nov. Tegmen small (under 10 mm. in length). Width just over one-third of the length. Humeral area narrow, and distinctly shorter than the anal area. Sub-costa slightly double-curved, unbranched. Radius strongly double-curved, almost reaching middle line of wing, with eight primary branches, of which the anterior six are simple. Upper branch of median unforked; upper branch of cubitus unforked. *Vena dividens* strong. First anal vein arising from *vena dividens*, but not ending distally on it. Intercalated ridges present, especially strong in radial, medial, and cubital areas. Cross-veins faintly indicated.

For this form the specific name *Striatotegmen africanum* sp. nov. is proposed.

Type. Insect on shale, and counter-impression. S. Af. Mus. Cat. No. 5634.

Locality. Road-cutting, Siberia, Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Gen. et sp. indet.

Text fig. 4.

A fragment from Siberia (S. Af. Mus. Cat. No. 2340) shows portions of two Blattoid tegmina. Parts of the radius, median, and cubitus of each tegmen are seen, but nothing of the subcosta nor of the anal area. Both ends of each tegmen are missing. Intercalated ridges are seen between the branches of the cubitus and median, but none in the area covered by the portion of the radius.

Nothing of the subcosta is seen, and but little of the radius. The distal branches of the radius are forked.

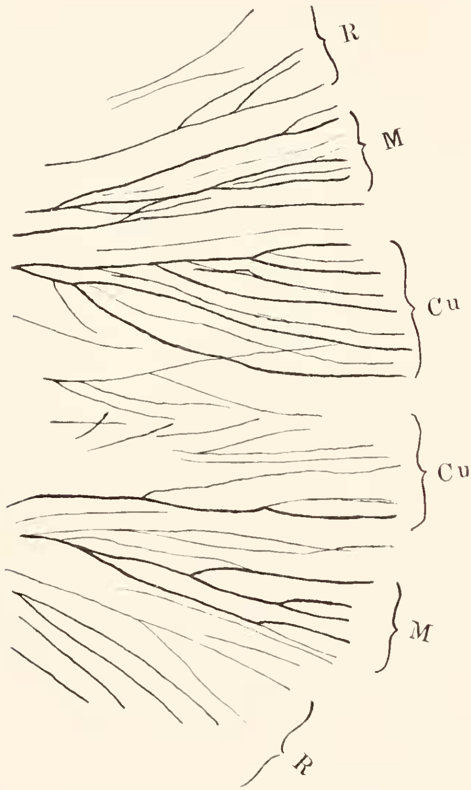


Fig. 4. *Blattoidea incert sed.*

Most of the distal portion of the median is preserved. The appearances of the two tegmina are slightly different. Each shows the primary branch forked near the extreme end, and, in addition, three other branches which arise by dichotomous division of a branch from the main stem. Intercalated ridges occur on one tegmen; on this side there appears to be a second primary unforked branch of the median which is connected to the first fork of the first primary branch by a diagonal cross-vein.

The cubitus occupies a larger area than the median. It is dichotomously forked, and intercalated ridges are well-marked.

There is no sign of a strong *vena dividens*, nor any indication of the anal area.

Locality. Road-cutting, Siberia, Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Fam. GRYLLIDAE.

Archaegryllodes stormbergensis, gen. et sp. nov.

Text fig. 5.

This is founded on portion of the tegmen of a male Gryllid, about 11 mm. long as preserved and 5 mm. broad.

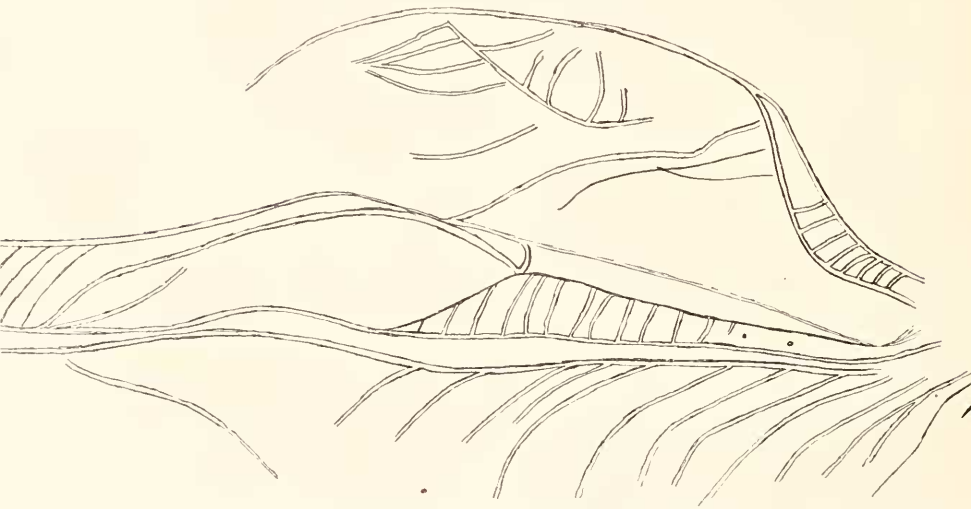


Fig. 5. *Archaegryllodes stormbergensis*, Htn. × 12.

The general arrangement of the main veins is similar to that in the recent form *Brachythripus* and is distinct from the hitherto earliest-described Gryllid — *Protogryllus* from the Upper Lias of Mecklenburg.

The subcosta is long and has a number of curved oblique branches in its proximal half. The radius lies close behind the subcosta.

The median is weak and joins the radius about half way along the latter forming a space with an acute distal angle. Distal to this a branch of the median again reaches up to the radius. Cross-veins connect the proximal portions of the radius and median.

There are indications of a drum between the branches of the cubitus, but the veining is not distinct. There are cross-veins between the second branch of the cubital and the first anal.

This is the earliest Gryllid described; and that fact, coupled with its lack of similarity with *Protogryllus* seem to justify the erection of a new genus which can be called *Archaegryllodes* n. gen., the species represented by the specimen under discussion being termed *A. stormbergensis.*

Type. Partial tegmen on shale. S. Af. Mus. Cat. No. 2341.

Locality. Road-cutting, Siberia, Wodehouse, C. P.

Horizon. Shale-band, near base of Cave Sandstone.

Orthopterous eggs.

Text fig. 6.

On the same slab of shale as that which contains the type of *Archaegryllodes stormbergensis* (No. 2341) are from ten to twelve

Fig. 6. Eggs of Orthopteron? × 8.

elongate oval bodies, which seem to be eggs of an Orthopteron. Each is about 1 mm. long by 0·4 or 0·5 mm. broad., and the specimens lie together in one mass.

There is a rough approximation to the form of a double row of eggs placed transversely, although one or two have been displaced from their original position; but the general appearance seems to indicate that the eggs were originally in an ootheca similar to that of some Orthopterous insects, but that the cover has disappeared.

PISCES.

TELEOSTOMI.

Gen. SEMIONOTUS, Ag.

Semionotus capensis, Sm.—Woodw.

1888. Smith—Woodward. Quart. Journ. Geol. Soc. XLIV, p. 138.
1901. Schellwien. Schrift. Physik.-oekonom. Gesell. Konigsberg. XLII.
1909. Broom. Ann. S. Afric. Museum VII, part 3, p. 262.

Since Broom's description, the South African Museum has received no further examples of this well-known fish, and it will suffice to quote the main points of Broom's analysis of the form.

"The majority of specimens measure from 160 to 210 mm. in length. In the example which is 210 mm. long, the body is 42 mm. in depth at the deepest part, and the head measures 48 mm. to the back of the operculum.

Schellwien has recently described a number of specimens and has shown the more important features of the skull structure. The specimens I have examined confirm most of his observations, but in one or two points I am inclined to differ from him.

Almost every detail of the skull is now known except the basicranial region. The frontals are large, and extend from the nasal region to behind the plane passing through the back of the orbit. The back part of the bone is about twice as wide as the middle portion. Behind it is a large oblong parietal. Below the parietal is a slightly narrower squamosal. My specimens do not satisfactorily show the supratemporal region, but Schellwien finds a narrow supratemporal and a post-temporal.

The opercular bones are very like those of *Lepidotus.* The operculum differs in being relatively considerably wider in its lower half. Inferiorly it joins the subopercular in a manner very similar to that in the better known genus. The subopercular in *Semionotus* is only about one-third the size of the operculum instead of half as large as in *Lepidotus*, while the interopercular is less than half the size of that in *Lepidotus.* In front of these three opercular bones is a narrow curved preopercular, along which there runs a mucous canal.

In Schellwien's diagrammatic restoration the postorbital seems to me to be rather too small, while the interopercular is much too large. Above the anterior end of the long preopercular is an elongated suborbital smaller in size than the postorbital. The portion of the figure dealing with this region is, in my opinion, erroneous.

The lower jaw has an elongated triangular dentary and a powerful angular.

The palato-pterygo-quadrate arch is fully ossified, but the exact limits of the different elements cannot be made out with certainty. There is a long narrow bone below the quadrate stretching from the articular region to the lower end of the hyomandibular. This would seem to be the symplectic. The hyomandibular is a powerful bone and fairly similar to that of the ordinary Teleosteans. In addition to supporting the opercular bones and the quadrate arch, it supports the hyoid arch. There is a large quadrangular epihyal and an elongate triangular ceratohyal. The interhyal has probably been cartilaginous, as has also probably been the hypohyal and the urohyal. Under the subopercular are six branchiostegals.

The clavicular arch consists of the clavicle, supraclavicle, postclavicle and post-temporal, but there seems to be no trace of an infraclavicle. A mucous canal crosses the supraclavicle obliquely as in the Palaeoniscias. There is a small ossification which possibly may be the coracoid as is thought by Schellwien.

The pectoral fin consists of 14 rays with 5 or 6 fulcra in front. The rays are much flattened distally, but apparently not branched.

The pelvic fin consists of 7 rays which are branched distally. The fulcra are powerful.

The dorsal fin begins exactly in the middle of the back of the fish, and consists of 13 rays, of which the last 3 are small. All the rays are branched distally and articulated. In front are a row of very powerful fulcra, 9 in number. The anal fin consists of 9 rays with 9 powerful fulcra in front.

The caudal fin consists of 16 rays, all of which are branched and articulated. Below and in front of the first ray are 14 fulcra, and 14 fulcra also lie above the tail, gradually passing into the dorsal scales in front. The rays of the dorsal, anal, and caudal fins are double. Though the tail is in a sense brevi-heterocercal the upper portion is really continued as a long, slender process bearing small rhombic scales about 20 mm. beyond the end of the middle of the tail."

Type. In British Museum.

Locality. Ficksburg, O. F. S.

Horizon. Cave Sandstone.

Helichthys (?) sp.

A piece of shale from the deposit at Siberia, C. P., shows portion of the body of a small fish including the proximal portions of the anal and pelvic fins.

The body must have been fairly long and shallow. The pelvic fin is not entire, but the preserved portion consists of 13 rays, spread out into something of a fan-shaped body. They show no evidence of bifurcation. The anal fin is preserved in its proximal half; it is composed of 35 or 36 rays, of which the first seven at least increase rapidly in size from the first. There is no evidence of the presence of fulcra. The dorsal fin is not preserved.

The flank-scales are small, rhomboidal, without external ornament. There seems to be evidence of a single longitudinal groove on the inner surface.

It is possible that the form is allied to that described by Broom as *Dictyopyge formosa.* It is doubtful, however, whether that species can be ranked in the genus *Dictyopyge* as defined by Egerton. Except in the pectoral fin no fulcra are seen; while there is no evidence of bifurcation of the fin rays in the specimens of *formosa* which we possess. Rather does the form seem to be generically identical with *Helichthys*, agreeing in the comparative scarcity of fulcral bones, in the simple unbifurcated rays, and in general characters. Fulcra are not well-marked, but are present.

It is considered, therefore, that the type specimen of *Dictyopyge formosa* (S. A. Mus. Cat. No. 2761) must be known as *Helichthys formosa.*

Type. Incomplete small fish. S. A. Mus. Cat. No. 5130.

Locality. Siberia. Wodehouse, C. P.

Horizon. Shale-band near base of Cave Sandstone.

Class REPTILIA.

Super-Order ANOMODONTIA, Owen.

Order THERIODONTIA, Owen.

Pachygenelus monus, Watson.

1913. Watson. Geol. Mag. N. S. Dec. V. Vol. X., p. 145, figs 1, 2.

This form is known only from the anterior portion of a small dentary. There are only two incisors, of which the first is much bigger than the second. The canine is large, of oval section. There is a long diastema between the canine and the first molar. "The (molar) teeth are small, single-rooted, and narrow from side to side; the root is deep and closely fits its alveolus." "The crown is of an irregular oval shape, widest in front, where it is about three-quarters of its length. There are four cusps arranged longitudinally and forming the outer side of the tooth; .... the first was much the largest, and they gradually decline in size and height to the fourth. On the inner side is a strong cingulum. This shows a very faint crimping".

Type. Imperfect dentary.

Locality. Witkop, Albert, C. P.

Horizon. Red Beds.

Tritheledon riconoi, Broom.

Text fig. 7.

1912. Broom. Ann. S. Afric. Museum VII, 5, p. 334, Pl. XXII, figs. 30–36.

The type of this form is a "portion of a left maxilla with the roots of 7 teeth and two imperfect immature teeth, portion of the left jugal, and a fragment of the left palatine" from Paballong, Mount Fletcher District, Griqualand East, which is in the collection of the South African Museum.

In 1914, the discoverer of this fragment, the late Dr. M. Ricono, forwarded to the Museum a small parcel containing a portion of a skull and eleven dissociated vertebrae from Paballong, all of which undoubtedly belong to the same animal as the fragment described by Dr. Broom. Dr. du Toit, who has since visited the locality, informs me that the fossil came from the Red Beds. It was found within a quarter of a mile of the spot from which the type of *Sphenosuchus acutus* came, and from an horizon within 10 or 12 feet of it.

This new skull fragment consists of the greater part of the right maxilla including the palatal portion, the base of the jugal arch, part of the left maxilla, and a portion of the right palatine. The first seven molars are present. They agree with the description given by Dr. Broom as far as can be seen from the crowns of the 4th and 6th teeth, which are the only teeth preserved entire. The 7 teeth occupy a length of 15·2 mm.

In front of the 1st. molar there is a markedly concave diastema of which a length of 9 mm. is preserved. There is no remnant of the canine present, and if the base of the canine was on the same level as the base of the molars, the diastema would probably have been about 12 mm. long. It has a maximum height of 4 mm. above the base of the teeth.

The maxillary part of the palate is complete on the right side. It is 18 mm. long, and narrows slightly anteriorly. Between the bases of the 1st. molars the palate, when complete, had a width of 26·5 mm., while at the point of junction of the maxilla with the premaxilla the width was 22 mm. The alveolar part of the bone which contains the roots of the molars is fairly massive, but the palatal portion of the bone has a thickness of but 2 mm.

In front of the maxilla a small palatal fragment of the premaxilla is preserved, while posteriorly a section of the right palatine is seen forming a vertical wall to the narial passages and curving downward and inward to form part of the secondary palate, articulating on the palatal surface with the maxilla. The vault of the palate is low, being a flattened concavity.

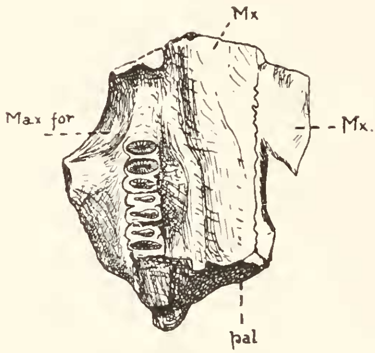


Fig. 7. *Tritheledon riconoi*, Br.
Palatal view of right maxilla.

By placing the type specimen in its correct position with respect to this fragment it is seen that in all probability the first molar tooth on the type is in reality the second molar of the animal. It would thus appear that this form has 10 molars; for it is improbable that any are missing from the posterior part of the type, the alveolar border of the maxilla thinning away rapidly behind the last of the series displayed.

All the vertebrae preserved are incomplete. The largest — probably from the mid-dorsal region — has a centrum 34 mm. long, whose ends are 22 mm. high and 20 mm. broad. The ends of the centra are slightly concave. The centra are regularly constricted, the median width being 16 mm., and along the ventral surface is a well-defined median longitudinal grove, which broadens at the two ends. The centra are relatively longer than those of *Cynognathus.*

The neural canal is well-defined. The transverse processes are placed midway along the vertebra, and arise at the level of the top of the centrum. The base of the process occupies at least two-thirds of the entire length of the centrum. No zygapophyses are preserved.

Type. Skull-fragment S.A.M. Cat. No. 1885.

Locality. Paballong, Mt. Fletcher, Cape Province.

Horizon. Red Beds.

LYCORHINUS ANGUSTĪDENS, gen. et sp. nov.

Text fig. 8.

The type of this new form consists of a portion of the left ramus of the lower jaw of a Cynodont from Paballong, Mount Fletcher, presented to the Museum by the late Dr. M. Ricono. The fragment shows the canine, 7 molars and the impressions of 4 others, making 11 in all. The ramus lacks the lower border, and is broken off anteriorly at the front of the canine and posteriorly at the ninth molar.

The canine is long and powerful, with a long root, and curves

Fig. 8. *Lycorhinus angustidens*, Htn.
Type dentary.

slightly backwards. The point is absent and the inner anterior side of the upper sixth is bevelled off by rubbing against the canine of the upper jaw. In section the tooth is oval with the longer diameter along the jaw. The anterior border is ridged and serrated for the greater part of its length; the posterior border is also ridged, but is unserrated.

Close behind the canine, separated from it by a diastema measuring at the most 1·5 mm, come the molars. They are all of the same pattern, increasing gradually in size to the fourth, and decreasing from the eighth. The roots are long and nearly circular in cross-section. Half-way up the crown on the inner side is a cingulum above which the crowns are laterally compressed, so that seen from above they are considerably longer than broad. Above the cingulum on the inner side the crown slopes upwards and outwards and the thinning of the crown thus produced is also accentuated apparently by a somewhat inwardly-directed slope of the outer face. Each molar from the 4th onwards is provided with two cusps, a large anterior cusp occupying two-thirds of the grinding surface, and a much smaller, somewhat lower posterior cusp. On the inner face there is a groove running between the ridges which descend from the cusps to the cingulum. The second and third molars are provided each with an additional cusp in advance of the large one which has been called the anterior cusp; and to a lesser extent this feature is also seen on the first and fourth molars. The crowns are but scarcely worn. The outer side is unfortunately not seen, but its general characteristics can be obtained from the impressions of the 8th, 9th, and 10th molars.

The total length of the fragment as preserved is 46 mm. The crown of the canine is 19·5 mm. high, and 7 mm. long at the base. The first ten molars together occupy a length of 33 mm. At the canine the depth of the dentary was about 17 mm.

Type. Portion of lower jaw with teeth. S.A.M. Cat. No. 3606.

Locality. Paballong, Mount Fletcher, C.P.

Horizon. Red Beds.

Super-Order ARCHOSAURIA.

Fam. SPHENOSUCHIDAE nov.

Sphenosuchus acutus, Htn.

Text figs. 9—16.

1915. Haughton. Ann. S. Afr. Mus. XII, 3, p. 98.

Since the original description of this form was published a certain amount of additional development has been done upon the type specimen, which necessitates slight additions and emendations. It has been thought best, therefore, to recast the description.

The skull is somewhat crushed but nearly whole, and shows all the external details. It is larger than that of ***Euparkeria***, and is comparatively more pointed, longer, and narrower. The orbits are rounded, and wholly in the posterior half of the skull. The supratemporal fossa is elongate, oval in shape, and larger than that of ***Euparkeria*** or ***Ornithosuchus.*** The shape of the infratemporal fossa is characteristic in that its anterior border, formed by the jugal and postorbital, passes upwards and forwards instead of upwards and backwards as in ***Euparkeria*** and ***Ornithosuchus***; so that the superior length of the opening is about equal to the inferior length.

The snout is characterised by the fact that the premaxilla does not form an anterior border to the nostrils, these being quite terminal. Further, there is no trace of a median septum dividing them. The roof of the snout is formed by the paired nasals, which are broken posteriorly. The extreme tip of the left nasal is missing but the bones were obviously pointed in front. The whole of the

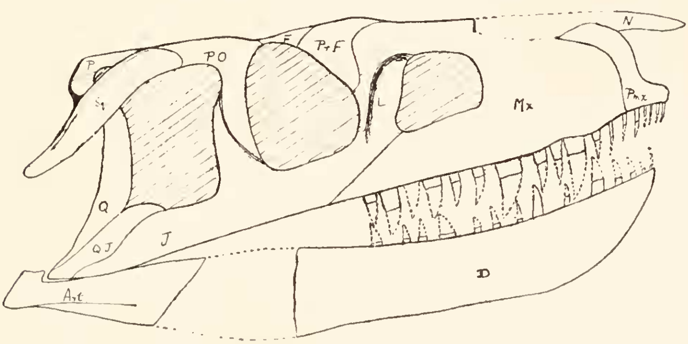


Fig. 9. Side view of skull of *Sphenosuchus acutus* Htn. × ½.
(Slightly restored.)

posterior and lower borders of the nostril are formed by the premaxilla, which sends back a process separating the forward portion of the maxilla from the nasal. The nostril seems to have had an upper prolongation between the nasal and premaxilla. The premaxilla carries apparently three or four simple pointed teeth.

There is no septomaxilla present on the face.

The antorbital vacuity is large, and is sunken in the face, having borders which make an oblique angle with the sides of the face. The whole of the anterior and lower borders is formed by the maxilla, which extends back only as far as the front of the orbit — not nearly so far as in *Euparkeria*. The maxilla carried about 12 teeth, of which 8 are preserved on the right side. Unfortunately, not one possesses the crown; but a small tooth in the lower jaw shows serrations on the anterior border similar to those of the carnivorous Dinosaurs. The teeth are flattened laterally, and vary considerably in size. The first maxillary tooth has an antero-posterior diameter of just over 1 mm.; the probable 6th, which is the largest, has a diameter of 7·5 mm. The teeth do not increase nor decrease regularly in size from front to back of the jaw, but are variable.

The surface of the maxilla is plentifully supplied with grooves and small foramina for blood-vessels.

The nasal is an extremely long bone forming the upper surface of the skull from the tip of the snout nearly to the plane of the

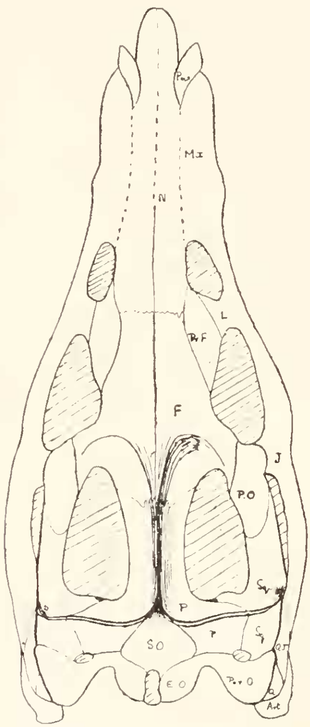


Fig. 10. Top view of skull of *Sphenosuchus acutus* Htn. × ½. (Slightly restored.)

front of the orbit. It forms none of the posterior border of the nostril. The greatest width across the pair of bones is 20 mm. — at the back — while the length is about 88 mm.

The lachrymal forms the whole of the upper border and most of the posterior border of the antorbital vacuity, besides forming the larger part of the anterior orbital border.

The prefrontal is a small bone lying between the frontal, nasal, and lachrymal. Below it has a lobe-like extension articulating with the lachrymal, so that it forms about 18 mm. of the orbital border; but its width throughout most of its length is only about 6 mm.

I can see no evidence of a postfrontal. Even if one be present the frontal is still peculiar in that it passes back to form part of the anterior border of the upper temporal fossa, separating the postorbital from the parietal. The interorbital region has a median elevation, broadened at the level of the postorbital bars, and narrowing posteriorly until it forms the median parietal crest. On each side there is a slight supraorbital crest; and between this and the median ridge is a well-defined channel. The frontal forms half of

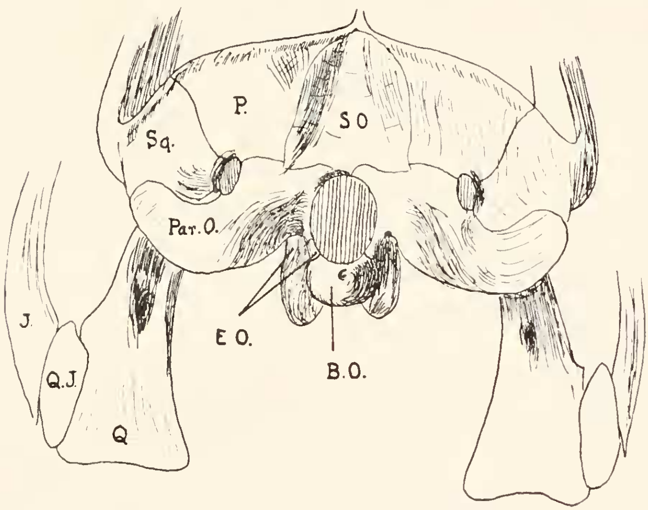


Fig. 11. *Sphenosuchus acutus*, Htn.
Occipital view of skull. × 1.

the supraorbital border. Its greatest length is in the middle line, the sutures with the parietals passing well forward from a point one-third along the parietal crest nearly to the anterior extremity of the supratemporal fossa.

The postorbital bar differs from that in *Euparkeria* and the allied forms in that its upper end is in advance of the lower. The descending portion of the postorbital is thus inclined backward instead of forward, lying in front of the ascending process of the jugal. The postorbital forms most of the outer border of the upper temporal fossa and a small portion of the upper border of the lower opening, anteriorly articulating with the frontal, and posteriorly overlying a part of the squamosal. Nowhere does it meet the parietal.

The jugal is a tripartite bone. Its anterior process forms the inferior border of the orbit, and articulates with the lachrymal and the maxilla It does not pass up in front of the orbit as in *Euparkeria.* The ascending process lies behind and superiorly internal to the postorbital and is inclined slightly forward. The posterior process forms most of the zygomatic arch, lying outside the quadrato-jugal.

The lower temporal opening has a rhomboidal shape, being bounded by the postorbital, jugal, quadrato-jugal, quadrate, and squamosal. It is slightly bigger than the upper opening.

In both *Euparkeria* and *Ornithosuchus* the quadrato-jugal is a fair-sized bone whose articulation with the jugal passes downward and forward, and which passes up in front of the quadrate to meet the squamosal. In this form, however, the quadrato-jugal is a comparatively small flat bone which lies in the lower posterior corner of the lower fossa and whose articulation with the jugal passes downward and backward. It lies under the jugal and overlaps part of the quadrate. There is no foramen between it and the quadrate.

The quadrate is a long, strongly developed, fixed bone with a somewhat expanded lower end. Its upper end is fixed between the squamosal and the opisthotic. The external surface shows a well-marked longitudinal depression at the lower end of the upper half. The front edge of the bone is thin, the posterior border well rounded.

The squamosal is a strong bone, articulating with the postorbital, quadrate, parietal, opisthotic, paroccipital, and exoccipital. It forms the outer posterior corner of the skull, *i. e.* half the outer and posterior borders of the supratemporal fossa. It passes over on to the occipital plate and takes part in the border of the small posttemporal foramen.

The parietal has a strong median crest which divides posteriorly and forms the upper border of the occipital plate. The bone passes over this lateral crest to form part of the occipital plate. It articulates on the plate on the inner side with the supraoccipital, on the outer with the squamosal, and below with the exoccipital, forming a small part of the border of the posttemporal fossa. Anteriorly the bone articulates with the frontal, and below with the opisthotic and alisphenoid. As in *Ornithosuchus* there is no interparietal,

The foramen magnum is an oval opening 12 mm. high and 10 mm. broad, lying high in the skull but well in the lower half of the occipital plate.

The supraoccipital forms a very small portion of the upper border of the foramen magnum. It is a triangular bone with a narrow short shaft passing down to meet the foramen magnum. Its apex lies under the bifurcating ridge of the parietal. The surface is slightly concave.

The suture between the exoccipital and paroccipital process is not to be seen. The latter is fairly high and fairly thin; its outer corner is bent almost horizontally and rests on the backwardly-directed part of the squamosal.

The basicranial region differs from that of the Theropodous Dinosaurs as exemplified by *Plateosaurus erlenbergensis.*

The basioccipital forms the majority of the rounded condyle, which lies wholly below the foramen magnum and is slightly hol-

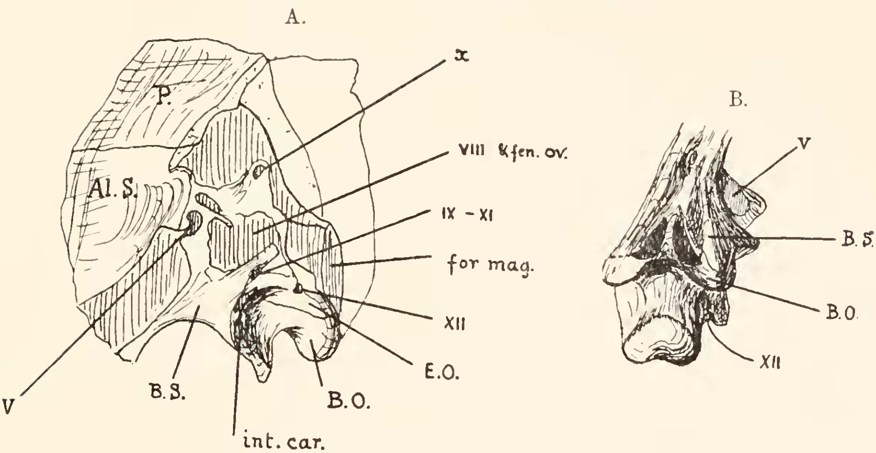


Fig. 12. *Sphenosuchus acutus*, Htn.

A. Side view of basicranium and brain-case.

B. Ventral view of basicranium.

lowed out in the middle of its hinder surface by a small notochordal pit. The bone also forms the base of the foramen magnum. Anteriorly it thins considerably and then thickens again; seen from the side its lower border is very strongly concave. The basioccipital tubera are strongly projecting and between them the transverse ridge is deeply hollowed out. The tubera are formed wholly of the basioccipital, in strong contra-distinction to those of *Plateosaurus* and are thus somewhat reminiscent of the tubera in the Anomodontia. This likeness is further intensified by the fact that the basisphenoid sends back a process on either side to support the anterior wall of each tuber. Between these basisphenoidal processes and anterior to the transverse ridge the basioccipital rises considerably so that seen from below it has a deep central pit. This pit is triangular in shape with its base behind and its apex in front. The base is formed wholly by the basioccipital. The upper portion of the sides is also formed by the basioccipital, but the larger, lower portion is formed by the basisphenoid. Superiorly this pit divides into two canals separated by a rod of bone which passes upwards from the transverse basioccipital ridge and then turns forwards. The openings to the canals are elongate vertically. Superiorly the basioccipital meets the exoccipital. On the left hand side of the skull the suture can be seen running from just below the top of the condyle — the exoccipital forming a very small portion of the condyle — forwards and slightly upwards to a point above the basioccipital tuber, and then passing downwards so that the exoccipital forms part of the lateral ridge running down to the tuber and meets the basisphenoid. The exoccipital forms all the lateral border of the foramen magnum, and the two almost meet above the foramen. The foramen for the XIIth nerve (hypoglossus) is single and small.

The basisphenoid sends back two processes as supports for the tubera, as mentioned above. In front of these the bone narrows somewhat and then sends forward the two pterygoid apophyses. At its narrowest the bone is deeply grooved in the median line. The lower border of the pterygoid apophysis bends down sharply.

Between the exoccipital and the basisphenoid on the side is a small foramen, presumably that of the carotis interna. Between the exoccipital and a dumb-bell shaped piece of bone forming part of the side wall of the brain and seen in oblique section is another foramen. The bone is probably a portion of the prootic, and the foramen, which lies above and slightly in advance of the supposed foramen for the carotis interna, is probably the foramen lacerum for the IXth–XIth nerves. On the dorsal side of this bridge of bone is a large irregular shaped opening which I take to be the fenestra ovalis and the opening for the VIIIth (auditory) nerve. Anterior to this and looking downwards and forwards is the large circular foramen ovale for the Vth (trigeminal) nerve.

Anterior to the foramen magnum the brain case heightens rapidly. Posteriorly it is considerably constricted and above the foramen ovalis the bone of the side-wall is pierced by a small circular opening, probably for a blood-vessel. Anterior to this the brain-case expands laterally and is bounded by the parietal above and the alisphenoid on the side — the two bones being divided by a straight horizontal suture.

The condition of the basicranium is somewhat similar to that seen in *Thecodontosaurus antiquus*, but differs in that the basisphenoidal tubera are placed further back and more ventrally in this new form, so that the lower surface of the basioccipital instead of passing almost entirely forward has a very concave profile when viewed from the side. The basisphenoid, too, differs in that it is longer in comparison with its width, neither the outward ridges of the bone which lead to the tubera nor the forwardly directed pterygoid apophyses diverging at so great an angle from each other as in the higher form.

The postpalatal vacuity lies directly below the orbits, and has a length of 26 mm., and a width of 9 mm. Almost the whole of its inner border, its anterior border, and part of its outer border are formed by the palatine. Its hinder border, and the remainder of the outer border is formed by the transpalatine.

The internal nares are not seen, but must have been considerably in advance of the postpalatal vacuity.

The anterior prolongation of the pterygoid passes far forward as a narrow bone with a rounded keel, separated from its neighbour by a well-marked groove. At the level of the front of the postpalatal vacuity it begins to broaden out and passes back as a gradually broadening plate articulating with, and lying below, the palatine. Posteriorly the mesial rounded keel becomes less pronounced and the platelike portion of the bone has a slight median depression.

The palatine is not wholly displayed. It articulates with the pterygoid internally, with the maxilla externally, and with the transpalatine posteriorly, forming the anterior and inner borders of the postpalatal vacuity. The front part of the bone carries a pronounced ridge which runs zig-zag across the bone with deep hollows in front and behind. There is no evidence that this ridge carried teeth.

The transpalatine is a stout bar with a strong expanded articulation with the maxilla externally. It separates the postpalatal vacuity from the large pterygoid vacuity; internally it is broken off, but the impression of the upper surface of the bone on the matrix remains in part, and it seems to have met both the palatine and the pterygoid.

Of the whole palate the premaxilla, maxilla, and prevomer form but a small part: in this, as pointed out in an earlier paper, the form agrees with *Erpetosuchus* and differs from *Ornithosuchus*.

The lower jaw is incomplete. About 100 mm. of the right ramus is anchylosed to the anterior 40 mm. of the left ramus, while a small portion of the back of the jaw is attached to the left quadrate. I am thus unfortunately unable to say whether or not a fossa was present. Remnants of 12 teeth are preserved on the right dentary, and of 5 or 6 on the left. Of these latter the 4th is small and nearly complete. It shows that the teeth were flattened, pointed, and simple, provided with serrations on the anterior border. The dentary forms the whole of the anterior half of the outer surface and thickens in front to meet its neighbour over the whole of the symphysis. The splenial forms a large part of the inner surface of the anterior half of the jaw, but takes no part in the symphysis. It has a straight articulation with the dentary along the lower border of the jaw. The fractured end shows a small part of the angular lying within the splenial and dentary. There is a postarticular process passing behind the extremity of the quadrate.

Fig. 13. *Sphenosuchus acutus*, Htn.
Anterior caudal vertebra. × 1.

Vertebrae. The anterior cervical vertebrae have been displaced and the centra are missing. The elements of the atlas cannot be distinguished, although a small curved bone lying on the right exoccipital is probably a part of the pro-atlas. The dorsal spine of the axis is preserved. It is 30 mm. long, higher in front than behind, and overlaps the 3rd. cervical. This latter shows well-developed, strong anterior zygapophyses, shorter postzygapophyses, a straight flattened dorsal spine, and a well-marked neural canal. The dorsal spines of the 4th and 5th cervicals are also present. They are like that of the 3rd cervical, slightly expanded at the crest, with a shallow groove running down the posterior border. The anterior ribs are double-headed.

There is an anterior caudal preserved (Text fig. 13). It is 16 mm. long and has a total height of 37 mm. The body is somewhat constricted in the middle, having a minimum width of 8 mm. The ventral surface is broadly rounded. The ventral border is concave with the posterior end lower than the anterior. The anterior surface is concave. The posterior surface is concave in the middle, but its border slopes away to the edges of the surface so that its outer half is convex. There is thus a large surface for articulation with the haemapophysis below the concave portion of the posterior face of the centrum. The neural canal is circular in cross-section. The transverse processes rise high up and pass outwards, slightly upwards and slightly backwards. They are long, narrow, and thin. The zygapophyses diverge from each other strongly. The prezygapophyses have flat upper faces which look inwards. The neural spine is high

Fig. 14. *Sphenosuchus acutus*, Htn.
Internal view of left scapula. × 1.

and thin, narrower and higher than is usual in the Dinosauria or Crocodilia. Its base is broader posteriorly than anteriorly, and lies wholly in the hinder two-thirds of the neural arch. The width across the transverse processes is 30 mm.; that across the prezygapophyses is 12·5 mm.; the length of the upper border of the dorsal spine is 8 mm.

Shoulder girdle. The shoulder girdle is preserved entire, and consists of two scapulae, two coracoids and an interclavicle.

The scapula is 81 mm. long and expanded both at its proximal and distal ends. The width of the distal end is 43 mm., of the proximal end 40 mm., while the narrowest part of the shaft — which occurs just above the proximal expansion — measures but 15 mm. in width. There is no acromion process.

The bone figured and described in the original paper as a clavicle is in reality a coracoid. The left coracoid is perfect save for the extreme distal point. The coracoid is a long, thin bone, whose shape can best be understood from the figure. The ventral margin is slightly convex and thin. Above this thin border the bone swells

Fig. 15. *Sphenosuchus acutus*, Htn.
Inner view of left coracoid. × 1.

and on the outer side there is a very slightly roughened elongated surface apparently for the insertion of the coraco-brachialis muscle. Above the interclavicular portion the anterior border is concave to a point directly below the coracoid notch, and then is again somewhat concave, the two curves being separated by a well-defined obtuse angle. The upper border of the post-glenoid prolongation is slightly concave. Anterior to what is apparently the scapular articular surface there is a small coracoid notch measuring only 2·5 mm. in diameter, and beyond this is a thin spatulate pre-glenoid prolongation with a length along its upper border of 11 mm. The greatest length of the bone is 77 mm. The width at the coracoid notch is 13 mm.; that at the broadest part of the postglenoid prolongation is 14 mm. The length of the postglenoid process is 45 mm. while that of the interclavicular articular surface is 37 mm.

This coracoid differs from that of any known forms. In the Phytosauria the coracoid is rounded in form and has a large coracoid notch, and the pre-glenoid portion is much longer than the postglenoid. In the Pseudosuchia the form is variable. *Ornithosuchus* has a rounded coracoid with a short posterior ventral process, and a supracoracoid foramen. *Euparkeria* has a large rounded coracoid. *Schleromochlus* has a long, flattened, rod-like coracoid like those of the Birds and Pterosauria. In the Crocodilia the coracoid approximates somewhat to that of *Sphenosuchus*. It also is composed of two expanded ends joined by a relatively narrow neck. But in the Crocodilia the bone is much higher and relatively shorter, and there is a foramen instead of a coracoid notch. This latter feature, however, is variable in the Crocodilia; for Andrews has figured two species of *Metriorhynchus* from the Oxford Clay, one of which has a coracoid notch and the other a coracoid foramen. In none of the Triassic Coelurosauria is the coracoid known; but in *Aetonyx* and other Triassic Saurischia it is a large rounded bone with a supracoracoid foramen, somewhat similar to that of *Euparkeria*. The South African form which most closely approximates to *Sphenosuchus* in this respect is *Notochampsa*.

Humerus. The humerus is 113 mm. long. The proximal end is broad; in the inner view it is seen to be hollowed out between the delto-pectoral crest and a well-marked ridge which runs down on the inner side from the proximal condyle. The delto-pectoral crest lies considerably below the level of the head of the bone, so that the proximal expanded portion occupies two-fifths of the total length. The shaft is slightly curved, and oval in cross-section, the distal end being more strongly bent than the proximal. In the narrowest part the shaft has a diameter of 10 mm. The distal end is but slightly expanded and shows two distinct rounded condyles, of which the inner is much the larger. Seen in lateral aspect, the bone presents somewhat the appearance of that of *Ornithosuchus*, but it is longer, more slender, and the distal condyles are more rounded.

Tibia and *Fibula.* There is also preserved a tibia and the distal third of a fibula from the same limb. The tibia is a long, thin bone slightly curved, with an expanded proximal end, and a robust distal end. Its greatest length is 120 mm.; the distal end is 15 mm. wide, the shaft 9 mm., and the proximal end 29 mm. The tuberositas tibiae is the highest point of the bone. From it the articular surface slopes downwards, gradually being rounded off into the posterior face of the bone. The inner edge of the proximal surface is evenly rounded: on the anterior half of the outer edge there is a prominent lateral condyle from which a short, prominent ridge passes down on to the shaft. This condyle lies well below the level of the head of the bone. At the distal end there is a differentiation into two processes, one of which lies higher than the other, as in the Triassic Saurischia; but the step from one to the other is not so deep as in, say, *Thecodontosaurus*.

A B

Fig. 16. *Sphenosuchus acutus*, Htn.
A. Inner view of left humerus.
B. Outer view of right humerus.
Both figures × ½.

The distal portion of the fibula shows the bone to have been more slender than the tibia. The distal end is slightly expanded. The bone is oval in cross-section.

Type. Skull and part of lower jaw with bones of the shoulder girdle, part of fore limbs, and part of hind limb, with vertebrae and rib fragments. (S.A.Mus. Cat. No. 3014.)

Locality. Paballong, Mount Fletcher, Cape Colony.

Horizon. Red Beds.

Affinities. In the general form of the skull *Sphenosuchus* agrees with most of the members of the super-order Archosauria, i.e. in the possession of supra-, infra-, and post-temporal arcades and vacuities.

In some Dinosaurs the post-temporal vacuity is closed. In *Sphenosuchus* it is very small, much smaller than in the Phytosauria or genera like *Euparkeria.*

The skull has a smaller quadrato-jugal than *Euparkeria*, but shows an advance on that form in the loss of the interparietal and the reduction of the lachrymal.

Chief interest lies, however, in the post-cranial part of the skeleton and in the lack of armour. This latter feature is noteworthy as the larger number of the genera comprising the order Thecodontia, to which this form was originally assigned, possess armour in the form of scutes which are sometimes numerous and heavy. No armour has, however, yet been seen in *Thecodontosaurus*, *Massospondylus*, and the genera of the Saurischia.

The shape of the coracoid (erroneously described in the original description as the clavicle) is unique among reptiles, and strongly resembles that of many Birds. Among Reptiles, it is approximated most closely by the bones in *Notochampsa* and the Crocodilia. *Euparkeria* has a rounded coracoid, and so has *Massospondylus*, so that *Sphenosuchus* cannot be ancestral to the latter nor to the Saurischia. Its humerus and tibia, however, are more like those of the Saurischia and *Massospondylus* and its allies than other Archosauria; and the shape of the distal end of the tibia shows that the astragalus was probably fairly immovably fixed to the tibia. Further, the possible lack of clavicles is important. The other bones of the scapular arch are so well preserved and so nearly in place that it is scarcely possible to suppose that bony clavicles, if present in the living animal, were not preserved. Lying anterior to the arch and dissociated from the scapula and coracoid is a thin elongate bone — not complete — which might be a clavicle or a neck rib or even a long bone of the hyoid arch similar to the ceratobranchial described by Broom in *Euparkeria*. The absence of clavicles would remove the form altogether from the order Thecodontia. Further, it could only be put with difficulty into the Saurischia on account of its peculiarly specialised coracoid, which must be taken as a proof of a certain similarity in musculature between this form and the Birds. On the other hand, the coracoid is more elongate and birdlike than that of *Archaeopteryx*, which has already acquired feathers; and it is probable that this peculiarity in the coracoid of *Sphenosuchus* is merely a specialisation which was not a step on an advance from the Reptile to the Bird. The absence of clavicles would prevent *Sphenosuchus* from being on the direct line of evolution of the class Aves.

Taking all the facts into consideration, it is necessary to found for the genus a new family, which may be called the *Sphenosuchidae*, and which on account of the uncertainty as to the occurrence or absence of clavicles, cannot be satisfactorily included in any of the defined orders of the Archosauria.

Fam. NOTOCHAMPSIDAE, nov.

Notochampsa istedana, Broom.

Text fig. 17, 18.

1904. Broom. Geol. Mag. Dec. V, Vol. I, p. 502.

The only hitherto-published description of *Notochampsa* is that by Broom who gave a very brief notice of the two forms from the Stormberg Beds which he included in the genus. At the time of writing that paper, the remains of the larger animal (*N. istedana*) had not been completely developed, but Broom considered that enough was shown to place the forms in the Crocodilia (Mesosuchia of Huxley). A short time ago Watson suggested that the larger form was possibly not a crocodile at all, but was related to *Stegomus*. I have therefore further developed the fossil in the hope that it would be possible to settle its systematic position. There are now displayed the impressions of most of the bones of the top of the skull, most of the right ramus of the lower jaw with the whole symphysis, the shoulder girdle (right scapula, two coracoids, and an interclavicle), the proximal end of the right humerus, the humerus, radius, ulna, carpus, and metacarpus of the left side, part of the femur, tibia, and fibula of the left side, most of the dorsal armour, and some ribs. These remains merit a somewhat fuller description than that already given.

Skull. Unfortunately, although further development has shown a little more of the top of the skull, nothing can be seen of the structure of the palate.

In the middle line, as preserved, the skull has a length of 101·5 mm., while its greatest length is 117 mm. The length of the lower jaw from the symphysis to the articular surface is only 106 mm. Little, therefore, can be missing from the front of the snout although the anterior borders of the nares are not seen. The nares must, in consequence, have been almost terminal. In his restoration of the skull Broom figures the nares as being typically crocodilian, i.e., coalesced into one central opening in the premaxilla, and thus adds about 14 mm. to the length of skull as preserved. This, I think, is a misinterpretation of the structure because, in the first place, the disparity in length between the mandible and skull becomes too great and, secondly, there seems to be sufficient evidence in the nasal region itself to prove that the nostrils were separate and somewhat lateral. The whole structure of the remaining portion of the snout seems to point to this conclusion. On the righthand side the im-

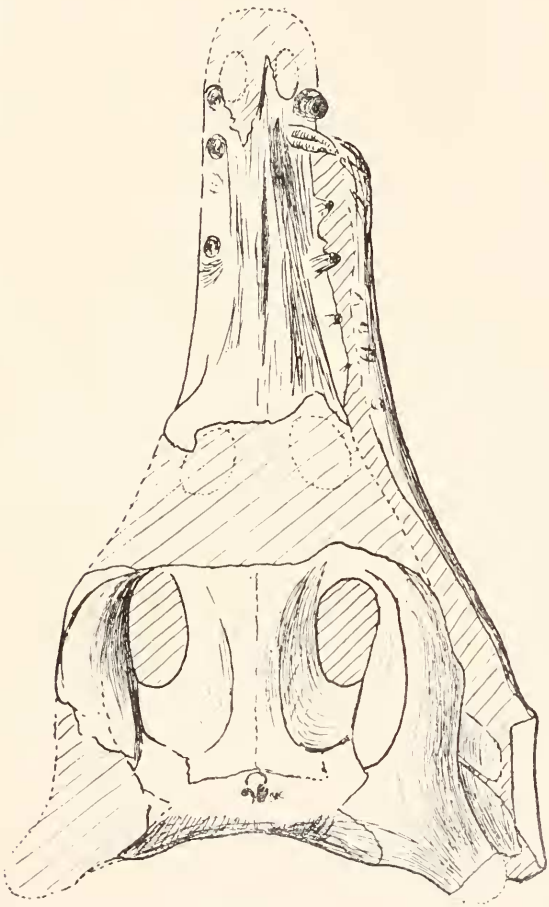


Fig. 17. *Notochampsa istedana*, Br.
Top view of skull. × 1.

pression of the bone is excavated as if it were the posterior border of the nostril. This portion of the snout seen in profile is distinctly raised, whereas the remainder of the snout is slightly concave along the median line, and between the nostril and the centre line is a shallow concavity. If this reading of the structure is correct, then the nostrils were somewhat laterally placed and separate as in the Pseudosuchia. It demands an additional length of about 5 mm. to the tip of the snout, thus making the upper and lower jaws more commensurate than does the earlier restoration.

The snout is fairly long, and tapers slightly anteriorly. Most of its upper surface is formed by the nasals, which are separated by a long median suture, and terminate behind in a digitating suture with the frontals.

The maxilla bears a number of teeth, about 8 or 9 in all probability. The first two preserved on the right maxilla are large teeth with long roots each set in its own socket, and with backwardly-curved pointed crowns somewhat oval in section. There were no prominent anterior or posterior edges. The posterior teeth were smaller than the others, but there is no regular diminution in size.

The snout is broken off anterior to the orbits, and the whole of the orbital region is missing. Just anterior to the hiatus the snout swells laterally and becomes raised on the two sides, the median depression remaining constant. The lateral prominences look to be each the impression of a separate bone, although sutures are extremely difficult to delineate. Each contains a portion of the bone figured by Broom as lachrymal, and each is probably wholly a prefrontal. If this be so, the lachrymal was wholly on the side of the skull.

Only the impressions of the lower surface of the bones surrounding the vacuity are present.

The upper temporal vacuities are present. Their anterior borders are formed by the postorbitals. Broom figures the squamosal as forming the whole of the bar between the upper and lower temporal fossae: but on the right hand side there is a well-marked separation between the bone forming the inner part and that forming the outer part of this bar, and the separation is seen also in part on the left hand side of the skull. The inner of the bones I take to be the upper portion of the quadrate, which just meets the postorbital anteriorly, and has the relations of the quadrate in the recent Crocodilia. Externally and posteriorly it articulates with the squamosal.

The squamosal also passes outwards, backwards, and downwards to form the posterior border of the lower temporal vacuity and to meet the quadrate. On the inner side it meets the supraoccipital and exoccipital.

The parietal bar is very broad.

The quadrate is partially displayed. The form of its articular surface is not seen. The inner edge of the bone is bent upwards to meet the squamosal; and its other relations have been stated above.

The lateral temporal opening was long and fairly low. In it can be seen a portion of the quadrato-jugal, lacking the outer edge, and articulating with the quadrate.

The supraoccipital articulates above with the parietal in a fairly long suture. Ventrally it narrows rapidly and articulates on its oblique edges with the exoccipitals, which are apparently large bones.

The weathering away of the bone shows a canal opening into the auditory region between the quadrate and the parietal on the posterior border of the upper temporal opening, and this is continued into the post-temporal vacuity, bounded by the squamosal and parietal above and the exoccipital and supraoccipital below.

Mandible. Part of the lower jaw is preserved. The symphysis is fairly short, and formed apparently wholly by the dentaries. The lower jaw is slender, its deepest part being just behind the Meckelian cavity.

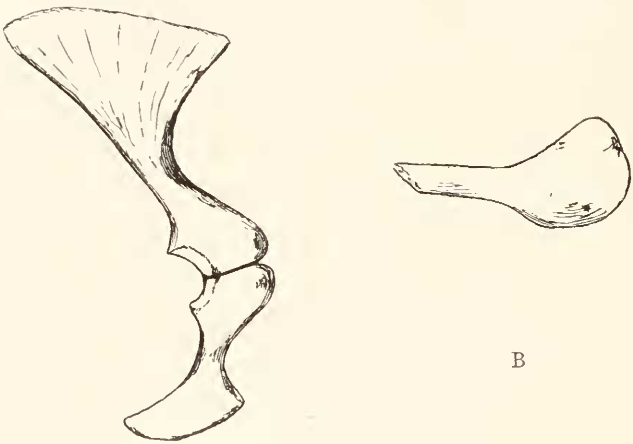
Of the right ramus, the dentary is wholly preserved. It meets its neighbour in a symphysis 12 mm. long. The alveolar border is straight and carries about 12 teeth of which 9 can be seen. The first two are in the position of incisors and point strongly forwards. The third is considerably larger than any of the others. Posterior to it the teeth seem to be of approximately equal size to one another. At the level of the last three or four teeth the dentary is extremely shallow, while it broadens again towards the Meckelian cavity, of which it forms the anterior half of the border. The ventral face of the symphysial region is convex from side to side, and pitted.

The splenials are not preserved; but the shape of the inner surface of the right dentary shows their approximate positions. The bone did not enter the symphysis. For over one-half its length it lay along the inside of the dentary. For a distance of 18 mm. it was separated from the dentary by the angular, lying along the inner surface of that bone almost to the level of the outer fossa.

The angular has relations with the other bones, as far as can be seen, similar to those in the Crocodilia. It forms the posterior border of the outer fossa, and passes on the ventral side below the dentary, separating it from the splenial. None of the other bones are seen.

Scapula. The right scapula is displayed in full, as well as the glenoid end of the left scapula. The bone is extraordinarily expanded at its upper end, and somewhat swollen below. The posterior border from the narrowest part of the bone upwards is almost straight, save at the upper extremity; but the anterior edge is strongly bent owing to the anterior prolongation of the upper part of the bone. The lower part of its anterior border is swollen and convex, while the articulation with the coracoidal element is almost straight. Approximately half the glenoid cavity is formed by the scapula. From the narrowest part upwards the bone is very thin. From the upper posterior corner to the middle of the glenoid cavity the scapula measures 43 mm. At its narrowest it is 4·5 mm. wide; at its upper border it is 30 mm. wide. The articulation with the coracoid measures 8·5 mm.

Coracoid. Both coracoids are seen. The bone is smaller than the scapula, strongly compressed and expanding considerably at each end.



A B

Fig. 18. *Notochampsa istedana*, Br.
A. Scapula and coracoid.
B. Proximal half of humerus.

It forms the lower half of the glenoid cavity. Anterior to the glenoid cavity and just below the articulation with the scapula the bone is pierced by the coracoidal foramen. The distal expansion is very broad, terminates in a convex border and is prolonged more posteriorly than anteriorly.

The coracoid has a length of 25 mm. in the middle line. Its lower border measures 15 mm., while its narrowest part has a width of only 3 mm.

The *Interclavicle* is a narrow elongated strip of bone, not wholly preserved.

Humerus. The humerus has a long, thin, flattened shaft with a considerably expanded upper end. The lower end is not preserved on either side of the body. The total length of the bone was probably about 60 mm. The maximum width at the proximal end is 14 mm., while the shaft is 4 mm. broad and 1·5 mm. thick as preserved. The head is rounded, and there is no very prominent deltoid crest although some distance below the head of the bone a slight crest was present. The anterior face of the expanded portion is concave.

The *radius* and *ulna* are both long, slender bones but slightly expanded at their ends. The bone lying as the outer of the two on the left-hand side of the body is slightly longer than the other, and this I take to be the ulna. The left forearm is lying parallel to the body with the elbow behind and the hand in front, bent almost at an angle of 150° to the plane of the humerus.

Radius. The radius has a length of 52 mm., while the middle of the shaft has a greater diameter of 2·5 mm. The bone is compressed and has its end expanded to a width of about 4 mm. Save at the lower end, where it is slightly curved away from the ulna, it is straight throughout its length.

Ulna. The ulna is a slightly curved bone 54 mm. long, apparently somewhat more slender than the radius, but with similar expanded ends. Just below the surface for the articulation with the humerus the radial border is markedly concave.

Carpus. The carpus of the left side is partially displayed. Two bones of the proximal row can be seen, one below the ulna and one below the radius. These I regard respectively as the ulnare and the radiale.

The *ulnare* is an elongated bone with a narrow shaft and expanded ends. In cross-section it is apparently oval. Its length is 10 mm., the proximal width 4 mm., and the distal width 5 mm., while the shaft of the bone has a width in its narrowest part of less than 2 mm. The proximal articular surface has a small outer convexity, the remainder being hollowed out. The distal surface is cushion-shaped. Attached to the lower end of the bone is a small bone, oval in section as seen, 2 mm. high and 4 mm. broad, which may be the fused 3rd, 4th, and 5th carpals. The *radiale* is a similar hour-glass shaped bone 11·5 mm. long with its ends somewhat less expanded than those of the ulnare. The narrowest part of the bone is 2 mm. wide.

Metacarpus. Remains of all five metacarpals are seen. The third and fourth articulate with the bone lying below the ulnare, but not the fifth. Each metacarpal is an elongated bone with expanded ends. The first is 9·7 mm. long, the second 10 mm., the third 9·5 mm. and the fourth 8·3 mm., while the fifth is not fully displayed.

Femur. The distal half of the femur is slightly curved and has an expanded end, which was probably slightly cartilaginous. The preserved portion of the bone is 48 mm. long, and the distal end measures 11·5 mm. in its greatest diameter. The shaft at its narrowest is between 5 and 6 mm. thick. The outer condyle is larger than the inner and on the anterior surface between the two is a shallow, broad depression.

The *tibia* and *fibula* are both long, slender bones, longer and more robust, however, than the bones of the lower part of the fore-leg. The *tibia* has a length of 62 mm. Its shaft is long and straight; the proximal end of the bone is swollen to a thickness of 6·5 mm., and rounded. The distal end is somewhat crushed, but it is wider than the proximal end and has a protuberance on the fibular side. The *fibula* is a more slender bone, 60 mm. long, with slightly expanded ends.

Armour. The back was covered with a series of paired dorsal scutes, one of which was figured by Broom. There were apparently neither lateral nor ventral ossifications — at least, none are preserved on this specimen. Each pair of scutes covered one vertebra. Remains of 20 pairs are preserved, almost wholly as impressions of the under surface of the bone. Each scute was roughly rectangular, but towards the outer end of the posterior border there was a projecting process. From the twelfth pair onwards the width gradually decreases. The first scute is short, the second slightly longer. The 3rd is a little longer than the 4th or 5th. From this onwards the length is constant. The 11th. scute is 20 mm. broad and 9·5 mm. long at its inner edge. The 19th. has a breadth of 14·5 mm. and a length of 9 mm.

Affinities. In the elongation of the rostrum the form agrees with the Crocodilia and Phytosauria: but in the possession of paired and lateral outer nares it differs from the former, and in the short premaxillary and forward position of the nostrils from the latter. The elongation of the rostrum is a secondary character.

I am not able to determine with absolute satisfaction whether or not a preorbital vacuity was present. The orbit itself is absent, but both prefrontals can be seen. On the right hand side below the prefrontal on the side of the skull there is a distinct depression with superior, anterior, and inferior borders of bone. This may — and probably does — represent a preorbital vacuity, looking wholly outwards and placed below the orbit and but slightly in advance of it, a condition paralleled to a certain extent in the Phytosaurians *Mystriosuchus* and *Rhytidodon*.

The scapula is without parallel among Archosauria in the extreme broadening of its dorsal half. The coracoid has the general shape seen in the Crodilia; but an even greater departure from the rounded bone of the Pseudosuchia and Phytosauria is presented by the coracoid of *Sphenosuchus*, described in this paper, which is undoubtedly a Pseudosuchian of rather advanced type. In the possession of an interclavicle and the absence of clavicles *Notochampsa* agrees with the Crocodilia and differs from the Dinosauria, Phytosauria, and earlier Pseudosuchia.

The fore-limb is not Crocodilian in structure. The humerus in its expanded proximal portion with concave anterior surface, its deltopectoral crest well below the level of the head of the bone, and its narrow shaft is reminiscent of that of *Stagonolepis* which, however, departs from the normal Phytosaurian form and approximates to that of the Pseudosuchia and Saurischia.

The long and slender limbs show affinities with such forms as *Stegomus* and *Schleromochlus*, although the front limb approximates in length to that of the hind limb much more nearly than in the latter form. The genus herein differs greatly from the Jurassic Crocodilia.

The armour is peculiar in that it apparently consists only of two rows of scutes along the back. These are broader than long as in *Stegomus*, *Aetosaurus* and *Dyoplax*. Possibly, however, ventral armour was also present.

With the form described as *Pedeticosaurus leviseuri* by van Hoepen *Notochampsa* possesses several characters in common. Both have the snout somewhat elongate, with the nostrils separate, lateral, and nearly terminal. Both have thecodont teeth, of which the two just behind the premaxilla seem to be the longest and strongest. In *Pedeticosaurus* there is a small antorbital vacuity on the side of the face — smaller than in other Pseudosuchia — an arrangement which may, as stated above, be present in *Notochampsa*. There is also a general agreement between the two forms in the broadened distal end of the scapula, the long and slender bones of the upper arm and fore-arm, the elongate carpals, the comparatively short ribs, and the double row of plates down the back. The bone called by van Hoepen the left scapula appears to be more likely to be a coracoid. If that be so, it will agree with the coracoids of *Notochampsa* in its general shape, having two expanded ends connected by a narrower shaft. The hind leg in *Pedeticosaurus* is relatively somewhat longer than in *Notochampsa*.

The points of agreement are, I think, sufficiently numerous provisionally to place the two genera *Notochampsa* and *Pedeticosaurus* in the same family which must be called the *Notochampsidae*. This displays affinities both with the Pseudosuchia and the Crocodilia.

By von Huene the Crocodilia are thought to have been derived directly from the Aetosauria. Such a descent implies, among other things, elongation of the snout, the loss of preorbital vacuity, the loss of the clavicles, and the production of a typically Crocodilian coracoid. These changes are partly brought about and partly foreshadowed in the Notochampsidae: and although the limbs are not modified in the Crocodilian manner save in the lengthening of the carpals, it may be concluded with some degree of truth that the family occupies an intermediate position between the Aetosauria and the Crocodilia, possibly on the direct line of descent. It is unfortunate that nothing is known of the palate in either of the two members of the family.

Type. Skull and portion of skeleton and armour. (S. A. Mus. Cat. No. 4013).

Locality. Funnystone, Barkly East, C.P.

Horizon. Cave Sandstone.

PEDETICOSAURUS LEVISEURI v. Hoepen.

1915. van Hoepen. Ann. Transv. Mus. V, p. 83. Pls. XIII–XIV.

The type consists "of a nearly complete individual on two slabs of matrix. The fossil is an impression of the right side of the skull and limbs, and besides this, consists of some vertebrae, a few ribs, a great part of the tail and of dermal ossifications".

The skull is only seen in lateral view. It has a total length of abouth 90 mm. The snout is low and fairly long, the front of the orbit lying a little in advance of the middle of the skull. The orbit is large and rounded, the antorbital vacuity small with a straight lower border. The nostrils are almost terminal. The bar separating the upper and lower temporal vacuities is not clearly displayed. The lower border of the lower opening is formed mainly by a shallow jugal. Posteriorly this meets a bone, which, as preserved, has a free upper anterior end, and occupies the same position as the bone which I have called quadratojugal in *Notochampsa* and *Sphenosuchus.* Behind this is a portion of the quadrate with which the lower jaw still articulates.

The premaxilla carries three small teeth; the maxilla probably carries 16 or 17 teeth, of which the anterior two or three are large. All are pointed, backwardly curved, aud apparently unserrate.

The bone which van Hoepen has called a "hyoid" is apparently a double-headed anterior cervical rib.

The account given by van Hoepen of the post-cranial skeleton is correct save that the bone which he describes as the less-completely preserved scapula I take to be a coracoid, elongate in shape somewhat similar to that seen in the Crocodilia and in *Notochampsa*. It is also possible that the small fragment lying above the supposed coracoid and below the humerus of the other side is the impression of part of a small straight interclavicle. The assumption of the presence of a coracoid is justified by the long straight distal articular surface of the scapula lying anterior to the glenoid cavity; this is equal in length to the articular surface of the supposed coracoid, which has a comparatively narrow middle portion with strongly expanded ends.

If a coracoid be truly present, then an interesting comparison can be drawn between *Pedeticosaurus* and *Notochampsa*, as I have pointed out in the re-description of the latter form. *Pedeticosaurus* is a slightly smaller animal having, however, its hind legs longer and more strongly developed than those of *Notochampsa*. The resemblances are close enough to suggest a family connection, and I have therefore placed both genera in the same family.

I have to thank Mr. M. Leviseur and the Bloemfontein Museum authorities for permission to examine the type.

Type. Incomplete skeleton on two slabs in the Orange Free State Museum.

Locality. Rosendal, Senekal Distr., Orange Free State.

Horizon. Cave Sandstone.

Order CROCODILIA (?).

Erythrochampsa nov.

Erythrochampsa longipes (Broom).

1904. Broom. *Notochampsa longipes.* Geol. Mag. N. S. Dec. V. Vol. I. p. 582. figs. 2 and 4.

Pelvis. In his original description of this form, Broom says "the pelvis is typically Crocodilian in that the pubis does not enter the acetabulum. The ilium is of small size."

The pelvis as preserved is seen partly on the main slab and partly on a small piece of rock which was broken off in the development of the fossil for the purpose of examining the pelvis. This latter shows the two ischia, most of the two prepubes, and a portion of the left ilium (partly in bone and partly as a mould). The main slab shows moulds of these bones with small pieces of bone adhering.

The *ilium* is incomplete. It was a stout bone, nearly as large as the ischium, with a long dorsal border. There is a long pre-acetabular portion with a bluntly-pointed extremity.

The *ischium* is of the usual Crocodilian form. Ventrally it forms a long union with its fellow by means of a straight suture 15 mm. long. The ventral portion of the bone is a triangular plate with an acute posterior angle and a more obtuse anterior angle. The dorsal portion of the bone is bifurcated, with a larger posterior portion for articulation with the ilium, and a prominent anterior protuberance directed upwards and forwards for articulation with the unossified pubis.

On neither side is the prepubis complete. Each is a slender bone with a spatulate anterior portion. The two bones do not meet ventrally and must have been connected by cartilage. The proximal end is slightly expanded and lies at present some distance in front of the ischium and wholly disconnected from it. The length was 23·5 mm., and the greatest breadth at the spatulate end 4·5 mm., while at its narrowest the shaft is just under 1·5 mm. broad. The shaft is nearly circular in cross-section.

Femur. The right femur is partially preserved. It consists of a slightly bent shaft with somewhat swollen ends. The ends of the bone are spongy while the shaft is hollow — a condition which is seen in the other bones of the hind limb and the pelvis. The length is about 48 mm. The head is 4·3 mm. broad, the shaft 3·8 mm. In cross-section the shaft is a somewhat flattened oval. The distal end has two condyles separated by a well-marked intercondylar groove. The outer condyle is larger than the inner. The width of the distal end is 8 mm.

Tibia. The tibia is 4 or 5 mm. shorter than the femur. It is a very slightly curved shaft with an expanded proximal end flattened antero-posteriorly. The fibular side of the shaft is somewhat flattened, while the inner side is regularly curved. Distally the bone widens out. The breadth of the proximal end is 6 mm., while the width of the shaft is 3·5 mm.

Fibula. The fibula is approximately of the same length as the tibia, but is a much more slender bone. Between the shaft and the proximal end there is a narrow neck. The shaft has a longitudinal ridge on the inner anterior border. The distal end is not seen. The shaft is 2 mm. broad.

Tarsus. The structure of the tarsus is somewhat difficult of determination. The cleavage of the rock has broken the bones across the middle so that neither the dorsal nor palmar surfaces are seen. The *astragalus* is much larger than the *calcaneum*, which is a small bone with a small posterior tuber joined to the main body of the bone by a narrow neck. There are two other bones of which the one articulating with the calcaneum may be the cuboid and the other the reduced fifth metatarsal or the fused 4th and 5th tarsalia.

Metatarsus. Metatarsals I — IV are similarly elongated narrow cylindrical bones with slightly expanded ends. The 2nd and 3rd are larger than the others, while the 4th is the shortest. The lengths from the 1st to the 4th are 22 mm., 23 mm., 23 mm.. and 20 mm. respectively.

One phalanx of the 2nd. digit and two phalanges of the third are preserved. Each is a fairly long slender bone with concave proximal and convex distal articulation.

Armour. Portions of the dorsal and ventral armour are preserved. One of the dorsal plates has been figured by Dr. Broom. It has a width of 13 mm., and a length of 8 mm. in the middle line. Its dorsal surface is pitted save for the portion overlapped by the anterior plate. At the outer sixth the plate is bent downwards, the bend being strengthened by a dorsal ridge. The total width of the body was probably about 25 mm. The ventral plates are paired, but are smaller and more numerous than the dorsal plates. In the abdominal region each was about 9 mm. wide and 4 mm. long, while in the caudal region they were smaller.

The two forms described by Dr. Broom as *Notochampsa* were included in the one genus on account of resemblances between the dorsal plates. Further investigation shows that while the pelvis in "*N. longipes*" is typically Crocodilian the skull of *N. istedana* shows features which remove it from the true crocodiles. The question then arises, are the two forms congeneric? Dorsal plates are known, not only in the Crocodilia, but in the Pseudosuchia such as *Schleromochlus*, *Aetosaurus*, and *Euparkeria*; and it is doubtful whether they can be considered of generic importance. Unfortunately the pelvis is absent in the type of *N. istedana* and also in the allied type *Pedeticosaurus*. If Broom's *N. longipes* is to be kept in the genus *Notochampsa* then the genus must be considered to be characterised by the possession of a skull differing from that of a true Crocodile and of a typically Crocodilian pelvis. This is not impossible; but until more is known of these forms it would seem best to separate the two forms from one another, classing *istedana* as one of the higher Pseudosuchians and erecting, as above, a new genus *Erythrochampsa* for the more truly Crocodilian *Erythrochampsa longipes.*

Type. S. Af. Mus. N⁰. 445 f.

Locality. Eagles Crag, Barkly East, C. P.

Horizon. Red Beds.

Fam. THECODONTOSAURIDAE von Huene.

1905. von Huene. Zeitschr. d. dtsch. geol. Ges. LVII, p. 345.

Thecodontosaurus browni (Seeley).

1895. Seeley. ***Massospondylus* (?) *browni***, Ann. Mag. Nat. Hist., Ser. VI, vol. 15, pp. 102–132.

1906. von Huene. Geol. u. Pal. Abh. XII, 2, p. 45, figs. 82–85, Pl. XII (XIX), figs. 7–8.

1911. Broom. Ann. S. Afric. Mus. VII, 4, p. 293.

The type consists of two femora, 2 cervical vertebrae, a dorsal vertebra, 3 caudal vertebrae, and some foot-bones from the Telle River, separating Herschel from Basutoland. There is some doubt as to whether all the remains are from the same animal, and von Huene in his re-description has classed the vertebrae with *Thecodontosaurus skirtopodus.* From von Huene's account, the following are taken as the salient points of the form.

The femur is small, markedly S-shaped, with a compressed distal end and a sagittal groove which divides the articular surface. The bone is strongly compressed laterally. The fourth trochanter lies wholly in the upper half of the bone. The head is rounded and very thick. The length of the type is 24 cm.

Von Huene notes that the femur is as large as that of *Thecodontosaurus cylindrodon*, but at the distal end is smaller and has higher and smaller condyles than *T. skirtopodus.* The proximal end is smaller and thicker than in *T. antiquus* and *T. cylindrodon.*

Van Hoepen has described under the name of ***Massospondylus browni*** a fairly complete skeleton in the Transvaal Museum. I believe this to be a specimen of ***Massospondylus harriesi*** and have discussed it in my description of that form.

Type. Isolated bones in the British Museum.

Locality. Telle River, Herschel, C. P.

Horizon. Red Beds.

Thecodontosaurus skirtopodus (Seeley).

Text figs. 19, 20.

1894. Seeley. *Hortalotarsus skirtopodus.* Ann. Mag. Nat. Hist. (6). Vol. XIV, p. 411–419.

1906. von Huene. *Thecodontosaurus skirtopodus.* Geol. u. Palaeont. Abh. N. F. Bd. VIII, Hft. 2, p. 44, figs. 72–78. Pls. XII, XIII.

The type is a portion of a hind limb from Barkly East. Von

Huene has also described some vertebrae, humeri, a femur, and a tibia from "the Karroo formation" — now in the Vienna Museum — as members of this species.

Discussing the generic position of the form von Huene says "The form of the tibia is entirely characteristic of *Thecodontosaurus*; the long, laterally-directed projection at the proximal end, the broad lateral condyle at the proximal end, and the nature of the expansion of the proximal and distal ends are elsewhere only seen in *Thecodontosaurus* and *Anchisaurus*. The astragalus, also, corresponds closely with that of *Thecodontosaurus* from Bristol. I can see no ground for separating *Hortalotarsus* from *Thecodontosaurus*."

While collecting at Foutanie, Fouriesburg, O. F. S., Mr. A. R.

Fig. 19. *Thecodontosaurus skirtopodus* (Seeley).
Right ulna. × ½.

Walker obtained some bones from the top of the Red Beds. They comprise (S. A. M., Cat. No. 3429) some vertebrae, a scapula, the distal end of a humerus, an ulna, an ilium, part of an ischium, a femur and a tibia which belong to an animal somewhat smaller than, but closely comparable with, the type of *T. skirtopodus*. The bones are in good condition and worthy of a short description, especially as some portions of the skeleton were hitherto unknown.

Scapula. The right scapula is almost complete. Its length as preserved is 125 mm., but it lacks the distal end. It is small and slender, the minimum width across the bone being 21 mm. Distally the shaft expands very slightly, but proximally it has a greatest width of 47 mm. The proximal portion is very like that of *Massospondylus carinatus*. On the lateral face the supracoracoidal surface is concave. The whole bone is curved in its length, convex outwards. At the glenoid cavity the bone has a thickness of 17 mm. Both the anterior and posterior borders of the blade are fairly thin and keeled, but proximally the anterior border becomes thicker and more rounded.

Ulna. The right ulna is complete. Its length is 87 mm. The proximal articular surface is triangular with an acute rounded anterior angle, and an obtuse lateral angle. The posterior end stands higher than the anterior. Below the proximal end the bone narrows rapidly. In its proximal half the medial face of the bone has a shallow broad longitudinal groove. Distally the bone is twisted and flattened so that the broad faces of the distal end look directly forwards and backwards. The distal end is 19 mm. broad. The medial end of the articular surface is pointed, the lateral end truncate. The

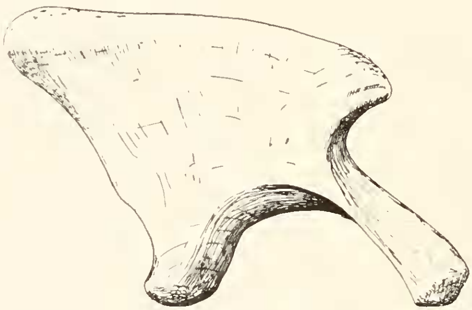


Fig. 20. *Thecodontosaurus skirtopodus* (Seeley). Right ilium.

maximum thickness at this surface is 11 mm. At its thinnest the shaft is 12 mm. broad and 7 mm. thick.

Ilium. The right ilium is typically Thecodontosaurian with its short anterior spine and its elongate posterior spine. The length of the upper border is 105 mm.: the border is slightly curved, more so anteriorly than posteriorly. The posterior spine is more pointed than in *T. antiquus.* On its inner surface the inner crest is strongly developed. The acetabulum is 60 mm. broad and 30 mm. high. The supra-acetabular crest is strongly developed above the anterior part, but disappears posteriorly. The height from the postacetabular process to the upper border of the bone is 76 mm. The preacetabular process is 48 mm. long.

Ischium. The distal end of a left ischium is 117 mm. long. The shaft is slender, strongly expanded distally. The anterior edge is straight and sharp, the posterior border regularly concave and flattened.

The bone was in contact with its fellow for a length of about 80 mm. At the bottom of the groove on the posterior surface the bone is 17 mm. thick from back to front. At the distal end the maximum thickness is 29 mm.

Femur. The distal portion of a right femur is complete from the trochanter quartus downwards. The distal end agrees closely with that figured by von Huene in its general contours, its compression sharply marking it off from *Massospondylus carinatus.* The length from the bottom of the fourth trochanter to the distal end is 105 mm. Both condyles are high; at the lateral condyle the distal surface is at its broadest. There is a deep, narrow groove between the condyles on the posterior surface. The minimum breadth of the shaft is 24 mm. The length of the distal articular surface is 39 mm., its breadth at the lateral condyle 34 mm., and at the medial condyle 29 mm.

Tibia. The tibia is complete save for the proximal articular surface. The length is 174 mm. The bone seems slightly crushed, so that the medial edge of the proximal end is not very convex. The medial condyle lies nearer the posterior end of the surface. Behind the anterior point the lateral border is somewhat concave. The shaft is flattened laterally and has a minimum thickness of 35 mm., and a minimum breadth of 11 mm. At the distal end the bone is broader in front than behind, the breadths being 31 mm. and 17 mm. respectively. The anterior condyle lies 13 mm. above the posterior.

Discussing the relations of this species with European members of the genus von Huene says *Thecodontosaurus skirtopodus* has somewhat shorter dorsal vertebrae than *T. antiquus*, the cross-section being the same. The humerus is of similar size to *T. antiquus*, but the processus lateralis reaches much deeper here than there. A bone, which is doubtless the end of the ischium, agrees with a similar bone in *T. antiquus* and differs considerably from *T. polyzelus.* The distal end of the femur is smaller and thicker than in *T. antiquus* and *T. cylindrodon*, and the condyles are higher than in *T. polyzelus.* The length of the tibia agrees with that of *T. MacGillivrayi*; the proximal end is tolerably small, the lower half of the shaft and distal end thicker than in *T. antiquus.* The astragalus is as in *T. antiquus.* Metatarsal IV corresponds best with *T. polyzelus.*

Type. Portion of hind limb in British Museum.

Locality. Barkly East Division, C.P.

Horizon. Cave Santstone.

Thecodontosaurus minor Htn.

Text fig. 21.

1918. Haughton. Ann. Mag. Nat. Hist. IX, II, p. 468.

"The specimens forming the type of this new form were presented to the South African Museum by the late Dr. M. Ricono. They consist of a left tibia, a cervical vertebra, and a portion of the left ilium.

Left tibia. The tibia is 109 mm. long. The proximal articular surface is 31 mm. long, and 18 mm. broad. This surface for the most part slopes obliquely backwards and laterally, the inner border being convex from front to back and higher in front than behind. The tuberositas tibiae is almost the highest point of the bone; it is prolonged anteriorly and turned slightly outwards. The lateral condyle is strongly developed. Below the head the shaft thins rapidly until at its middle it has an anteroposterior thickness of 12 mm., and a width of 10 mm. Thence it thickens towards the distal end. The anterior face is flat with a prominent edge on the lateral side and a rounded edge medially. The outer sharp edge is continued down to the anterior distal process. The posterior border of the shaft is rounded.

The distal surface is trapezoidal in form. The inner anterior border is 20.5 mm. long, the posterior outer border 16 mm. long, while the posterior inner border is 12 mm. long. The anterior process lies 7 mm. above the posterior process. Between the two on the outer surface of the bone is a shallow groove.

Cervical vertebra. The length of the body is 31 mm. The anterior articular surface is slightly larger than the posterior. Both are considerably higher than broad. The body is pronouncedly amphicoelous. There is a prominent median ventral keel, sharper in its anterior half. The whole body is strongly compressed laterally, having a width at the middle of 5 mm., and the anterior end of 8 mm. The canal has a height and breadth anteriorly each of 5 mm. The ends of the zygapophyses are missing. The dorsal spine was low and fairly long with a somewhat convex upper border.

Ischium. A portion of what is probably the left ischium is preserved, including the proximal articular surface. The bone is bent strongly backwards, more so than in *Thecodontosaurus antiquus* as figured by von Huene, so that the ischium must have been directed very strongly backwards. At the broken distal end the bone is 12 mm. thick, and 6·5 mm. broad. The inner border of the proximal surface is straight, the lateral border has a prominent outward

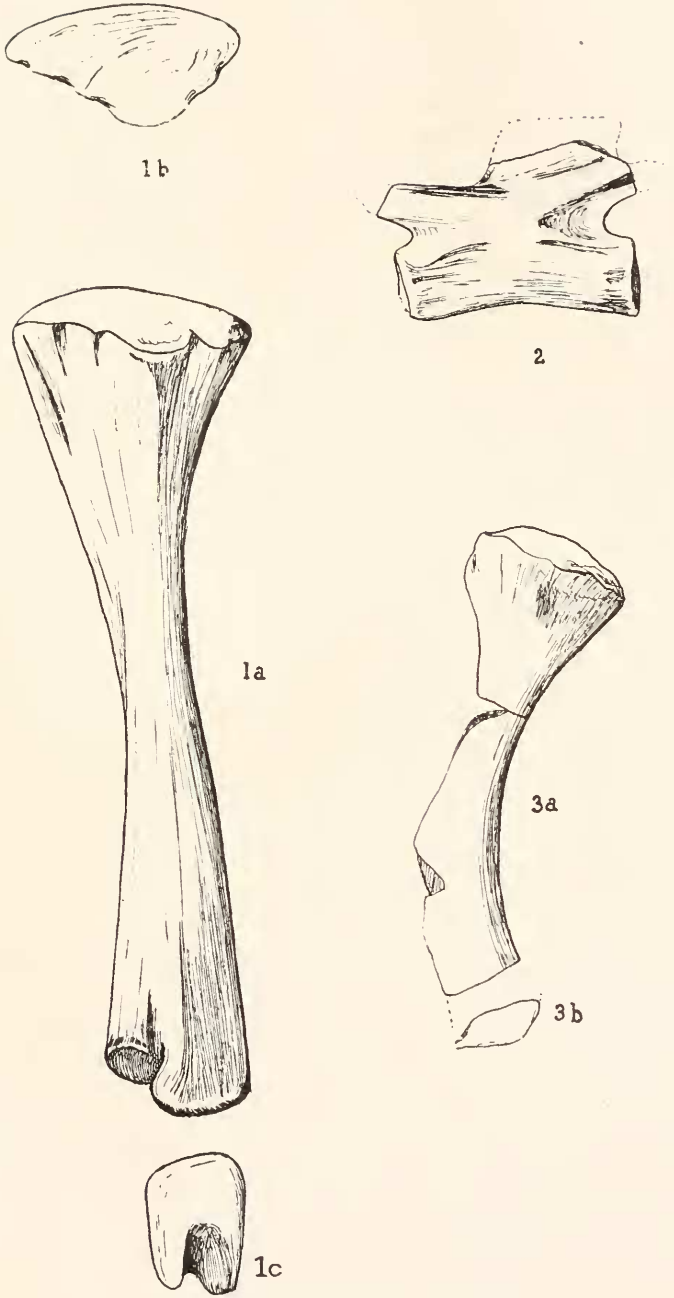


Fig. 21. *Thecodontosaurus minor*, Htn.

1*a*. Left tibia. 1*b*. Left proximal end. 1*c*. Left distal end.
2. Cervical vertebra. 3. Ischium. All natural size.

projection — the maximum width of the surface being 9 mm. The nature of the tibia and the ischium mark these remains off from the *Plateosauridae* and place them among the *Thecodontosauridae.* They indicate a member of this family smaller than any hitherto described from South Africa and which cannot be exactly identified with any European species. I propose therefore to give it a new specific name ***Thecodontosaurus minor.***

Type. S. A. M. Cat. No. 3451.

Locality. Pitsing, Maclear, C. P. Cutting in road to Naude's Nek.

Horizon. Red Beds."

There is in the Bloemfontein Museum a slab of Cave Sandstone from Ladybrand, O. F. S., which I was kindly permitted to examine. The slab contains the cast of a right femur, tibia, the distal end of the fibula, metatarsals I–IV, and the first three digits of the pes of a Dinosaur; also part of the right ischium and two fragments of jaw with teeth. The form seems to correspond pretty closely with the type of *Thecodontosaurus minor*, and I refer it to that species. It differs from *Gyposaurus* in being smaller and in having the metatarsals proportionately shorter.

One fragment of jaw is 50 mm. long and 9 mm. deep at the mentum. 14 mm. from the front it carries a single tooth 6·5 mm. long and 1·5 mm. in diameter. At the back of the fragment there are five teeth closely set together, the five occupying a space of 12 mm. and gradually decreasing in size from the first backwards. The largest is 6 mm. long. The teeth are widest some distance above the jaw and are serrated, at least on their posterior borders, in their upper halves. 3 mm. in advance of the largest is a slightly more slender tooth.

The other jaw fragment is 25 mm. long and carries 6 teeth in a distance of 18 mm. The longest tooth is 7 mm. long. All the teeth are serrated coarsely on their posterior and anterior borders.

The femur as preserved is a slightly curved shaft with very slightly expanded ends. The ends are, however, incomplete. The greatest length in a straight line is 135 mm., and along the front curve is 154 mm. The proximal width is 32 mm., the distal width 30 mm., and the width at the narrowest part of the shaft is 23·5 mm. The tibia is 117 mm. long, has a proximal width of 33 mm., and a distal width of about 23 mm. The following give the measurements of the metatarsus and pes.

	Length	prox. width	distal width
Metatarsal I	40		
1st phalanx	28	14	10
claw	36	15	
Metatarsal II	56	17	14
1st phalanx	26	13	
2nd phalanx	19	14	13
claw	29	12	
Metatarsal III	64	?	16
1st phalanx	26	18	?
2nd phalanx	21	14	12
3rd phalanx	16	11	11
claw	21	10	

The ischium as preserved has a greatest length of 100 mm. Near its junction with the pubis and ilium it has a width of 45 mm,, while at its narrowest part the width was probably not more than 15 mm.

Thecodontosaurus dubius sp. nov.

Two slabs of Cave Sandstone from Ladybrand, O.F.S., presented to the South African Museum by Mr. van Niekerk contain the larger part of the skeleton of a *Thecodontosaurus* which seems to be specifically distinct from any yet described from South Africa. A slab and counter slab from the Cave Sandstone of Rosendal, O.F.S., now in the Bloemfontein Museum, which I was kindly permitted to examine, contain remains of a somewhat smaller animal apparently of the same species.

As usual with the Cave Sandstone fossils the bones are badly preserved, and it has only been possible to expose one side of the type specimen. On the larger slab the dorsal and sacral vertebrae, pelvis, and the hind limbs are seen in ventral aspect, while in the smaller slab the caudal vertebrae are seen in lateral aspect mostly as moulds. In the Bloemfontein specimen besides an imperfect pelvis and hind limb there is preserved a very fine series of 54 caudal vertebrae.

In the type specimen 13 dorsal vertebrae are seen on the ventral surface — all crushed and weathered. The length of the posterior vertebrae is 44 mm. each, and the breadth across the articular surface is about 24 mm. Three sacral vertebrae are displayed. The length of each of the first two is 45 mm., and the maximum breadth of the centra 30 mm. They are stouter than, and not compressed medially so much as, the dorsal vertebrae.

There are 20 caudal vertebrae preserved, having a total length of 710 mm., but the anterior caudals are not present. The anterior centra of those preserved are almost as high as long, having a length of 33 mm. and a height of 30 mm.; posteriorly the centra become lower so that the 13th has a height of 13 mm. to a length of 30 mm. Similarly the dorsal spines and the haemapophyses become shorter posteriorly. The 2nd haemapophysis preserved is 90 mm. long, the 15th 42 mm.

Both ilia are preserved, but incompletely. The anterior spine is missing, but the posterior spine of the left bone is long. The height of the upper border above the end of the postacetabular process is about 80 mm. The posterior spine was probably squarely truncate.

Both pubes are present, lacking their distal ends. The shaft was 38 mm. broad and thin. The proximal end is broadened and the pubic foramen is large and rounded. Both ischia are present in contact with each other and with the pubes; but they lack the distal ends. The proximal mesial parts of the bones are very thin. The ischium passes very strongly backwards.

Both hind legs are preserved in a flexed condition, but the feet are not in good condition.

The femora are only seen from the anterior side. The bone is slightly S-shaped, bent more proximally than distally. The right bone is 270 mm. long, the left 280 mm. The shaft of the larger bone is 35 mm. wide at its narrowest. The distal end of the right femur is 55 mm. broad. The 4th trochanter is not visible on either bone.

The right tibia is almost entire. It is 260 mm. long as preserved, but lacks the distal end. The proximal end is 70 mm. broad, with a somewhat sharp inner anterior end. The anterior face of the bone is flattened just above the middle, but becomes rounded distally. The shaft is 27 mm. broad at its narrowest and 25 mm. thick.

The left fibula is 250 mm. long, slightly bent, and slender. The ends are only slightly expanded.

Of the metatarsals 4 are preserved on the left side, probably I–IV. They are seen on their under surfaces. Their lengths, taken in order, are 71, 102, 110 and 95 mms.

This form is thus seen to be slightly larger than *Thecodontosaurus browni*.

Type. S. Af. Mus. Cat. No. 3712.

Locality. Ladybrand, O.F.S.

Horizon. Cave Sandstone.

Gyposaurus capensis Broom.

1906. Broom. *Hortalotarsus skirtopodus.* Trans. S. Afric. Phil. Soc. XVI, 3, p. 201, Pl. III.

1911. Broom. Ann. S. Afric. Mus. VII, 4. p. 293.

The type consists of a partial skeleton in a block of sandstone, in which the following portions are displayed: Eleven dorsal and six caudal vertebrae, a few ribs and some abdominal ribs, part of the right scapula, both ilia, the right pubis and ischium, the right femur and fibula, tarsus and pes. The bones are only partly preserved, and the ends are imperfectly ossified.

In his 1911 paper Broom placed the form in a new genus on the following grounds. "Among the chief characteristics of this new genus the most noteworthy is the remarkable shape of the ilium. The iliac crest has a greater anterior extension than in any other known carnivorous Dinosaur, and the preacetabular process is relatively small. The femur is relatively stout, and has the *trochanter quartus* small and high up, and the *trochanter major* almost rudimentary".

The animal is of the same size as *Thecodontosaurus skirtopodus.* The ungual phalanges of the foot seem to be shorter than in that species, but the general proportions of the remainder of the foot are very similar.

Type. Partial skeleton in sandstone. S. A. Mus. Cat. No. 990.

Locality. Ladybrand, O. F. S.

Horizon. Cave Sandstone.

Aristosaurus erectus van Hoepen.

1920. van Hoepen. Ann. Transvaal Mus. VII, 2. p. 77. Plates IX–X.

The form is a small one, the type consisting of the larger portion of an animal exhibited on a slab and counter-slab of sandstone.

A portion of the left maxillary and left dentary is preserved. The crowns of the teeth are broad, flat, and have the edges serrated. The number of dorsal vertebrae is probably 14, and possibly 15. There are certainly two sacral vertebrae, and possibly a third. Van Hoepen says of the type "As appears from many loose sutural connections, our animal is a young individual, and has not yet reached the stage of life in which it possesses a true third sacral vertebra." The shoulder girdle is described as consisting of two scapulae and two coracoids. The coracoid has a supracoracoid foramen, which is fairly large and close to the middle of the scapular border. The proximal end of the humerus is very broad, its upper border convex. Below the processus lateralis the lateral border is strongly concave. The shaft of the bone is narrow. The ulna is just over two-thirds the length of the humerus.

The spina posterior of the ilium is broad and truncated, the spina anterior short. The acetabulum is well in the anterior half of the bone. The pubis has a regularly concave lateral border and a straight medial border. The pubic plate is narrowest near its distal end, but it is slightly broader at the extreme end. The appearance of the pelvis has suggested to van Hoepen that there was a complete longitudinal symphysis between the pubes and ischia of the two sides of the animal.

The femur is pronouncedly sigmoidal in lateral view; the fourth trochanter is in the upper half of the bone. The tibia has a very large proximal end, and the tuberositas tibiae did not project very far. There is no thickening at the distal end of the bone. The hind feet are entire in the type. The fourth metatarsal is slightly longer than metatarsal II. Metatarsal III is more slender than the latter.

Discussing the affinities of the type van Hoepen says: „The nearest relations of our form are amongst the *Plateosauridae* and *Anchisauridae*. and it is clear that it belongs to either one or the other. The *Plateosauridae* are all medium sized to large Dinosaurs with fifteen dorsal vertebrae, whereas our form is small and has most probably fourteen dorsal vertebrae, agreeing in this respect with the *Anchisauridae*. There is further agreement with the *Anchisauridae* in the relation of the lower arm to the humerus; radius and ulna are longer than half the humerus. The length of the shaft of the humerus. stands to the length of the whole humerus as 58 : 93 or 0·62. This relation brings our form in close proximity of *Thecodontosaurus antiquus*. Taking all these facts into consideration it seems clear that our form is an *Anchisaurid*.

Comparison with *Anchisaurus* shows that the dorsal vertebrae are comparatively longer, and that the pubes of the two forms differ greatly. *Massospondylus* is a much larger form. The distal ends of its ischia are coalesced, and each is more or less triangular in section. In our form the distal ends of the ischia are flattened through pressure, but it is difficult to accept that their section was originally triangular. Moreover, they are not coalesced. The relations of the ileum of *Massospondylus carinatus* are different from those in our form, for it is longer than the latter with regard to its shortest height above the acetabulum. Relatively the dorsal vertebrae of our form are longer than those of *Massospondylus carinatus.* The relations of the lengths of the metatarsals in *Massospondylus harriesi* is different from that in our form. In *Massospondylus harriesi* metatarsal II is longer than metatarsal IV, whereas in our form metatarsal II is shorter than metatarsal IV.

In comparing with *Ammosaurus* and *Gyposaurus* I need only refer to the great difference in the ilea.

The only other genus of the family is *Thecodontosaurus.* Superficially there is great resemblance between our form and the known species of *Thecodontosaurus.* A closer study, however, reveals remarkable differences.

A comparison of the ileum of our form with that of *Thecodontosaurus antiquus* shows that in the latter the spina posterior is much more produced. The acetabulum cuts deeper into the ileum of our form, which resembles the *Plateosauridae* in this respect. The highest point of the acetabular concavity is situated much nearer towards the middle of the bone than in our form, and this is another point of resemblance with the *Plateosauridae.* The ilium of our form is manifestly different from that of *Thecodontosaurus cylindrodon*, and also in the direction of the *Plateosauridae.*

The pubis of our form differs considerably from that of *Thecodontosaurus antiquus*, as far as the latter is known. In our form the lateral edge of the pubis is regularly concave, whereas in *Thecodontosaurus antiquus* its upper end is sigmoidal. There is also great difference in the shape of the pubic foramina. The shape of the proximal end of the ischium of *Thecodontosaurus antiquus*, as far as preserved, is quite different from that of our form, a difference which is best understood from a comparison of the figures.

Another difference becomes conspicuous when the length of the humerus is expressed in lengths of dorsal vertebrae. Taking one of the hinder vertebrae v. Huene came to the following results: In *Thecodontosaurus antiquus* the humerus is about five times as long as the vertebra, and in *Thecodontosaurus skirtopodus* about four and a half times. In our form the length of the eleventh dorsal vertebra is 29 mm. The length of the right humerus is 93 mm., which means that the humerus is only 3·2 times as long as the vertebra. Therefore, the humerus of our form is relatively much shorter than that of *Thecodontosaurus antiquus* and of *T. skirtopodus.*

There is great difference between the ischium of *Thecodontosaurus minor* and that of our form.

The points of difference enumerated above show sufficiently that our form does not belong to any of the known genera of the *Anchi-*

sauridae. It, therefore, represents a new genus, for which I propose the name *Aristosaurus* n. g. with the species *Aristosaurus erectus* n. sp. *Aristosaurus erectus* is much more highly specialised than *Thecodontosaurus*, *Ammosaurus*, *Anchisaurus* and even than *Massospondylus*. The build of the pelvis, and especially the position of the ischium, shows adaptation to a usually bipedal mode of locomotion. The same may be concluded from the far forward position of the acetabular concavity in the ileum. The position of the trochanter quartus seems to be very low down on the femur. Its upper end is 41 mm. from the proximal end of the bone. The length of the trochanter is at least 18 mm. Therefore the lower end of the trochanter is situated at more than 59 mm. from the proximal end of the bone, which means very near to the middle of the femur. However, conclusions may not be drawn from this fact, because exact measurements cannot be obtained.

The humerus is much shorter in relation to the body than in the other *Anchisauridae*. The anterior extremity is also relatively much shorter in relation to the posterior one than in all other *Anchisauridae* excepting *Anchisaurus solus*. As in the *Plateosauridae* the tibia of *Aristosaurus* is much longer than the humerus. This is also the case in *Anchisaurus solus*. In the other *Anchisauridae* it is the reverse. All this tends to show that *Aristosaurus* is an *Anchisaurid*, highly specialised in the direction of the *Plateosauridae*, and of the bipedal mode of locomotion."

Type. In the Transvaal Museum.

Locality. Rosendal, Senekal Dist., Orange Free State.

Horizon. Bottom of Cave Sandstone.

Although not specifically identifiable, the two bones in the collection of the Rhodesian Museum, Bulawayo, which were sent me for inspection by the Director of the S. Rhodesia Geological Survey, should be mentioned here as they are of interest in being the only known fossils from the Forest Sandstone of that region.

One bone, from Dingaan farm, Bubi District, is the distal end of a left fibula, measuring 120 mm. in length as preserved. The dimensions of the distal articular surface approximate to those of *Thecodontosaurus skirtopodus* (Seeley), but the bone differs from any of the described fibulae of this family or of the Massospondylidae or Plateosauridae in having a shaft subcircular in section, whereas those of the described species are more oval in section.

The other is a complete dorsal centrum from Waterfall farm, Bubi district. It differs from that of *Gyposaurus africanus* (Broom) in that it is as high as broad. The length is 43 mm. and the lower border is moderately concave. The dimensions make it possible that it belongs to the same species as the other specimen. The articular surfaces for the arch are beautifully displayed. There is a fragment of an arch showing a transverse process with a very concave under surface and incomplete neck and caudal vertebrae together with fragments of ribs.

Fam. MASSOSPONDYLIDAE von Huene.

1914. von Huene. Fossilium Catalogus I, 4, p. 13.

Massospondylus carinatus Owen.

1854. Owen. Cat. Foss. Rept. Mus. R. Coll. Surgeons, p. 97.
1890. Lydekker. Cat. Foss. Rept. Amphib. Brit. Mus. IV, p. 246.
1895. Seeley. Ann. Mag. Nat. Hist. (6) vol. 15, p. 102.
1906. von Huene. Geol. u. Pal. Abh. N.F. Bd. VIII, hft. 2, p. 36, Pls. XIII–XVI.
1911. Broom. Ann. S. Afric. Mus. VII, 4, p. 291.

The following details of the type specimen are taken from von Huene's account, checked by examination of casts of the type which are in the South African Museum.

The cervical vertebrae are elongate, with a keeled under surface as in *Plateosaurus*. The zygapophyses are long anteriorly, and posteriorly are elongate with oblique articular surfaces. The neural spine is short, low, and thin.

The centrum of the 1st dorsal vertebra is characterised by the extraordinarily high thin keel on the ventral surface. A few of the other dorsal vertebrae are known. They are compressed in the middle and the ventral side is rounded.

The anterior caudals are very short and high, and broadly rounded below. The later ones are provided with a keel below and carry posteriorly a ventral groove, which divides partially the face for the articulation of the haemapophysis. The middle and hinder caudals are longer, but do not reach the length of the cervicals.

The scapula is small and slender and is characterised by a high alar process at the distal end on the upper side: the coracoidal half of this process is thin and concave from without, as in *Plateosaurus*, but more strongly so; the medial side of the process is flat. The distal end is broadened.

In the humerus the proximal end is broad, the upper border obliquely bent down to the processus lateralis which is sharply cut off from the ridge, but is not bent so strongly forwards as in many other Triassic Theropoda. The caput humeri lies on the medial angle and is posteriorly thickened; the highest part of the upper border is similarly thickened. The distal end is broad and has its condyles directed strongly forwards.

The first metacarpal is an extraordinarily compact broad short bone. The proximal surface is triangular.

The ilium has a sharp but short anterior process; the spina posterior is long and moderately broad. The upper surface is bent inwards in the middle. The ridge above the acetabulum is not so roof-like as in many other genera. The crista interior on the inner side of the posterior process is not very prominent.

The middle and the distal end of the pubis is broadened and thin, the lateral and distal edges being thickened.

The femur is slender and lightly bent from front to back. The tibia has its distal end compressed from front to back, while the proximal end is convex medially and has a large tuberosity laterally. The anterior process is somewhat bluntly rounded. On each side of the tuberosity the lateral edge is hollowed out.

Von Huene separates the genus from *Plateosaurus* on account of its *Thecodontosaurus*-like tibia. The scapula, ilium, pubis, femur and hand are more strongly built than in *Thecodontosaurus.*

Type. Isolated bones in British Museum.

Locality. Beaucherf, Harrismith, O.F.S.

Horizon. Red Beds.

Massospondylus harriesi Broom.

Text figs. 21–29.

1911. Broom. Ann. S. Afric. Mus. VII, 4. p. 299. Plates XV–XVII.
1920. van Hoepen. *Massopondylus browni.* Ann. Transv. Mus. VII, 2. p. 118. Plates XVII–XXIII.

In his original description Broom says "This Dinosaur resembles *Massospondylus carinatus* sufficiently closely to suggest the advisability of placing it at least provisionally in the same genus. The remains consist of an imperfect humerus, a nearly perfect radius and ulna, and a perfect manus, as well as portions of the femur and tibia, and a number of toe bones all of one individual, and the perfect pes of another individual."

Re-examination shows that the remains supposed to constitute the first individual really contain two individuals. The supposed femur is in reality the distal half of a humerus, larger than that belonging to the complete fore-arm; and doubt is thus thrown upon the identity of the tibia and bones of the hind foot with the forearm, although all are marked with Mr. Walker's collecting number "I". Certainly the supposed femur is no part of the type animal, and must be considered separately.

The pes described by Broom is admittedly part of another individual; but comparison of it with a few portions of a pes marked "I" and found with the fore-limb renders it probable that it belongs to the same species as the latter. I consider, however, the fore-limb as the type of the species.

Comparison with *M. carinatus* is confined to examination of the distal end of the humerus, the 1st. metacarpal, and the proximal end of the tibia. Broom has figured the 1st. metacarpal, displaying its general similarity with that of *M. carinatus*, the inner distal condyle of each being small compared with forms such as *Gryponyx*. The distal end of the humerus is somewhat distorted, but the condyles seem to bear a similar relation to one another to those of *M. carinatus*.

The tibia approximates more closely in size to that of *M. carinatus* than does the fore-limb, and probably belongs to a larger individual, possibly the same as that from which the larger humerus (described as femur) belongs. The proximal end of the tibia is slightly longer and considerably thicker in *M. carinatus*; the greater thickness being mainly due to the more prominent development of the tuberosity on the lateral face. The anterior process is similar in each. The posterior border of the bone is more concave proximally in *M. carinatus* than in *M. harriesi*.

The larger humerus consists of the distal portion from the condyles to the lower end of the deltoid crest. In shape and general proportions it corresponds closely with the humerus of the type fore-limb, the distal end being crushed in the same direction as the type. The width of the distal end as preserved is 114 mm. There is a broad shallow groove between the condyles on the posterior face, and a deeper excavation on the anterior face of the bone. Its size corresponds roughly to that of the humerus of *M. carinatus*.

The right pes has been fully described and figured by Broom. In size it stands much closer to the fragmentary remains of *M. carinatus* than does the fore-limb, and is thus of a larger individual which shows few features distinguishing it from *M. carinatus*.

Whilst collecting in the Herschel Division of the Cape Province I was fortunate enough to obtain from the hill overlooking the Blikana Trading Store (and thus from an horizon in the upper third of the Red Beds) an almost complete specimen of an animal which can most easily be referred to this species. The caudal region had weathered off and was not obtained; but the remainder of the skeleton was found lying articulated with the exception of the head, which was at a distance of about 3 feet from the front of the neck. The specimen is one of the most complete known from the Stormberg Beds and has thus been thought worthy of a fairly full description, as it throws light upon the real position of these medium-sized forms. The specimen is in the collection of the South African Museum — Catalogue no. 5135.

Skull. The skull was lying detached from the neck at a distance of some 3 feet from it and was, unfortunately, shattered by a blow from a pick before its presence was realised. It has been possible,

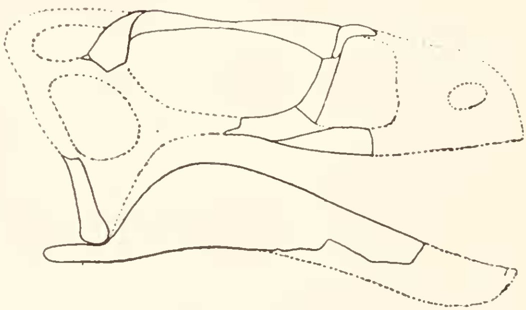


Fig. 22. *Massospondylus harriesi*, Br.
Restoration of a side view of skull (5135).
(The teeth are omitted from this restoration). × ½.

however, to reconstruct several portions of it from the fragments collected.

The basicranial region exhibits strong likenesses to that of *Thecodontosaurus antiquus* and is also fairly close to *Sphenosuchus acutus.* The occipital condyle is rounded and intermediate in size between that of *Sphenosuchus* and of *Thecodontosaurus.* It is formed almost wholly of the basioccipital, the suture between that bone and the exoccipital running as in *Sphenosuchus.* Anterior to the condyle the bone thins and then expands rapidly, its lower surface at the same time curving strongly downwards to form a long transverse basioccipital ridge. This ridge is not furnished with a median notch like that of *Sphenosuchus.* Its upper surface forms the floor of the brain-case for some considerable distance, the suture with the exoccipital being plainly seen on each side. The anterior portion of the bone is furnished with a median medullary ridge.

The suture between the basioccipital and basisphenoid is not traceable, but I am inclined to believe that it runs along the transverse ridge. If this be so, the structure is different from that of *Sphenosuchus*, where the suture runs along either side of the intertympanic foramina which lie wholly in the basioccipital, and agrees with that in *Plateosaurus* and *Thecodontosaurus*. The median excavation is smaller than in *Sphenosuchus*. The distance between the hinder end of the basisphenoid and the pterygoid apophyses of the bone is comparatively greater than in *Thecodontosaurus*. These apophyses are as in the European genus. Seen from above the anterior portions of the two apophyses meet superiorly to form a crest in advance of the circular hole for the hypophysis cerebri (pituitary fossa). The basisphenoid is furnished laterally just behind the root of the pterygoid apophysis with a deep groove corresponding in position to the recessus basisphenoidei of *Thecodontosaurus* figured by von Huene. The bottom of this pit is presumably pierced by the carotid foramen opening into the pituitary pit. Superiorly the relation of the basisphenoid with the bones of the side-wall of the brain case are obscure.

The foramen ovalis is only presented in section on the left side. It occupies the same position as in *Thecodontosaurus*, perforating the side-wall of the brain behind the sella turcica.

The exoccipital is of the form seen in *Thecodontosaurus*. Its lower border is grooved proximally, the groove running inwards and forwards to the foramen lacerum for the exit of nerves IX–XI. This opens into the bottom of the side-wall of the brain-case. Separated from this foramen by a thin plate of bone is a larger opening, the foramen jugulare for the passage of the VIIIth nerve. Mesial to the internal opening of this foramen is a shallow pit in the brain case. The opening for the XIIth nerve is only seen in vertical section passing through the exoccipital above the level of the condyle. Behind and above the foramen lacerum the side wall of the brain is furnished with two small foramina, presumably venous.

The exoccipital articulates with the basioccipital below and the supraoccipital above. It has a strong paroccipital process.

Save in details of relative sizes, this basicranium is similar to that of *Thecodontosaurus*, and differs in certain features more from *Sphenosuchus*.

A portion of the right side of the skull and lower jaw is preserved, attached to a part of the top of the skull. The snout is missing.

The orbit was large, its length as preserved being 54 mm. Its anterior border is formed by the pillar-like lachrymal which divides the orbit from the antorbital vacuity. The limits of the prefrontal are doubtful, but it seems to be a small bone wedged between the lachrymal and frontal and extending forwards over the antorbital vacuity.

The frontal is a large bone meeting its neighbour in the middle line to form with it the whole of the interorbital space. It forms the whole of the upper border of the orbit and extends back to form part of the border of the anterior temporal vacuity. The postfrontal, if present, as a separate bone, is small and forms no part in the formation of the orbit although it may be part of the anterior border of the upper temporal vacuity. There is some doubt as to its separate identity and I am inclined to consider it as fused with the frontal as in *Sphenosuchus*.

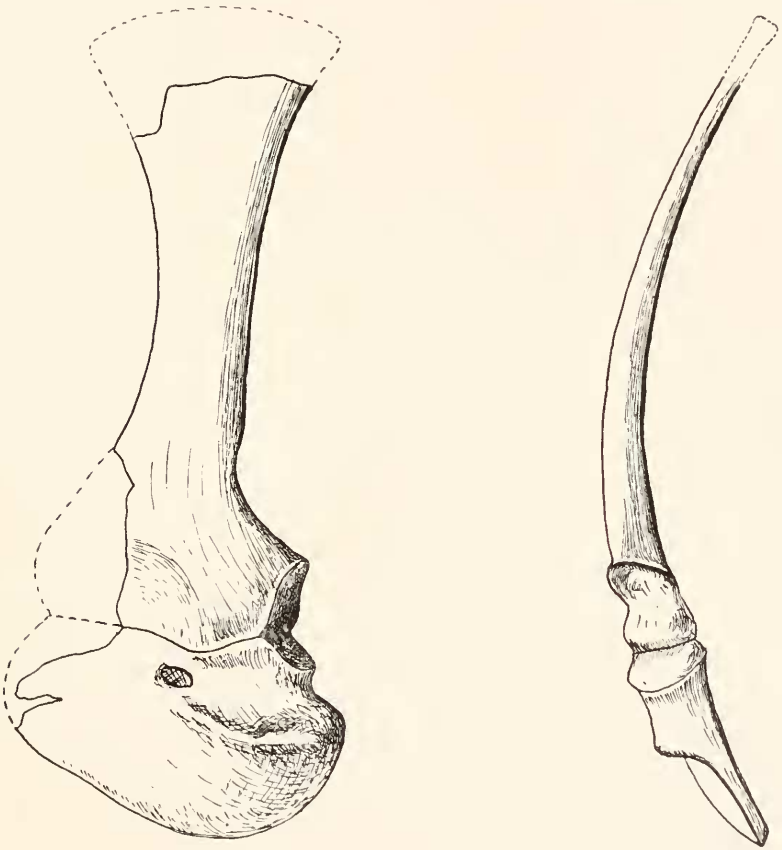
The jugal forms the lower border of the orbit and meets the lachrymal and maxilla anteriorly. The maxilla, as preserved, carries 4 or 5 flattened teeth. The teeth are seen better, however, in the lower jaw.

A length of 110 mm. of the lower jaw is present, the front missing. From the post-articular process the upper border rises in a regular high curve, concave at first and then convex, to a point below the middle of the orbit, whence it passes downwards and forwards. The lower border is almost straight. The teeth carried by the dentary are variable in size, large and small teeth apparently alternating. The teeth are flattened with the upper halves of the anterior and posterior borders serrated, as in *Thecodontosaurus*. The largest tooth seen is 7 mm. long and 3·5 mm. broad. There are 7 serrations in a distance of 4 mm. The cross-section of the tooth is an elongate oval.

Vertebrae. The cervical vertebrae are somewhat crushed and incomplete. The later cervicals agree closely with those of *Massospondylus carinatus*. The middle cervicals are very elongate, compressed in the middle, with a median ventral keel in the anterior half. The zygapophyses are long with very oblique articular surfaces. The neural spine is thin, low and long. The transverse process is in the form of a long ridge at the level of the top of the centrum. The whole body of the bone is slightly curved. The most complete bone gives the following measurements:

Length of centrum	105 mm.
Height of centrum . . , .	40 mm.
Greatest length	133 mm.
Max. height (probable) . . .	85 mm.

What is probably the last cervical has a centrum 73 mm. long and 44 mm. high. The centrum is strongly compressed laterally and has a very sharp median ventral keel. The side of the centrum is furnished with a prominent parapophysis placed just behind the middle of the bone for the articulation with the rib. The anterior



A B

Fig. 23. *Massospondylus harriesi*, Br.
Left scapula and coracoid (5135).
A. External view. B. Ventral view.

cervicals have very shallow and elongate centra and comparatively massive processes. They are, with the exception of what is probably the first, very elongate; but the preservation is not sufficiently good to admit of full description. The anterior cervicals are very bird-like in general appearance.

Shoulder Girdle. Both scapulae are preserved, but are somewhat incomplete at the distal end and each lacks the end of the supracoracoidal wing. The proximal end is very similar to that of the smaller scapula assigned by von Huene to *Massospondylus carinatus.* The glenoid cavity is the same size, the posterior half of the articular surface for the coracoid slightly larger and the shaft of the bone a little broader. The distal end expands fairly considerably, but not so much as in *Sphenosuchus acutus.*

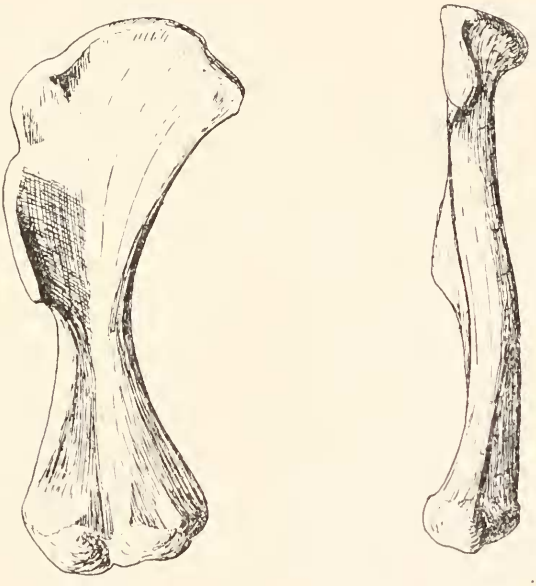
The chief measurements are:

Probable greatest length . . .	280 mm.	
Greatest width	104 mm.	
Minimum width of shaft . . .	40 mm.	
Greatest thickness at articulation with coracoid . . .	30 mm. (left)	43 mm. (right)

The left coracoid is almost entire, the right one represented by the posterior half. The inner surface is concave, the outer slightly convex except for a strong thickening in the middle of the lower portion of the bone. This thickening takes the form of a strong short longitudinal swelling which rapidly subsides into the bone at its upper and lower ends. This thickening is for the reception of the coraco-brachialis muscle, according to von Huene. In front of the coracoidal portion of the glenoid cavity the border is concave to the anterior ventral angle. The anterior border is regularly curved. The left coracoid is 135 mm. broad, 80 mm. high, and has a maximum thickness at the scapular surface of 30 mm.

Attached to the upper portion of the anterior border of the left coracoid is a small piece of bone lying generally in a plane at right angles to that of the coracoid and bent in a convex manner when viewed from in front. In collecting the shoulder girdle a number of pieces of thin bone were found in situ in the region of the two coracoids. These have been fitted together as much as possible and seem to give indisputable evidence of the presence of two clavicles and an interclavicle. These bones are too fragmentary to permit of full description. The largest fragment is a piece which I take to be the interclavicle. As preserved it is 86 mm. long. The bone is a thin plate broadening somewhat posteriorly, and possibly anteriorly, slightly convex from side to side ventrally save in the anterior portion where there is a prominent longitudinal swelling for the attachment of muscles, similar in form to that on the coracoids. The dorsal surface is flat, so that the edges of the bone are thin. Lying at the anterior end of the dorsal surface is a fragment of a clavicle, which here at its distal end is a thin plate of bone.

Humerus. The left humerus is slightly larger than the right and has the deltoid portion bent into the body of the bone slightly more than the other. Both humeri are complete and are of the general type seen in the Vienna specimen of *Thecodontosaurus skirtopodus*, although the bottom of the deltoid crest is just *below* the middle of the bone. The deltoid crest is sharply cut off from the lateral edge



A B

Fig. 24. *Massospondylus harriesi*, Br.
Right humerus (5145).
A. Anterior view. B. Medial view. × $\frac{1}{3}$.

of the proximal portion by an abrupt change in the outline of the bone; and the process is but slightly bent from the general plane of the upper half of the bone.

The outer edge of the proximal end is strongly thickened to form a rounded knob about 35 mm. from the medial angle.

The medial edge of the bone forms a regular sweeping concave curve from the caput humeri to the inner condyle. The distal end is strongly broadened, and on the inner face there is a shallow depression between the two condyles. Anteriorly there is a medial ridge which bounds one side of a shallow hollow lying above the inner condyle. The outer condyle is slightly larger compared with the inner than in the type of the species.

The chief measurements are:

	Right humerus	Left humerus
Greatest length	219 mm.	223 mm.
Breadth at distal end . .	75 ,,	78 ,,
Width at narrowest part of shaft	29 ,,	29 ,,
Width at top of deltoid crest .	80 ,,	70 ,,
Greatest width of proximal end	94 ,,	87 ,,
From lower end of deltoid crest to furthest part of distal end	108 ,,	110 ,,
Length of deltoid crest . .	55 ,,	55 ,,
Thickness of head . . .	16 ,,	17 ,,
Max. thickness of proximal end	27 ,,	29 ,,
Thickness at inner condyle .	25 ,,	24 ,,
Thickness at outer condyle .	24 ,,	26 ,,

Radius. Both radii are preserved, the left bone being crushed proximally. The right is slightly shorter than the left, but each has the same general form. The right radius is 132 mm. long, the left 135 mm., each being considerably shorter than the ulna.

The proximal articular surface is saddle-shaped. Below it the bone rapidly thins, so that the whole bone is a straight cylindrical shaft with expanded ends. The anterior edge is provided with a rounded ridge. At the distal end the posterior-medial face has two knobs, presumably for muscle articulation, a larger medial one and a smaller posterior one. At the proximal end the medial groove for the insertion of the humero-radialis muscle is very prominent.

Breadth of proximal surface . .	36 mm.
Thickness of proximal surface . .	25 ,,
Breadth of distal end . . .	32 ,,
Thickness at distal end . . .	23 ,,
Minimum width of shaft . . .	16 ,,

Ulna. Both ulnae are preserved, but the left is somewhat imperfect. The right gives the following measurements:

Greatest length	152 mm.
Width at proximal end . . .	52 ,,
Width at distal end	40 ,,

Width at narrowest part of shaft .	17	mm.
Thickness of proximal end . .	31	,,
Thickness of distal end . . .	20	,,

The distal quarter of the bone is twisted to the left as in the type. The bone is more elongate than that of *Plateosaurus quenstedti* and the proximal end is more expanded. The proximal half is somewhat similar to that of *Plateosaurus erlenbergensis*, but the articular surface slopes more strongly and the lateral angle lies nearer the anterior point. The medial border of the proximal end is concave and below it the surface of the bone is hollowed out. The anterior border of the bone is concave, the posterior border straight except at the distal end, where it curves outwards and slightly backwards.

Fig. 25. *Massospondylus harriesi*, Br.
Right ulna (5135). × $\frac{1}{3}$.

Hand. On the right side there are preserved the three carpale, the 1st. metacarpal and the whole of the 1st. digit. Of the left hand there are the 1st. and 2nd. carpale, all the metacarpals, and the 1st. digit. In addition there is an isolated claw of the right hand.

The 1st. carpale articulates distally with the 1st. metacarpal and the 2nd. carpale. It is an irregularly oval-shaped thin bone, with a maximum length measured from the mediai end to the lateral end of 39 mm. in the left hand and 36 mm. in the right. The thickness between the dorsal and ventral edges is 25 mm. (24 mm. on right side). Between the proximal and distal surfaces the distance is 13 mm. (12 mm. on right).

The 2nd carpale is a small bone, articulating proximally for most of its length with the 1st carpale, distally with the 2nd metacarpal, and medially with the 1st metacarpal. Its dorsal surface is small, its palmar face rectangular with an area of 23 mm. × 12 mm. (18 × 13 on right). The distance between the dorsal and palmar surfaces is 19 mm. (16 mm. right).

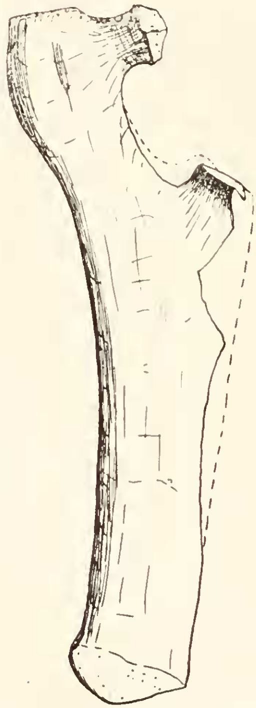


Fig. 26. *Massospondylus harriesi*, Br.
Left pubis (5135).
Ventral view. × $\frac{1}{3}$.

The 1st metacarpal has a maximum length of 42 mm., a proximal width of 38 mm., and a distal width of 35 mm. The proximal end is almost triangular in shape, the ulnar edge having a length of 25 mm. In shape it compares closely with that of *Massospondylus carinatus*, but the distal articular surface is thicker than in the larger form. Also the ulnar proximal edge of the dorsal surface is pointed and not flattened as in *M. carinatus*.

The 2nd metacarpal has only the proximal half remaining. Its end is 20 mm. broad and 24 mm. thick. On the radial side it has dorsal and palmar knobs with a hollow between, and on the ulnar side there is also a groove for muscle insertion. The dorsal side is slightly hollowed, but the palmar side is flat. The shaft of the bone is slender and circular.

The 3rd metacarpal is 53 mm. long, 29 mm. broad proximally, and 21 mm. broad distally, and the thinnest part of the shaft has a breadth of 13 mm. For the 4th and 5th metacarpals the corresponding measurements are 42 mm., 20 mm., 16 mm. and 9 mm., and 28, 18, 13, and 11 mm. respectively.

In the 1st digit the 1st phalanx is 37 mm. long. Its proximal width is 31 mm., its distal width 23 mm. It is so twisted that the claw curves strongly inwards and but slightly downwards. The claw has a length as preserved of 65 mm., and when complete was probably 75 mm. long. It is strongly curved and compressed dorso-ventrally. The greatest breadth at the proximal end is 36 mm. and the thickness, which is greatest on the radial concave side of the claw, 24 mm. There is a large bony process on the radial side at the proximal end for the insertion of the flexor tendon.

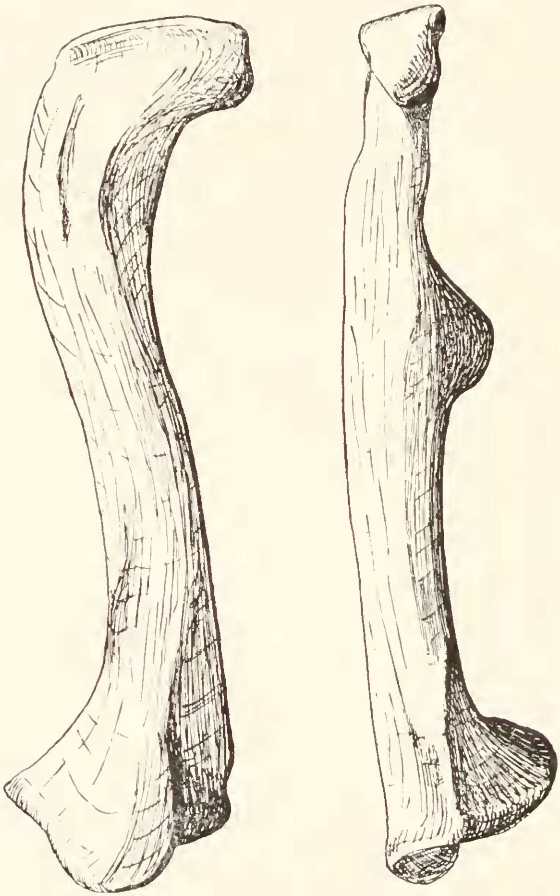
Pubis. Both pubes are preserved, entire save for the ischial articular surfaces. The head of the right pubis is somewhat distorted and the bone has a maximum length of 270 mm. The maximum length of the other bone is 285 mm. The breadth at the distal end is about 50 mm. and the thickness 23 mm.; but the breadth decreases to 43 mm. and the thickness to 12 mm. in the middle of the bone. The medial portion is very thin; the lateral border fairly sharply rounded. At a distance of 210 mm. from the distal end the public plate is turned abruptly downwards at right angles in its medial portion while the lateral part, now forming the pubic neck, is curved more gently upwards and outwards. The subacetabular process is 50 mm. long and 30 mm. broad. The pubic foramen is large.

The pubis is seen to be longer than was supposed by von Huene for ***Massospondylus carinatus.*** The distal end is somewhat thicker than in the Plateosauridae.

Femur. The femur fairly slender and slightly bent backwards at its distal end. The proximal end is bent strongly inwards, more so than in ***M. carinatus.*** The trochanter minor is not defined, but the trochanter major stands out as strong, somewhat curved, crest on the anterior face of the bone. The chief measurements are:

Greatest length	355 mm.
Width at head	75 „

Thickness at head	32	mm.
Distance from head to top of trochanter major	55	,,
Width at top of trochanter major .	51	,,



A B

Fig. 27. *Massospondylus harriesi*, Br.
Right femur (5135). $\times \frac{1}{3}$.
A. Anterior view. B. Medial view.

The 4th trochanter is a fairly short high thin crest on the posterior face, lying well within the upper half of the bone.

Distance from head to top of trochanter IV	88 mm.
Distance from head to bottom trochanter IV	142 ,,

The distal end of the bone is bent backwards and swells considerably to form the condyles. The lateral condyle is narrow and turns

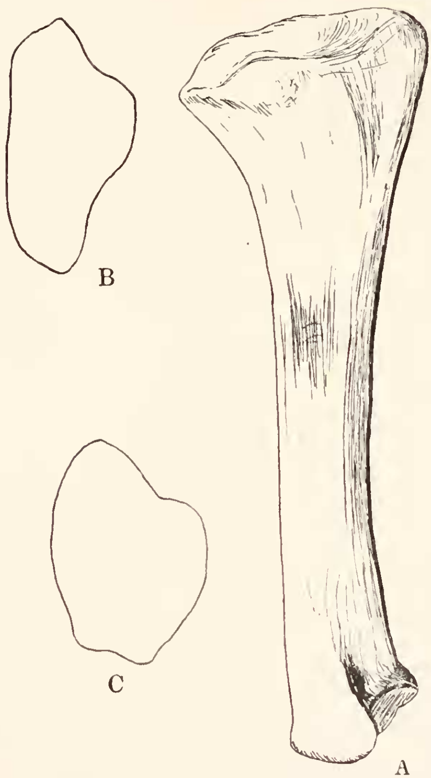


Fig. 28. *Massospondylus harriesi*, Br. (5135).
A. Right tibia lateral view.
B. „ „ outline of proximal end
C. Left tibia outline of proximal end × $\frac{1}{3}$

outwards, and from it a sharply rounded ridge runs up the bone a distance of about 80 mm. The inner condyle is broader and less deep, and stands higher than the lateral condyle. Between the two is a narrow, deep groove, narrower than that of *M. carinatus.* The articular surface is inclined at an angle of about 70° to the anterior slope of the bone. On the anterior face there is a short median depression above the condyles.

Maximum thickness at distal end	.	79 mm.
Thickness of lateral condyle	. .	20 ,,
Thickness of medial condyle	. .	39 ,,
Depth of lateral condyle	. . .	73 ,,
Depth of medial condyle	. . .	63 ,,

Tibia. The right and left tibiae are complete. The proximal portion of the right has been flattened laterally, so that the head is considerably narrower than that of the left. The outline of the head of the bone differs in the two. The right tibia has a concavity both before and behind the lateral tuberosity as in *Massospondylus carinatus*; the left tibia has the anterior concavity, but behind the tuberosity the edge is regularly convex to the posterior point. It can thus be seen that considerable care must be taken in distinguishing forms by such features as the shape of the tibial head, which is variable even in an individual.

The general shape of the proximal end approximates closely to that of *M. carinatus* and needs no detailed description. As a whole the bone is slender with the distal end but slightly expanded. The anterior condyle lies above the posterior and looks both outwards and downwards. The chief measurements are:

	Right	Left
Greatest length . . .	300 mm.	298 mm.
Length of proximal end .	100 ,,	87 ,,
Width of proximal end .	50 ,,	61 ,,
Minimum width of shaft .	24 ,,	28 ,,
Minimum thickness of shaft	35 ,,	23 ,,
Length anterior border, distal end . . .	59 ,,	65 ,,
Length posterior border, distal end . . .	45 ,,	41 ,,
Max. thickness, distal end	42 ,,	37 ,,

Fibula. The right fibula and most of the left are preserved. The bone is slender, flattened laterally, slightly expanded at the end and almost straight. The inner face at the proximal end is hollowed out with a well-marked sharp crest bounding it anteriorly. In the mid-part of the bone the medial face has a slight longitudinal ridge anteriorly. At the distal end the anterior and posterior faces are flattened and the lateral edge is broadly rounded. The lateral side has a strong longitudinal crest running for a short distance up from the condyle. In rear of it is a shallow groove, bounded posteriorly by another short prominent ridge. The distal articular surface is convex.

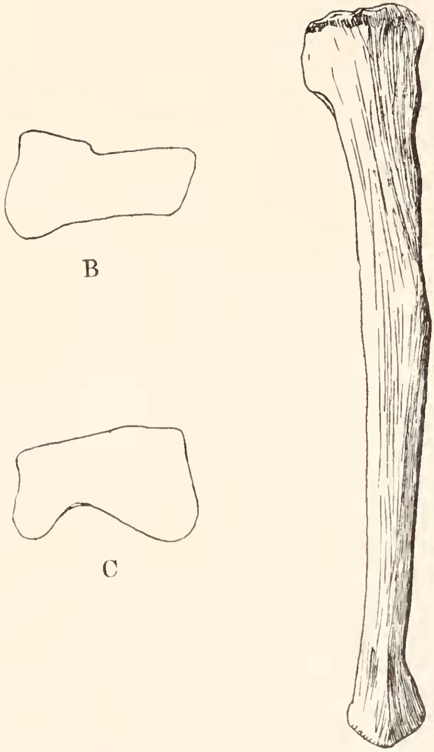


Fig. 29. *Massospondylus harriesi*, Br. (5135).
A. Right fibula, lateral view.
B. Right astragalus. Front view.
C. „ „ . Top view.
All × $\frac{1}{3}$.

	Right	Left
Total length of bone . .	290 mm.	—
Length of proximal surface	48 „	46 mm.
Width of proximal surface	27 „	30 „
Minimum width of shaft .	15 „	15 „
Length of distal surface .	42 „	49 „
Width of distal surface .	29 „	21 „

Hind Foot. The right hind foot was found in situ, while most of the bones of the left foot were recovered from the talus below the site.

Astragalus. — The astragalus is preserved on both sides of the body. The maximum width from side to side is 72 mm. in the right bone and 76 mm. in the left. The maximum thickness in the medial half is 43 mm. (left, 40 mm.) and the maximum height in that half 31 mm. (left, 30 mm.). The lateral portion shows a high flattened upper portion for articulation with the anterior distal condyle of the tibia and posteriorly a low elongate narrow surface. Below the anterior articular face the bone is undercut posteriorly. The lower anterior angle is a short rounded prolongation, the posterior corner being broadly rounded. The lateral face shows a small shallow concavity for articulation with the calcaneum.

The thickness at the lateral end is 31 mm. (left, 27 mm.), the height 37 mm. (left, 37 mm.), and the breadth of the anterior upper surface 17 mm.

The under surface is broadly convex with a faint median ridge running from left to right.

Calcaneum. — A bone which I take to be the calcaneum is preserved in connection with the right foot. It is roughly triangular in outline, with a small lateral protuberance. Its upper surface is concave, its lower convex. Its greatest width is 36 mm. and its maximum thickness 21 mm.

Tarsalia. — The only other bone of the tarsus preserved is tarsale III, which is found in both feet in articulation with the third metatarsal. In section it is triangular, and its upper surface slopes from the back inwards and forwards so that it is thickest in its posterior and lateral parts. Its under surface is hollowed with a short medial anterior peg to fit closely to the proximal surface of the metatarsal. Its anterior edge is 28 mm. long, its medial face 31 mm., and its other face 41 mm. Its greatest thickness is 20 mm.

The following table gives the chief measurements of the metatarsals and phalanges of the right foot. The 3rd. digit is missing ; it was not preserved with the remainder of the animal, and was possibly lost during life.

	Length.	Prox. breadth.	Distal breadth.
Metatarsal I	86 mm.	33 mm.	30 mm.
Digit 1. 1st phalanx	51 ,,	29 ,,	23 ,,
claw	72 ,,	22 ,,	—
Metatarsal II	128 ,,	—	—
Digit 2. 1st phalanx	48 ,,	36 ,,	32 ,,

		Length.	Prox. breadth.	Distal breadth.
	2nd phalanx	36 mm.	29 mm.	25 mm.
	claw	61 ,,	24 ,,	—
Metatarsal III.		142 ,,	36 ,,	33 ,,
Metatarsal IV.		125 ,,	47 ,,	28 ,,
Digit 4.	1st phalanx	41 ,,	30 ,,	26 ,,
	2nd phalanx	36 ,,	29 ,,	25 ,,
	3rd phalanx	27 ,,	21 ,,	21 ,,
	4th phalanx	23 ,,	20 ,,	19 ,,
	claw	47 ,,	18 ,,	—
Metatarsal V.		67 ,,	37 ,,	—
Digit 5.	1st phalanx	17 ,,	— ,,	—

Comparison of these with the type pes of ***Massospondylus harriesi*** shows that the phalanges of the digits have almost indentical measurements in the two animals. The metatarsals in this animal have different lengths, however, those of *M. harriesi* being somewhat longer, except in metatarsal I.

The metatarsals show few distinguishing features. The proximal end of metatarsal II has the plantar edge considerably longer than the dorsal, while the medial and lateral faces are both hollowed out for articulation with the neighbouring bones. Metatarsal I looks almost entirely inwards. Metatarsal IV is a much flattened bone, and its distal end is slightly twisted inwards. Metatarsal V thins rapidly at its proximal end and from the lateral face, and lies almost entirely behind metatarsal IV. Its distal half shows the usual pads for the reception of tendons or muscles, especially on the plantar surface.

Among the collection of the Durban Museum submitted to me is an incomplete animal from Fontanie, Fouriesburg, O.F.S. (the type locality) consisting of a right scapula, a right humerus, a left coracoid, a left fibula and digits 1, 2, 3, of a left pes. These closely correspond with the type and must be placed within the species. The right scapula has the ventral edge a little straighter than in the Blikana specimen, being thus closer to the specimen described by van Hoepen as *Massospondylus browni.* The left fibula has a maximum length of about 285 mm. and a proximal surface 43 mm. long, and 20 mm. wide. The bone is flattened laterally, especially at the distal end. Its inner face at the proximal end is concave, its outer face convex. The proximal end is slightly more slender than in the Blikana specimen. The digits of the left pes correspond very closely to the type in size.

It seems to me that van Hoepen is probably in error in assigning the remains described by him from St. Fort, Bethlehem, O.F.S. to *Massospondylus browni.* The only possible comparison that can be made is between the femora, and it is apparent that, not only is the proximal end of the type of *M. browni* (i.e. *Thecodontosaurus browni*) stouter than in van Hoepen's specimen but the trochanter quartus is nearer the proximal end. Moreover, the type is a considerably smaller animal, and has been assigned by von Huene, whose judgment cannot lightly be set aside, to the genus *Thecodontosaurus.* There can be no doubt that Dr. van Hoepen's species belongs to the genus *Massospondylus*, and the question arises whether it is a specimen of *M. harriesi* to which it closely approximates in size.

Comparison can first be made with the almost complete specimen of *M. harriesi* from Blikana. This shows that the humerus is almost exactly the same shape, and very slightly smaller; the ulna differs in that the Cape specimen has a slightly more slender shaft and has a posterior prolongation at the proximal end, which may have been worn off in van Hoepen's specimen; the radius of the former has a more slender shaft, swelling somewhat more abruptly at the ends; the scapula and coracoid are very similar, save that the distal end of the St. Fort specimen is apparently slightly narrower, thus coming closer to the type; the femur of the Blikana specimen is more strongly bent in anterior view and straighter in lateral view — but the St. Fort animal is considerably crushed; the tibia and fibula both show slight differences, and the bones of the feet are slightly more slender and longer in the St. Fort animal.

When compared with the type of *M. harriesi*, however, the differences in the foot are not so great; and in view of the fact that van Hoepen's specimen in closer to the type than is the South African Museum animal which I have referred to *M. harriesi*, I cannot refrain from including it in the same species. Four specimens of *M. harriesi* are thus known — the type, the South African Museum animal, the bones described by Dr. van Hoepen, and a partial skeleton in the Durban Museum. Of these, the first and last are from the one locality, the third from a closely-neighbouring area, and the other from some distance away and a slightly lower horizon. From them we can see the amount of individual variation that may occur within one species; and such variation should be taken into account when the identification of forms is under consideration.

Type. Bones of fore limbs — S. A. Mus. Cat. No. 3394.

Locality. Foutanie, Fouriesburg, O. F. S.

Horizon. Top of Red Beds.

MASSOSPONDYLUS SCHWARZI, sp. nov.

The bones upon which this species is founded were unearthed by Professor Schwarz at Makomoreng, Mount Fletcher, C. P. They are in the collection of the South African Museum (Cat. No. 5134).

The species differs from *M. harriesi* and *Aetonyx palustris* in the comparative size of the metatarsals. Taking the first metatarsal as a standard, the second and third are longer in this form than in the other species, in this respect the foot approximating most to *M. harriesi*. In addition, the phalanges of the digits are relatively longer than in the other forms, those of the third digit being actually as large as in *M. harriesi* which has a third metatarsal 20 mm. longer than in this new form.

These differences seem sufficient to justify the provisional erection of a new species for these remains; they certainly cannot be placed in any described species until we know more concerning the limits of individual variation among these Dinosaurs. The distal end of the tibia is somewhat more swollen than in *M. carinatus*, but as the foot bonse seem to approximate more closely to *Massospondylus* than to *Aetonyx*, I shall provisionally name the form *Massospondylus schwarzi*.

The following table gives the chief measurements of the bones of the foot:

	Greatest length.	Proximal width.	Distal width.
Metatarsal I	71 mm.	33 mm.	30 mm.
1st phalanx	41 ,,	27 ,,	23 ,,
claw	imperfect	19 ,,	—
Metatarsal II	118 mm.	prob 25 ,,	33 ,,
1st phalanx	47 ,,	31 ,,	27 ,,
2nd phalanx	31 ,,	21 ,,	13 ,,
claw	imperfect	15 ,,	—
Metatarsal III	135 mm.	22 ,,	31 ,,
1st phalanx	47 ,,	31 ,,	22 ,,
2nd phalanx	34 ,,	23 ,,	20 ,,
3rd phalanx	30 ,,	21 ,,	19 ,,
claw	imperfect	19 ,,	—

Associated with the foot are some portions of the leg and sacrum which are too imperfect for accurate determination.

Type. Incomplete pes and distal end of tibia. S.A. Mus. Cat. No. 5134.

Locality. Makomoreng, Mount Fletcher, C.P.

Horizon. Red Beds.

Aetonyx palustris Broom.

Text fig. 30.

1911. Broom. Ann. S. Afric. Mus. VII, 4. p. 304. Pls. XV and XVII.

The type consists of "a few imperfect dorsal vertebrae, a good scapula and coracoid, a good humerus, a good radius and imperfect ulna, the greater part of each manus, the upper end of one tibia, and the almost complete right pes".

A little extra description can be added to that given by Broom. There are portions of three cervical vertebrae attached to one another, of which the middle one is almost complete. The centrum has a length of 70 mm. and a height at the articular surface of about

Fig. 30. *Actonyx palustris*, Br.
Right Metatarsal. I. (Durban Mus.).
Distal end, front view.

35 mm. The maximum height of the bone is 68 mm. As in *Massospondylus* the centrum is elongate and compressed with a concave ventral surface; but the median ventral keel is not nearly so prominent as in the larger form. The neural spine is slightly higher than in *M. carinatus*, but is of the same type. The zygapophyses, as far as they can be seen, agree with those of *Massospondylus*. The transverse processes are small.

Several vertebrae from the posterior part of the tail are preserved, seven of them in association, and others now isolated but forming, according to Mr. Walker's field numbers, a series of 8. The former are more complete than the latter.

The length of the centrum in the first series diminishes from 25 mm. to 23 mm. with the last having a length of 20 mm. The maximum height of the largest bone is 22 mm., and of the centrum 11 mm.

All are slightly expanded at the ends, with the ventral surfaces rounded. They call for little comment, being of the type seen in *Sellosaurus fraasi*, figured by von Huene, with the exception that the zygapophyses stand somewhat higher from the centrum in *Aetonyx*. The dorsal spine is very small.

In the other series the centra only are preserved. They vary in length from 33 mm. to 26 mm., and are thus anterior to those already described. The ventral surface of the centrum is rounded but in its posterior half it is somewhat flattened with two short incipient keels flanking the flattened portion. These keels arise from the small oblique ventral face of the hinder end, which carried a small chevron.

Type. Partial skeleton, S. A. Mus. Cat. No. 2768, 2769, 2770.

Locality. Foutanie, Fouriesburg, O. F. S.

Horizon. Top of the Red Beds, Stormberg Series.

There are in the Durban Museum collection several bones which I ascribe to a large specimen of this species. They are from Foutanie, Fouriesburg, but it is uncertain whether all belong to the one animal although the probability lies in that direction. They consist of metatarsals I–III of the right side, metatarsal I of the left side, the distal end of a fibula and the distal end of a tibia the latter somewhat doubtfully assigned to this species.

The metatarsals of the right foot are approximately of equal length with those of the type *Massospondylus harriesi*; but they are more slender. The 1st metatarsal differs from that of *Massospondylus* in having a narrower proximal end, the medial upper edge being more convex, and in the slope of the distal end being much more oblique with the lateral portion of the articular surface very much swollen. The total length of the left metatarsal I is 82 mm.

The distal end of the fibula differs from that of *M. harriesi* in having a more flattened shaft and less prominent ridges at the distal end on the posterior face.

Dromicosaurus gracilis v. Hoepen.

1920. van Hoepen. Ann. Transv. Mus. VII, 2. p. 103. Pls. XIII—XVI.

This is a form slightly larger than *Massospondylus carinatus*, but closely allied to *Massospondylus* and *Aetonyx*. The type consists of fragments of humerus and radius, a fairly complete cervical vertebra, some caudal vertebrae, the pubes, the ischia, a femur, a tibia, a fibula and some foot-bones.

Van Hoepen has pointed out certain differences between this and previously described forms. The outstanding features seem to be judging from the description and figures given, the straightness of the femur and the great height of the anterior end of the proximal surface of the tibia. Further, the lateral edge of the pubis is much straighter than in *Massospondylus harriesi* or in *Gryponyx africanus*, the only known South African forms of similar size in which it is satisfactorily preserved.

In connection with the original description and comparison of this form with *Massospondylus harriesi* it should be noted that the tibia and "femur" described by Broom, upon which van Hoepen based his comparisons, are probably not bones of the type at all, as pointed out in my re-description of *M. harriesi* in the present paper. Nevertheless, the tibiae of the two forms do vary in shape, the head of that of *D. gracilis* being much more inclined to the axis of the shaft than that of *M. harriesi.*

Type. Partial skeleton in the Transvaal Museum.

Locality. Naauwpoort Nek, Bethlehem, Orange Free State.

Horizon. Red Beds.

Fam. PLATEOSAURIDAE von Huene.

Plateosaurus stormbergensis Broom.

1915. Broom. Bull. Amer. Mus. Nat. Hist. XXV p. 162, figs. 48, 49.

A species of a large size, founded on a right femur, a right first metacarpal, portions of vertebrae and portions of the pubes.

The first metacarpal is much longer than broad, 99 mm. long and 56 mm. wide distally. The bone is more elongate than in *Massospondylus* or *Gryponyx*.

The femur differs from that of *P. cullingworthi* in its thinner proximal end, its narrower distal end, and the slightly lower position of the trochanter quartus. The medial distal condyle also appears to be much stouter in *P. cullingworthi.* It differs from *Gryponyx* in that the trochanter quartus does not lie wholly in the upper half of the shaft; but it is not so low down as in *Euskelesaurus* or *Melanorosaurus.*

The pubis has a broad anterior plate.

Two phalangeal bones collected by Dr. D. R. Kannemeyer at Witkop, Jamestown, C.P. — the type locality — and now in the South African Museum (Cat. No. 1875) probably belong to this species. One has a length of 55 mm., a proximal width of 32 mm., a proximal height of 28 mm. and a distal width of 30·5 mm. At the distal end the medial portion of the articular surface is bigger than the lateral. The other bone, which is probably the first phalanx of the first digit of the left foot, has an axis which curves outwards at the distal end. The greatest length is 53 mm., the proximal width 33 mm., and the maximum distal width 32 mm. At the distal end the palmar surface is much broader than the dorsal surface.

Type. In collection of American Museum, New York. (Cat. No. 5605.)

Locality. Witkop, near Jamestown, Aliwal North, C.P.

Horizon. Base of Red Beds.

Plateosaurus cullingworthi, sp. nov.

Text figs. 31—35.

At Kromme Spruit, Herschel, C. P. a number of fragments of large Dinosaurian bones belonging to 3 or 4 individuals were found weathered out down one of the slopes of a steep kopje formed of the basal rocks of the Red Beds. At one point near the top of the same kopje bones were found in situ. Excavation revealed a "pocket" of isolated bones belonging to two individuals — a larger and a smaller — of apparently the same species. Some of the weathered bones, including two femora, have also been associated with these remains; the remainder belong obviously to an animal of heavier build, having large and heavy dorsal vertebrae and have been described as a species of *Euskelesaurus*. The bones from the pocket, together with the two femora and one or two other bones are considered to belong to a new species of *Plateosaurus* which I have named in honour of Mr. C. W. Cullingworth to whose energy some of the finds are due.

Although this form shows some differences from the more typical members of the genus from Europe, especially in the greater length of the humerus compared with that of the other bones, it has not been considered advisable to separate it generically from *Plateosaurns.*

Vertebrae. Cervical. Judging from the curvature of the ventral border of the centrum, the only cervical vertebra preserved (S. A. M. Cat. No. 3345) is probably the 3rd. or 4th. or possibly the 5th. Taking a line at right angles to the end faces, the posterior ventral point lies 34 mm. below the anterior ventral point. The total length of the centrum is 157 mm. Its ends are roughly circular, the anterior 57 mm. high, the posterior 61 mm. The posterior end is more deeply concave than the anterior, and both have their ventral borders rounded off. From the anterior end there runs a strong ventral median keel which gradually dies away until it disappears in the posterior third of the centrum. The whole vertebra is compressed in the middle. The small diapophysis lies on the upper half of the centrum, 40 mm. from the anterior border. Below and anterior to it is a small horizontal parapophysis. Between the two is a fairly deep groove. The prezygapophyses extend well in front of the centrum and have slightly convex facets. Seen from in front they form between them a wide V-shaped groove for the reception of the preceding postzygapophyses. Their lower borders are horizontal, so that each process thickens rapidly laterally. The postzygapophyses are slightly shorter than the anterior processes. The facets are slightly concave. The whole process is strongly built. The neural spine is missing; but its base is long and narrow, and the spine must have been low.

Dorsal. An anterior dorsal centrum (Cat. No. 3345a) has a length of 102 mm.; its ends are 80 mm. high and 70 mm. wide. In the middle the body is strongly constricted, having a width of only 24 mm. The ventral border is concave and has a sharp longitudinal keel. The ends are concave, equally so, and their ventral borders are rounded off. The parapophysis for the capitulum of the rib is midway along the body in its upper half, directly below the transverse process. The transverse process is 50 mm. long, placed above the middle of the body. Its upper surface is flat and horizontal, and its distal end is considerably thickened so that its articular surface is roughly triangular with a width of 36 mm., looking downwards and outwards. The anterior border of the process passes directly into the outer border of the prezygapophysis; its hinder border is proximally emarginate. The width between the facets of the transverse processes is 115 mm. The prezygapophysis extends in front of the centrum, and is double the length of the postzygapophysis. The general shape of the processes is of the normal Plateosaurian type.

Two other dorsal centra are preserved (Cat. No. 3356) having the following measurements:

Length	105 mm.	110 mm.
Height of anterior end.	86 ,,	90 ,,
Height of posterior end	78 ,,	82 ,,
Width of anterior end.	68 ,,	72 ,,
Width of posterior end	63 ,,	72 ,,
Median width . .	30 ,,	37 ,,

Caudal. There are two imperfect caudal vertebrae, both from the mid-caudal region. One is 67 mm. long, has the anterior end of the centrum 52 mm. high and 48 mm. wide, the posterior end 50 mm. high and 44 mm. wide, and is considerably constricted in the middle width a minimum width of 24 mm. The ends are somewhat concave and the ventral borders of the ends are bevelled off, the anterior more than the posterior. The anterior zygapophysis are small and upwardly directed. The transverse processes arise at the top of the centrum and stand out horizontally.

In the other, the centrum is 75 mm. long with its end 48 mm. high and broad. It is but little compressed and the ventral surface is flattened. The prezygapophyses are directed strongly upwards, while the transverse processes are small and arise from behind the middle of the centrum. In neither vertebra are the neural spines or the postzygapohyses preserved.

Scapula. (Cat. No. 3348.) The proximal part of a left scapula is present, lacking the glenoid cavity and the coracoidal articular surface. The greatest breadth at the proximal end was probably 150 mm. The inner face of the scapula is flat, curving strongly inwards proximally; the outer face is lightly convex. Above the glenoid cavity the bone thins rapidly; the anterior border is uniformly thin save for a slight thickening near the coracoid. The supracoraco-scapular concavity is well-marked and large and the deltoid crest strongly developed. There is also preserved a fragment of the upper end which shows that distally the bone was expanded as in *Plateosaurus.* The narrowest part of the bone has a breadth of 71 mm. and a thickness of 24 mm.

Humerus. Two left humeri are preserved, one (Cat. No. 3342) of a larger, and one (Cat. No. 3350) of a smaller individual. The two agree closely with one another in general characteristics, although the smaller bone has been flattened so that the processus lateralis is not so strongly bent as in the larger bone.

From within the bone is seen to be very slightly S–shaped. The proximal part is very broad, the shaft thin. and the distal end broad. The proximal and distal articular surfaces are strongly inclined to one another. The head of the humerus lies somewhat within the middle line. The anterior edge of the proximal articular surface is a regular curve; the posterior edge has two saddle-shaped prominences due to thickenings at the inner angle and at the caput humeri. This latter is at the extreme end of the bone. At the outer side of the broad, concave bicipital fossa is the processus lateralis, a strong crest lying parallel to the inner border of the upper half of the bone, and whose anterior surface is inclined to the axis of the bone, the upper half pointing medially, the lower end outwards. The lower end of this crest at its junction with the shaft lies half-way down the humerus.

The distal end is broad, but the condyles are not greatly thickened, the whole articular surface being much narrower in comparison

Fig. 31. *Plateosaurus cullingworthi*, Htn.
Humerus No. 3342. × $\frac{1}{5}$.

with its length than in the European species of *Plateosaurus* or in *Pachysaurus*. Both condyles are somewhat thickened in front, but practically not at all on the posterior face. On the anterior surface there is a marked concavity above the condyles in the median line.

The following table gives the chief measurements of the two bones and compares them with those of the humerus of *Plateosaurus reinigeri*:

	No. 3342	No. 3350	P. reinigeri
Total length . . .	455 mm.	405 mm.	400 mm.
Length from lower end of lateral process to distal end of bone . . .	225 ,,	205 ,,	200 ,,
Length of lateral process	90 ,,	90 ,,	100 ,,
Thickness of lateral process	35 ,,	30 ,,	25 ,,
Distance between upper end of lateral process and inner angle of bone .	155 ,,	186 ,,	180 ,,
Thickness of caput humeri	68 ,,	55 ,,	55 ,,
Thickness of shaft . .	53 ,,	43 ,,	55 ,,
Breadth of shaft . .	63 ,,	53 ,,	—
Breadth of distal end .	166 ,,	157 ,,	140 ,,
Thickness at median condyle	51 ,,	50 ,,	48 ,,
Thickness at lateral condyle	52 ,,	59 ,,	50 ,,
Thickness between condyles	32 ,,	28 ,,	25 ,,

From the humerus of *Gresslyosaurus* the bone differs in that its proximal edge does not form such a high bow, its inner edge is straighter in the proximal half, and the lateral process is much more sharply bent over. The proximal edge is more curved than in the other species of *Plateosaurus* or in *Pachysaurus*; and the distal end is not provided with sharp longitudinal ridges as in *Teratosaurus*.

Radius. A left radius (Cat. No. 3347) has its lower end turned towards the ulna. The upper part is flattened and broadened, having slight median longitudinal grooves on both its medial and lateral surfaces. The proximal articular surface is saddle-shaped, concave in front, convex behind. From the higher posterior angle of the bone a strong crest passes downwards and curves outwards, ending abruptly on the posterior part of the lateral surface 60 mm. down the shaft. The proximal end is 83 mm. long and 43 mm. broad; the distal end 60 mm long and 53 mm. broad. The narrowest part of the shaft has a diameter of 35 mm. The distal end is trapezoid in shape, and its posterior half is obliquely inclined upwards and backwards.

Ulna. A left ulna (Cat. No. 3351) is compressed from side to side, slightly bent with the medial face convex. The proximal end is bent forwards and has an anteriorly directed prominent point. The hinder portion of the proximal end is slightly higher than the anterior portion, forming an incipient olecranon process. The lateral edge of the articular surface is 108 mm. long and is slightly concave. From the median angle to the anterior point the length is 88 mm., and to the posterior corner 68 mm. At the broadened end of the shaft the lateral surface is concave, while below it is flat; the medial surface is convex. The distal end is 70 mm. broad and 40 mm. thick. The whole length of the bone is nearly 300 mm. In general aspect the bone approximates closely to that of *Plateosaurus* except that the anterior portion of the upper articular surface is longer and narrower.

There is also preserved the proximal end of another left ulna somewhat smaller than the other. The median angle is slightly more forward, the distances from it to the anterior and posterior points being equal.

Ischium. A right ischium lacking the posterior end and the pubic articulation, and the iliac articular portion and the distal end of a

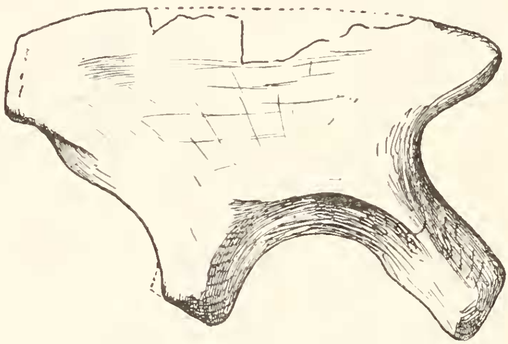


Fig. 32. *Plateosaurus cullingworthi,* Htn. Right ilium No. 2780. × ⅕.

left ischium probably belong to this species. The whole length of the bone was probably between 370 and 400 mm. The iliac articular surface is 135 mm. long and 85 mm. broad. Its inner edge is straight, its outer edge regularly convex. The groove on the hinder portion of the bone is not very pronounced. It begins 100 mm. below the proximal end. The broken end of the style shows a triangular cross-section, the medial face being 70 mm. long and the width of the bone 40 mm. The anterior angle is more acute than the lateral. The distal end of the bone — as seen in the fragment of the left side — is but slightly swollen. The posterior border curves slightly forwards distally. At the extreme end the inner edge is 95 mm. long and the bone is 63 mm. thick.

Femur. Two right femora (Cat. Nos. 3602, 3603) have been built up from fragments found weathered down the slopes. One is larger than the other, but the two are of closely similar shape and proportions.

The larger (3602) has a length of 600 mm. The breadth at the proximal end, from the border of the caput femoris to the lateral border is 175 mm. The proximal end is strongly rounded, and its shape approximates closely to that of *Plateosaurus erlenbergensis.* The upper end of the bone is 85 mm. thick, but it is compressed between the upper surface and the trochanter major. At the trochanter major

Fig. 33. *Plateosaurus cullingworthi*, Htn.
Right ischium. × $\frac{1}{5}$.

it swells again, but not to such an extent as in *Euskelesaurus.* The shaft is slightly S-shaped.

The lower end of the 4th trochanter lies 305 mm. below the top of the bone. The trochanter is slightly curved, concave medially, and lies nearer the medial than the lateral side of the bone. The distal end is broadened and thickened. The medial condyle is considerably larger than the lateral. Above the condyles on the hinder face the intercondylar fossa is shallow and broad; between the condyles it is narrower and deeper. The medial condyle is a large rounded boss. The lateral condyle is equally high, but it is narrower, and from it a well-marked fairly sharply rounded ridge passes on to the hinder face of the bone. The anterior face of the bone is flat in its lower half. The lower articular surface has a maximum width of 175 mm., and a height of 105 mm.

The femur differs from that of *P. stormbergensis* in the position of the 4th trochanter and in the greater thickness of the caput femoris.

Tibia. The right tibia (Cat. No. 3341) is a complete bone, whose total length is 440 mm. The proximal surface has a length of 175 mm.

Fig. 34. *Plateosaurus cullingworthi*, Htn.
Right femur (3602). $\times \frac{1}{10}$.

from the median condyle to the anterior point, and a maximum breadth of 99 mm. The surface is higher on the inner border than on the outer. At the distal end the anterior process stands at least 50 mm. higher than the narrower, prominent posterior malleolus. The anterior border of the distal end is 111 mm. long, the inner border 83 mm., and the posterior border (parallel to the anterior) 76 mm. long.

This bone is shorter than the tibia of *Gryponyx africanus*, but is much more robust. The head is the same length but wider. The distal end is very much stouter.

Metatarsals. The second and third metatarsals of the right side (Cat. No. 3343 and 3344 respectively) are preserved. The proximal end of the second is quadrangular, having both its longer edges concave. The larger axis of the parallelogram has a length of 92 mm., the shorter 53 mm. From the angles sharp ridges run down the bone. The length of the bone is 216 mm., while the distal end has a greatest breadth of 69 mm.

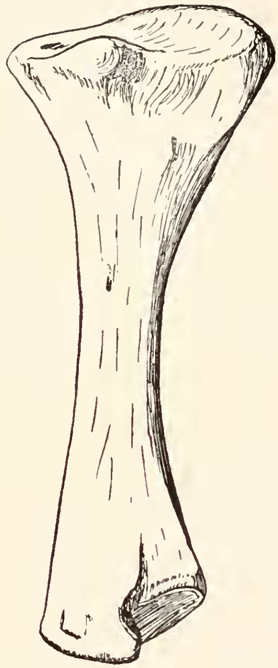
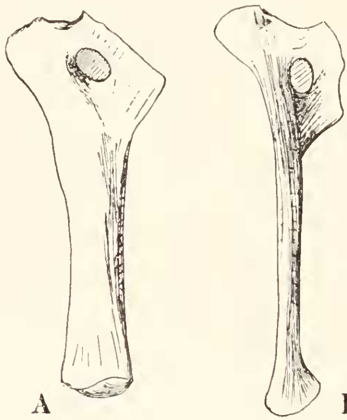


Fig. 35. *Plateosaurus cullingworthi*, Htn.
Right tibia (3341). Outer view.

The length of the third metatarsal is 226 mm. The proximal end is narrowly triangular, 89 mm. long and having a base of 52 mm. The distal end has a breadth of 66 mm.

A number of bones from the Red Beds just above the village of Lady Grey, C. P., seem to belong to this species. They can be correlated with the type by means of a left tibia, somewhat smaller than that described, but of similar shape and relative proportions; a right humerus, of the same size as No. 3350; the distal ends of the two ischia; the distal end of the right and the proximal end of the left femur, comparable in size with No. 3603; and part of the left scapula. In addition there is an ilium and part of a pubis, together with vertebrae, ribs, and other fragments.

Ilium. The greatest length of the right ilium is 325 mm. Most of the upper border is missing, but it was probably only slightly curved. The posterior process is truncated obliquely, its hinder border measuring 65 mm. The anterior process is fairly long, its lower border rounded, its upper border sharp and thin. The acetabulum is 165 mm. wide and 90 mm. high. The supra-acetabular crest is prominent around the anterior upper portion of the border,



A B

Fig. 36. *Gryponyx africanus*, Br.
Left pelvis of type.

A. Latero — ventral view.
B. Lateral view — ventral surface to right.

rounded on its outer and upper surfaces; but it dies away posteriorly. The preacetabular process is 130 mm. long and 65 mm. broad on the medial face.

Pubis. The larger portion of a right pubis is preserved. It lacks the anterior edge, the distal end and the subacetabular portion. The greatest length of the remainder is 360 mm. The posterior border is strongly concave, so that the plate broadens considerably distally.

Co-types. Portions of two animals in South African Museum. Catalogue numbers as in description.

Locality. Kromme Spruit, Herschel, C. P.

Horizon. Base of Red Beds.

Gryponyx africanus, Broom.

Text figs. 36–38.

1911. Broom. Ann. S. Afric. Mus. VII. 4, p. 294. Pls. XIV–XV.

In addition to the original description the following points may be noted.

Vertebrae. Two posterior dorsal vertebrae have been developed. The centra are each 75 mm. long; the anterior articular surface of the first is 55 mm. broad, the posterior surface of the second

Fig. 37. *Gryponyx africanus*, Br.
Left femur of type.
A. Anterior view. B. Medial view.

63 mm. broad and 85 mm. high. The middle portion of the centrum has a minimum width of 28 mm. The maximum height of the vertebra was 180 mm. The dorsal spine is thin, long and fairly low. A figure is given herewith.

Pelvis. The pelvis of the type is crushed, and has been restored and figured by Dr. Broom.

The two pubes form a complete symphysis. They are seen in the type from the ventral side. The greatest length of the left pubis is 440 mm. The pubic neck has a minimum width of 58 mm., and is situated at a distance of 95 mm. from the articular surface for the ilium. Its maximum thickness is not more than 20 mm. At the articulation with the ilium the pubis is 65 mm.

broad. The pubic foramen is large, oval in shape, with a long diameter of 49 mm. and a short diameter of 35 mm.

The pubic plate is long, comparatively narrow and thin — the lateral border sharply rounded and concave, the medial border thin and straight. At the distal end the plate widens and thickens, so that the distal surface is 70 mm. long and 40 mm. wide. At its narrowest part the plate is 55 mm. wide.

Femur. The right femur is markedly S–shaped and strongly bowed, the anterior face being convex. The length is between 535 mm. and 540 mm. The head of the bone is missing. Above the level of the trochanter major the outer edge curves regularly to the proximal surface and is parallel to the inner edge. The top of the trochanter major lies 100 mm. from the proximal surface. The upper end of the fourth trochanter is 175 mm. from the proximal end and the lower end about 260 mm. so that the trochanter lies wholly in the proximal half of the bone.

The distal end is 97 mm. broad. The inner edge is 110 mm. long, the outer edge 115 mm. The inner condyle is thicker than the outer, and the sulcus between them is deep and narrow. The ridge running from the outer condyle to the posterior face of the bone is longer and more prominent than that from the inner condyle.

Tibia. Dr. van Hoepen has pointed out that the figure given by Dr. Broom and designated "outer view of left tibia" is in reality an inner view of the right tibia.

The proximal end of the tibia seems to be somewhat flattened from side to side and its width was possibly somewhat greater than the 71 mm. given by Broom. The highest point of the bone lies a little in advance of the anterior corner on the antero-medial border. Instead of the medial border of the proximal end having a regularly convex outline its middle portion is concave, as shown in the figure. The lateral border has a pronounced concavity between the tuberositas tibiae and the lateral condyle. The anterior half of the proximal surface is concave; the posterior portion is also concave, and the two concavities are separated by a saddle. The medial border is higher than the lateral. The shaft narrows very rapidly below the articular surface and expands but slightly distally, increasing only in width and not in thickness. Below the proximal articular surface the lateral face is broadly grooved longitudinally, and separated from the posterior face by a rounded ridge which carries a small boss of bone. The anterior proximal edge of the bone is rugose.

The shaft has a minimum width of 46 mm. and a minimum thickness of 41 mm.

The distal articular surface has a maximum width of 90 mm. and

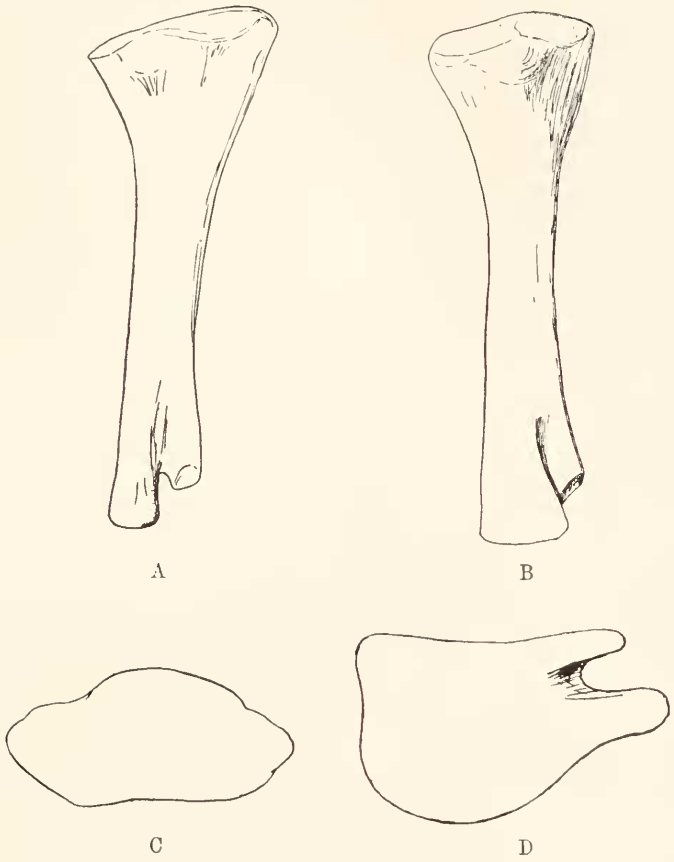


Fig. 38. *Gryponyx africanus*, Br.
Right tibia of type.
A. Latero — posterior view.
B. Posterior view.
C. Outline of proximal end.
D. Outline of distal end.

a maximum thickness of 53 mm. The posterior edge is 70 mm. long. The anterior condyle stands about 45 mm. above the posterior condyle, and its surface faces downwards and outwards. The sulcus between the condyles is narrow and fairly deep.

Type. Pelvis and hind limbs, right and left manus, and vertebrae. (S.A. Mus. Cat. No. 3357, 3358, 3359.)

Locality. Foutanie, Fouriesburg, Orange Free State.

Horizon. Top of Red Beds.

Gryponyx transvaalensis, Broom.

1912. Broom. Trans. Geol. Soc. S. Afr. XIV, p. 82, Pl. XIII, figs. 3, 4.
1920. van Hoepen. Ann. Transv. Mus. VII, 2. p. 102.

This is a very imperfectly known species, the type consisting of a claw phalanx and the distal end of a metatarsal.

The species is apparently about four-fifths the size of *Gryponyx africanus*; according to Dr. Broom "it differs in having a much less developed tubercle for the flexor tendon which makes the flexor surface less curved and gives the whole claw a less hooked appearance". Van Hoepen, however, considers that "the greater part of the tuberositas for the flexor tendon is broken away". He further thinks that the claw belongs, not to the right hand, but to the left; and that it differs from his *Massospondylus browni* (i. e. *M. harriesi*) in that the proximal end of the lateral side ridge lies relatively much higher with regard to that of the medial side in *G. transvaalensis.*

Type. Claw of manus and a metatarsal, in Transvaal Museum.

Locality. Wiepe 1258, N. Transvaal.

Horizon. Bushveld Sandstone.

Gryponyx taylori nov. sp.

Text fig. 39.

The remains forming the type of this new form were discovered in 1915 in the neighbourhood of Fouriesburg, Orange Free State, in an exposure near the top of the Red Beds. They consist of the pelvic girdle and sacral vertebrae found in conjunction.

Vertebrae. Three sacral vertebrae were found *in situ* between the two sides of the pelvis, somewhat flattened from side to side. The first centrum is not fused to the second.

The second and third vertebrae are of equal length, and each slightly longer than the first. The centra are higher than wide with concave ends. The ventral border of the first is more excavate than those of the other two; the centrum of the third is more excavate posteriorly on its lower border than anteriorly. The lower border of each is sharply rounded, but not keeled nor pointed. The first centrum is 79 mm. long, the others each 84 mm. The posterior surface of the third centrum is 82 mm. high.

The second sacral rib is missing; but it is apparent that the base of the third sacral rib is larger than the second, and the second than the first. Distally the sacral ribs are fused to form one long surface for the support of the ilium. The base of the first lies on the anterior part of the centrum just below the neural arch and only covers a small part of the body; that of the third occupies at least half of the anterior half of the body and extends up to the strong transverse process. Inferiorly the proximal part of this rib is strong and rounded; superiorly it thins considerably and then widens out to meet the under side of the fairly wide, horizontal, and backwardly directed transverse process. The anterior face of the rib is thus fairly strongly concave, the posterior face also being concave, but less so. The first rib is essentially of the same character, but is much smaller.

Of the zygapophyses only the prezygapophysis of the first vertebra is well seen. It is strong with a flat upper surface facing somewhat inwards. The first postzygapophysis is closely fixed to the prezygapophysis of the second vertebra.

The neural canal is high and narrow. The neural spines are higher than the centra, thin, broader above than below, and slightly backwardly directed.

Ilium. The left ilium lacks only the posterior process, which is present in the type of the genus.

The anterior spine is short and sharp, its lower border rounded and fairly thick, its upper border sharp and thin. Its lower border is straight. The preacetabular process is long and strong, widest at the end. In cross-section it is triangular, the apex of the triangle — formed of an obtuse angle — being on the outer side of the bone. The upper half of the process has a strong sharp ridge on its outer edge, which ridge gradually becomes less pronounced as it continues round the acetabular border until it disappears altogether just behind the mid-point of the upper border of the acetabulum.

The postacetabular process is short and broad, its inner surface flat, its outer surface broadly rounded. The hinder border is concave.

The body of the bone thins away rapidly above the acetabulum, and the upper border is bent inwards between the anterior and posterior spines.

The acetabulum is high and narrow. More than half of it is formed by the ilium.

Ischium. The expanded proximal portion of each ischium is preserved. The surface for articulation with the pubis is long and narrows below; both it and the iliac surface are thickened. The hinder surface of the bone is thickened and carries a longitudinal median groove which dies out about 50 mm. below the posterior upper border of the bone. The anterior border is thin.

Pubis. The left pubis is a long bone with an expanded proximal portion and a thickened distal end. The middle portion is slender, with a rounded and thickened anterior border having no longitudinal

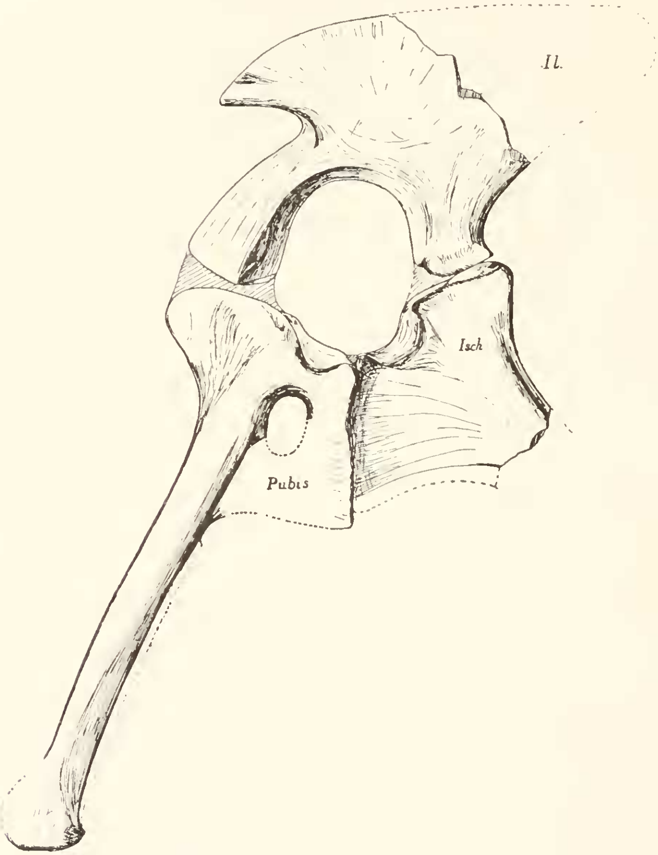


Fig. 39. *Gryponyx taylori,* Htn.
Left side of pelvis. × $\frac{1}{6}$.

groove, and thinning posteriorly. The posterior border is missing, but the bone seems to be narrower than in Seeley figure of *Massospondylus.* The pubic foramen is large and oval in shape.

The chief measurements of the pelvis are as follows:

Width of acetabular opening . . .	101 mm.
Length of preacetabular process . .	140 ,,

Greatest width of preacetabular process .	71 mm.
Width of postacetabular process . .	56 ,,
Length of anterior spine	63 ,,
Length of iliac surface of ischium . .	79 ,,
Length of ischio-pubic suture . . .	106 ,,
Length of pubis	432 ,,
Length of iliac surface of pubis . .	80 ,,
Thickness of distal end of pubis . .	72 ,,

In size this pelvis is almost identical with that of the type of *Gryponyx africanus*, but it differs in the possession of a much larger anterior iliac spine and in the different slope of the upper iliac border, agreeing therein both with *Massospondylus* and *Plateosaurus.*

In his discussion of *Massospondylus* in "Die Dinosaurier der Europeaischen Triasformation" von Huene lays emphasis on the fact that the distal portion of the pubis is short and thick, thus differing from all Plateosaurs. In this specimen, however, the pubis is long and slender distally as in *Gryponyx* and, therefore, the form cannot be placed in the *Massospondylidae.* In spite of the difference in the shape of the anterior spine of the ilium I am inclined to place it in the genus *Gryponyx*, naming it after Mr. H. M. Taylor, while collecting with whom I discovered the remains.

Type. Pelvic girdle and sacral vertebrae. S. Afr. Mus. Cat. No. 3453.

Locality. Fouriesburg. O. F. S.

Horizon. Top of Red Beds.

Euskelesaurus browni, Huxley.

1866. Huxley. Quart. Journ. Geol. Soc. XXIII, p. 1.

1894. Seeley. Ann. Mag. Nat. Hist. Ser. 6, Vol. XIV, p. 317.

1906. von Huene. Geol. und Palaeont. Abh. N.F. Bd. VIII, Hft 2, p. 123.

1911. Broom. Ann. S. A. Mus. VII, 4. p. 292.

The type specimens of this species are in the British Museum and in the Museum d'histoire naturelle in Paris. They consist of fragmentary vertebrae, femur, tibia and fibula, and pubis. The fragmentary nature of these remains renders comparison with other specimens unsatisfactory for specific identity. The type bones have been fully described and discussed by von Huene, who arrives at the following conclusions.

Euskelesaurus browni is not only larger than most other Plateosaurs but there are certain characters which, on the one hand, distinctly separates it from the other genera, and on the other hand brings it very close to them. The shortness of caudal vertebrae, especially the posterior ones, does not occur to such a degree in other Plateosaurs, likewise the shortness and compression of the phalanges of the foot and consequently also of the metatarsals. The greatest similarity is with *Gresslyosaurus*. The fourth trochanter lies in the lower half of the femur as in *Gresslyosaurus*, certainly rather lower than in that genus; but the whole femur is, in proportion to the enormous vertebral column in its central part, conspicuously shorter than in *Gresslyosaurus* and the other Plateosaurs. The tibia is extremely strong at the proximal end. The dorsal vertebral centrum is higher than in other Plateosaurs. The third sacral centrum is pointed below. The trochanter major of the femur is larger than in other Plateosaurs.

Type. In British Museum.

Locality. "Stormberg", C.P. Almost certainly from the Kraai River.

Horizon. Base of Red Beds.

EUSKELESAURUS CAPENSIS (Lydekker).

1889. Lydekker. *Orinosaurus capensis* Geol. Mag. Ser. 3, vol. VI, p. 353.

1906. von Huene. Geol. und Palaeont. Abh. N.F. Bd. VII, Hft. 2, p. 129.

This is known only from the proximal end of a tibia and a small portion of a femur. It is larger than the type species. The form of the proximal end of the tibia is characteristic, and it is possible that the species is generically distinct from *E. browni*. Too little is known of it, however, to warrant such a separation being made, and none of the bones in the South African Museum collection can be assigned to the species.

EUSKELESAURUS AFRICANUS sp. nov.

Text figs. 40–41.

From Kromme Spruit come a number of large bones found weathered down the slope of the kopje that yielded *Plateosaurus cullingworthi*. Of these, a number of vertebrae, two attached ischia, and some ilia are the most completely preserved. There are also portions of tibiae and of a femur which are, however, not sufficiently complete to admit of satisfactory comparison with those of *Euskelesaurus*. The animals represented by these bones must have been somewhat smaller than *E. browni* and I have therefore decided to keep them in the already-established genus and to designate them as *Euskelesaurus* *africanus* n. sp. The type is in the South African Museum (Cat. No. 3608).

Sacral vertebrae. Two fused sacral vertebrae are preserved, lacking the sacral ribs and the neural spines. They are probably the 1st and 2nd sacrals.

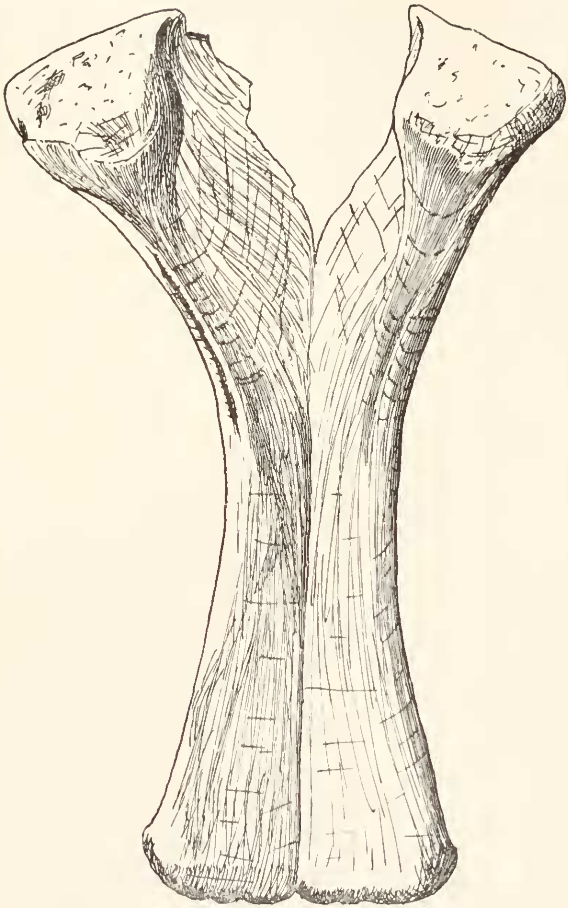


Fig. 40. *Euskelesaurus africanus*, Htn.
Ischia. Posterior view. × $\frac{1}{5}$.

The anterior centrum has a length of 140 mm.; its front end is flat and has a height of 120 mm. and a breadth of 130 mm. The sides of the body are swollen and the ventral surface is broadly rounded — not so much so as in the succeeding centrum. The sacral rib is represented only by a section across its junction with the body.

This is elongate with a convex anterior edge and a concave posterior edge, while the upper edge is nearly straight and lies just below the level of the zygapophysis. The prezygapophysis is short and its upper surface is concave, looking inwards and upwards.

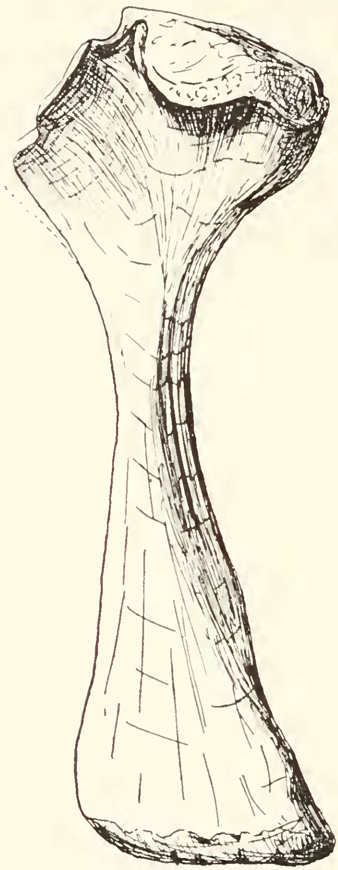


Fig. 41. *Euskelesaurus africanus*, Htn.
Left ischium, lateral view. × $\frac{1}{5}$.

The succeeding centrum had a length of 145 mm. Its posterior face was 130 mm. high and 140 mm. broad. Its ventral surface was very broadly rounded and without any trace of median keel. The sacral rib itself is lacking, but it must have been very large and strong, larger than that of the first sacral. Its base is on the centrum extending over the greater part of the side of the body from the front to the back and from the transverse process down to within 35 mm. of the ventral surface. The upper surface of the transverse process is flat and horizontal, the process passing outwards and backwards. The posterior zygapophysis is short; its under surface is concave facing outwards and downwards. The base of the neural spine is 100 mm. long and not more than 25 mm. wide. The width between the tips of the transverse processes was probably 290 mm.

Ischium. Both ischia are present, lacking only the subacetabular expansions.

The greatest length of the bone is 570 mm. Ventrally the two bones were probably in contact throughout their length; dorsally the distal ends have a straight contact for 250 mm. and then diverge gradually. Just above the point of contact on the posterior side the shaft has a breadth of 50 mm.; at the distal end it broadens out to 100 mm. The shaft is flat posteriorly, while its outer and anterior borders are concave. The most characteristic feature of the bone is the very pronounced thickening at the distal end — a thickening greater than that seen in any other known Plateosaur. Whereas at its narrowest the bone has a thickness of only 40 mm., just above the distal end it swells to a thickness of 140 mm. and a breadth of 100 mm.

The distance between the inner sides of the proximal ends of the two bones is 140 mm. The medial face of the proximal portion is concave, the lateral face convex. The greatest breadth across the iliac articular surface is 110 mm. The groove on the hinder face of the bone is about 150 mm. long and is well-marked.

Type. Sacral vertebrae, ischia. (S. Af. Mus. Cat. No. 3608.)

Locality. Kromme Spruit, Herschel, C. P.

Horizon. Base of Red Beds.

Gigantoscelus molengraaffi, van Hoepen.

1916. van Hoepen. Verhand. Geol.-Mijn. Genoot. Ned. en Kolonien. Geol. Serie III, p. 107, text fig. 3.

Founded on the distal end of a right femur. The bone is somewhat larger than that of *Euskelesaurus*, but is relatively thicker and has a narrower sulcus between the two distal condyles. The chief interest of the specimen lies in the fact that it is of a type that occurs apparently only near the base of the Red Beds in the Cape Province.

Type. Distal end of a femur in the Transvaal Museum.

Locality. Haakdoornbult, 344. Waterberg Dist., Transvaal.

Horizon. Bushveld Sandstone.

Eucnemesaurus fortis, v. Hoepen.

1920. van Hoepen. Ann. Transv. Mus. VII, 2. p. 93. Pls. XI. XII, XIII fig. 1.

The type of this form consists of the proximal half of a femur, a complete tibia, a proximal portion of a pubis, portions of dorsal and caudal vertebrae and some fragments, of a large form.

In addition to the comparisons made in the original description, the following may be added. The tibia approximates in size to that of *Melanorosaurus readi*, but the proximal end appears to be thicker (although in *M. readi* it is somewhat incomplete). Further, the proximal end slopes down to the shaft more gradually in *E. fortis* than in *M. readi*, and the shaft is more slender in the latter form. The differences, however, are not very acute and may well be merely specific. Until further comparisons are possible, however, there can be no great harm done in retaining separate generic names for the two forms. The femora, as far as they can be compared, seem different. The proximal end is broader in *M. readi*, owing to the fact that the lateral border does not pass so abruptly into the proximal border in *E. fortis*. In the latter, too, the fourth trochanter seems to occupy a slightly more medial position. In the former character, *Eucnemesaurus* occupies an intermediate position between *Plateosaurus* and *Melanorosaurus*.

From *Plateosaurus cullingworthi* the tibia of *Eucnemesaurus* differs markedly in general shape, the shaft of the former being much more slender in its middle portion; the articular surfaces are also of different shape.

Type. In the Transvaal Museum.

Locality. Zonderhout, near Slabberts, O. F. S.

Horizon. Red Beds (probably about half way up.)

Melanorosaurus, gen. nov.

This genus is characterised by the following features: Vertebrae lighter and smaller than those of *Gresslyosaurus* and *Euskelesaurus* when compared with the length and size of the femur: humerus with lateral process sharply bent over, proximal edge forming a moderately high bow, less marked than in *Gresslyosaurus*; femur with straight shaft, whose lateral border forms approximately a right angle with the proximal surface at the upper, outer corner, and with lower end of fourth trochanter below the middle of the femur: distal end of tibia broader in front than behind.

Melanorosaurus readi sp. nov.

Text figs. 42–47.

The bones forming the type of this species were found on the northern slope of the mountain Thaba 'Nyama ("Black Mountain"), lying between Josana's Hoek and Josana's Nek in the district of Herschel in the Cape Province. They were lying isolated and embedded in a soft red mudstone below a sandstone band not far above the base of the Red Beds. The bones consist of a tibia, a fibula, part of the pelvis, some vertebrae and metatarsals, together with a femur lying partly embedded in the overlying sandstone and the proximal half of a humerus found weathered down the slope. They are in the collection of the South African Museum (Cat. Nos. 3449, 3450). I can collate these remains with no hitherto-known species, and have much pleasure in naming them after Mr. B. Read, former Principal of the Bensonvale Training School, of whose kindness, display of interest, and hospitality I have a lively recollection.

Another individual (S. A. M. Cat. No. 3532) belonging, apparently, to the same species — but somewhat smaller than the type — is represented by some bones excavated below the Rooi Nek, between Kromme Spruit and Majuba Nek, Herschel, from an horizon about one-third the way up the Red Beds. These remains include a scapula and a complete humerus, and thus add to the knowledge of the form.

Vertebrae. With the type several isolated vertebral centra were obtained. The centra are all considerably longer than high. Their end surfaces are oval in shape with the larger axis vertical. One — probably a posterior cervical — has a sharp ventral surface, keeled at either end. The dorsals are rounded below; all the vertebrae are lightly built compared with those of *Gresslyosaurus*. The length of a dorsal centrum is 110 mm., the height of its anterior surface 95 mm.; while the width at the middle of the centrum is 45 mm. The ventral surface of the bone is not acutely concave.

Scapula. Among the bones from Rooi Nek an almost complete scapula is preserved. The bone has been flattened, so that its original curvature is lost. The upper end is somewhat expanded and is thinner than the proximal end. The anterior border is thin. Proximally the posterior border is rounded and comparatively thick, but distally it is thin. The glenoid cavity is not deep, but it is broad and fairly high. The articular surface for the coracoid is very broad. The greatest length of the bone is 450 mm. The width at the distal end is 175 mm., and that at the narrowest part of the shaft is 75 mm.

Humerus. The Rooi Nek specimen contains an almost complete right humerus. Its proximal edge forms a somewhat higher bow than is seen in the incomplete bone of the type from Thaba 'Nyama; but this latter shows signs of having been somewhat abraded before its final entombment. Nevertheless, the proximal end is not so strongly arched as in *Gresslyosaurus*, and the distal end differs con-

Fig. 42. *Melanorosaurus readi*, Htn.
Right humerus inner view (3532). × $\frac{1}{5}$.

siderably from that genus. The lower end of the lateral process lies nearly half-way down the bone.

The distal and proximal articular surfaces are inclined to one another at an angle of about 45°.

The distal end has been somewhat flattened, but it is broad and thin. The lateral condyle is considerably smaller than the medial, and there is a well-marked broad depression between them on the anterior face. The posterior surface of the distal end is almost flat, the lateral condyle being somewhat thickened.

The bone is 500 mm. long. The distance from the lower end of the lateral process to the distal end of the bone is 260 mm. The shaft is 55 mm. thick and 67 mm. broad. The distal end is 155 mm. broad, the thickness at the lateral condyle is 65 mm., and at the medial condyle 63 mm.

Radius. The left radius presents no features of unusual interest. It is slightly shorter than the ulna, having a length of 280 mm. The proximal and distal ends are each 89 mm. wide, while the shaft at its narrowest is 43 mm. wide.

There is also preserved a right radius, somewhat smaller than the

Fig. 43. *Melanorosaurus readi*, Htn.
Right ulna of type. × ⅕.

corresponding bone of the other side. It is 250 mm. long. The proximal end is flattened, while the distal end is thicker and stronger. In both bones the proximal articular surface is concave in front and convex behind as in *Plateosaurus* and other forms.

Ulna. The right ulna is complete, being 300 mm. long. The proximal end is expanded and has a triangular articular surface, of which the anterior and posterior angles are sharper than the lateral angle. The anterior point is directed forwards, the posterior one backwards and outwards. The posterior half of the surface is strongly convex in its middle portion, being raised considerably above the anterior half of the surface. There is thus a strong boss forming an incipient olecranon process. The maximum length of the proximal surface is 120 mm., its maximum width 60 mm.

The posterior border of the bone is bent in an S-shaped curve, the anterior border being regularly convex. In the former feature the bone differs considerably from that of *Plateosaurus erlenbergensis* which has a straight posterior border. The thinnest part of the shaft occurs about 10 cm. from the distal end, where it has an oval cross-section whose diameters are 35 mm. and 45 mm. The distal end is 95 mm. broad.

Ilium. In the Thaba 'Nyama specimen one ilium is complete. In the Rooi Nek specimen one ilium is complete and the other almost so. The shape of the ilium is most like that of *Massospondylus carinatus.*

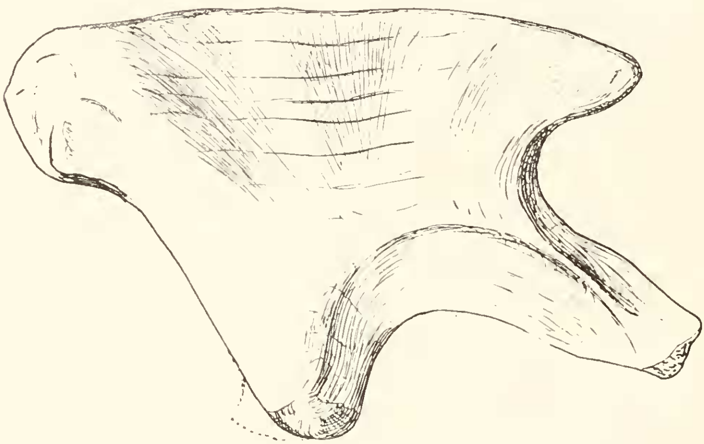


Fig. 44. *Melanorosaurus readi*, Htn.
Right ilium of type. × 1/5.

The upper edge is fairly straight and the anterior spine is not so long as in *Gresslyosaurus.* The acetabulum is bounded in its upper anterior quadrant by a sharp ridge which dies away towards the end of the preacetabular process. The postacetabular process is short; its posterior border is straight. except at the lower corner, where it is provided with a hook-like projection. The posterior iliac spine is short and high. The body of the bone is slightly bowed inwards.

The height of the bone from the bottom of the postacetabular process to the upper edge is 275 mm.; the greatest length is 415 mm. The width of the acetabulum is 210 mm., its height 120 mm.

Pubis. An incomplete pubis is preserved, which shows that the anterior portion is a broad, flattened plate.

Femur. This bone was in doubtful association with the other remains, and may possibly belong to another form. It is short compared with the length of the humerus, shorter than in *Gresslyosaurus.* It agrees with *Gresslyosaurus* and *Euskelesaurus* in that the lower end of the 4th trochanter is below the middle of the bone. In outer view the bone is straight and is considerably expanded distally. The width of the distal end at the lateral condyle is greater than that at the medial condyle; the groove between the two condyles is broad and fairly shallow.

The length of the femur is 620 mm., the breadth at the proximal end 170 mm. The lower end of the 4th trochanter is 350 mm.

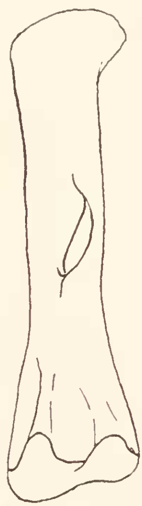


Fig. 45. *Melanorosaurus readi,* Htn.
Right femur. × $\frac{1}{10}$.

below the top of the bone. The minimum width of the shaft is 95 mm., its minimum thickness 73 mm. The width of the distal end is 175 mm.; the thickness at the lateral condyle 115 mm., and at the medial condyle 80 mm.

This bone, when compared with the tibia, is shorter than in other members of the Plateosauridae. In *Euskelesaurus*, however, where the femur is short and stout, the tibia is not known; but it is possible that the two bones in that genus bear somewhat the same relation to one another as in this form. It is in the size of the vertebrae that the two forms differ so markedly.

Tibia. The tibia is a massive bone 45 cm. long with a large proximal end, a straight shaft, and a broadened distal end. The tibial tuberosity is weathered away to a certain extent, but must have been prominent. The proximal articular surface has a greatest length of 195 mm., and a greatest width probably of about 100 mm. The inner border does not stand much higher than the outer. The inner border is convex with a shallow concavity at the middle. Between the tibial tuberosity and the anterior and posterior ends of

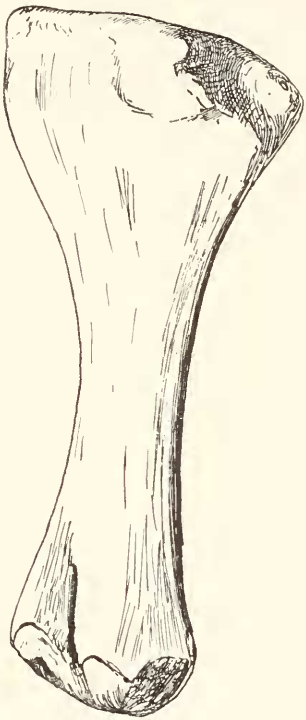


Fig. 46. *Melanorosaurus readi*, Htn.
Left tibia, outer view. × $\frac{1}{5}$.

the surface there is, in each case, a shallow concavity. The anterior portion of the surface is higher than the posterior, and is not excessively prolonged, but is bluntly rounded.

Just below the middle of the bone, where it is most slender, the shaft has an antero-posterior diameter of 80 mm., and a lateral diameter of 60 mm. The anterior surface is provided with a sharp keel in its lower half which passes down to the anterior condyle. The posterior surface is rounded, the outer and inner surfaces flattened.

At the distal end the anterior border has a length of 130 mm.

measured along the lower border and stands about 40 mm. above the posterior border, which is 90 mm. long. The inner border is strongly rounded with a length approximately equal to that of the hinder border.

Fibula. The left fibula is preserved entire, although the bone surface is somewhat shattered. Its greatest length is 477 mm. The proximal end is expanded, its inner surface slightly concave, its outer surface convex. The greatest breadth of the proximal end is 140 mm., while it is but 44 mm. thick. The anterior border of this end is thin and sharply rounded, while posteriorly the bone is thicker. The upper edge is higher behind than in front.

The shaft is flat on the inner side and strongly rounded laterally. It has a diameter of 50 mm.

Fig. 47. *Melanorosaurus readi*, Htn.
Metatarsal III. Front view. × $\frac{1}{5}$.

The distal end is slightly swollen in an antero-posterior direction. The lower surface is 85 mm. long and 53 mm. broad, convex on the inner side and obliquely flattened laterally. The anterior face of the distal end is broadly rounded, while the posterior face has a sharp ridge on its inner side, sloping away to the outer face as a flat surface.

Metatarsal. One of the metatarsals is preserved, probably the 3rd. It is a straight bone having a length of 200 mm. The proximal articular surface is triangular, the anterior angle being slightly obtuse. The surface is 80 mm. broad, and has a maximum thickness of 40 mm. At its thinnest part the shaft is 44 mm. broad and 26 mm. thick. The distal articular surface is 62 mm. broad. Distally, the anterior surface of the bone is very flat, while posteriorly it is slightly concave with a shallow wide median groove just above the articular surface.

Type. Incomplete skeleton. S. A. Mus. Cat. Nos. 3449, 3450.

Locality. Thaba 'Nyama, near Bensonvale, Herschel, C. P.

Horizon. Near base of Red Beds.

Order ORNITHISCHIA Seeley.

Geranosaurus atavus Broom.

1911. Broom. Ann. S. Af. Mus. VII, 4, p. 306. Pl. XVII, fig. 24.

"The collection of bones consists of badly crushed fragments of a skull with the anterior part of lower jaw fairly well preserved, some slender birdlike hind-limb bones, and a number of very imperfect vertebrae. The vertebrae seem too large to have belonged to the skull, and there being thus some doubt about the bones being those of one animal I think it better to describe the jaw-bones alone and to make them the type.

As preserved, the lower jaw has the left dentary fairly complete with a considerable portion of the right and the predentary nearly perfect.

The predentary has its upper surface displayed, which is concave. It is 12 mm. long and the same in width. The outer and anterior edges are sharp and doubtless formed a horny beak.

The dentary as preserved measures 73 mm. in length, and there is probably but little missing from the posterior end. The anterior half bears 9 teeth which have rounded roots in sockets. The teeth in the fragment of maxilla have flat chisel-shaped crowns with the outer face feebly ridged. Probably those of the mandible were similar in this respect. The most remarkable thing about the dentition is that the most anterior of the teeth is larger than the others, and may be looked upon as a canine. The total length of the series is 35 mm. Most of the teeth have a diameter of between 3 and 4 mm., but the anterior tooth has a diameter of 5 mm."

Associated with the lower jaw, on another small slab of stone is the imperfect mould of a tibia, fibula and some of the bones of the foot which bear nearly the same relation to the size of the jaw as does the tibia to jaw in *Nanosaurus*. It seems probable, therefore, that they are of the same species as the type jaw.

The *tibia* is long and slender, apparently agreeing with that of *Nanosaurus* in that it is compressed proximally with a somewhat triangular cross-section, while its distal end is more rounded in section. The proximal end is nearly all preserved. The anterior portion of the articular surface is higher than the posterior part and is considerably narrower, the tuberositas tibiae being well defined. The lateral process is rounded and strong. The shaft is slender; the distal end is only preserved in the form of a mould of the lateral surface. The total length is 146 mm.; the length of the proximal articular surface was about 25 mm.; the shaft at its narrowest probably had a width of not much more than 10 mm.

The *fibula* lies on the outer side of the tibia and closely appressed to it, crossing it at a low angle. It was apparently shorter than the tibia and very slender, being widened at its proximal end.

Part of the *pes* is preserved, consisting of a small tarsal bone and the most of one digit, probably the second. The *metatarsal* is 19 mm. long posteriorly and 14 mm. long anteriorly, the distal surface being inclined to the axis of the tibial shaft. The whole axis of the digit is inclined to that of the tibia, so that the animal appears to have been digitigrade. The first phalanx is short, its proximal end broader than the anterior end; the second phalanx is 18 mm. long. The claw is incomplete, but was long and comparatively slender.

Type. Incomplete lower jaw — S. Afr. Mus. Cat. No. 1871.

Locality. Top of Barkly Pass, Elliot, C. P.

Horizon. Cave Sandstone (base of).

PART II.

STRATIGRAPHY

Molteno Beds.

The general features of the Molteno Beds are described by Rogers and du Toit in "The Geology of Cape Colony" as follows:

"The Molteno Beds are first met with at a point a little to the east of Steynsburg and form the higher-lying ground in the Division of Molteno; they extend along the fort of the Stormbergen into Herschel, the Orange River Colony, and Basutoland, and along the base of the Drakensbergen through East Griqualand into Natal.

The formation consists of sandstones. shales and mudstones, the softer beds being much like those of the Ecca and Beaufort, grey, greenish or bluish in colour, but without the calcareous concretions so abundant in the lower groups.

Fossil plants are in places abundant, but seem if anything to be more plentiful in the lower half of the Molteno Beds: silicified wood is common in some of the sandstones.

The sandstones of the Molteno beds are quite unlike any that occur in the lower groups of the Karroo system. In general appearance and in the character of the surface to which they give rise, they resemble the Table Mountain Sandstone more closely than any other in the Colony, but they are coarser in grain and much looser in texture. In most localities the quartz grains are coated with a later deposit of quartz with more or less perfect crystalline faces which reflect light well, so that the rock sparkles in the sunlight. To such varieties the term "glittering sandstone" has been appropriately given.

Grains of felspar are abundant in these sandstones, sometimes in such quantity that the rock can almost be termed an arkose. The loose texture of the Molteno sandstone has allowed the felspar to weather considerably, and the dull white grains of weathered felspar are always conspicuous constituents of the sandstones, more especially in the finer grained varieties. Rounded or spherical nodules, hollowed out in the centre when the hard outer shell has been broken through, are quite a characteristic feature of the Molteno sandstones. The nodules are formed by the oxidation of pyrites and the deposition of some of the resulting iron compounds in a spherical zone about the lumps of decomposed sulphide. The hard shell is thus due to the addition of the hydrated iron oxides to the cementing material usually present.

The lowest of the coarse glittering sandstones has been termed the "Indwe Sandstone", and forms a reliable bench-mark from which the horizons of the different coal outcrops can be defined.

The finer grained varieties of sandstone . . . . are of a yellowish grey or cream colour and furnish a good building stone.

The coarse gritty sandstones occasionally become conglomeratic, the pebbles consisting principally of vein-quartz and of quartzite.

A peculiar feature is the occurrence in the Molteno sandstones of smooth rounded or oval pebbles usually a few inches across but occasionally ranging up to boulders a couple of feet in diameter. They are, as a rule, scattered irregularly through the sandstones, but in the Molteno Division they are particularly abundant along a certain horizon and form a bed of conglomerate a few feet in thickness. The pebbles are sometimes found resting upon a coal seam and partly imbedded in the base of the sandstone overlying the coal. The pebbles are almost entirely of white or brownish, sometimes glassy, quartzites like those of the Witteberg or Table Mountain series. They are most abundant to the south-west of the Stormbergen. Some of these pebbles show pitting externally due to the formation of cubes of pyrites a layer of which occurs just below the surface.

In the Molteno Beds there are numerous outcrops of coal, but the workable seams are restricted to three well-defined horizons. The lowest one is that of the Indwe seam: to this belong the coals at Indwe, Cala and that near Engcobo. The second is about eighty feet higher and is known as the *Guba seam*. The uppermost is the horizon of the *Molteno seam*, 300 ft. above the Indwe seam.

The layers of coal seldom exceed twelve inches in thickness (in the Guba seam there is one about 25 inches thick), but as several usually occur alternating with thin bands of black shale it is possible to extract from three to four feet of coal in mining operations.

On all three horizons these composite seams appear to occupy a number of detached areas, in between which the coal is either replaced by shale or else is entirely absent. In most cases this is due to non-deposition of carbonaceous material, but sometimes to erosion of the matter deposited, contemporaneous erosion, a phenomenon which is seen in thousands of cases throughout the Karroo beds. At Indwe the upper layers of coal and shale are in places missing, and the surface thus denuded is overlain by massive sandstone with pebbles at its base.

The coals of the Molteno beds are usually laminated and contain very thin streaks of shale; they are coals which where formed very probably at a considerable distance from the spot where the plants grew, and the alternation of thin layers of coal and silt evidently points to the vegetable matter having been deposited over the floor of the basin in the same manner as the silt."

In addition, it is well to give a few details with regard to the stratigraphy in the various Divisions in which the beds have been studied.

Glen Grey, Queenstown & Wodehouse Divisions. In this area the Molteno Beds are essentially arenaceous in character more so than in the country to the north. The Indwe Sandstone forms the most important subdivision, and sometimes the second thick sandstone from the base, the Gubenxa Sandstone, can be identified. There is a general thickening of the beds towards the south and south-east, as is evidenced by the fact that the thickness of the strata below the Indwe Sandstone is 150–250 feet in Aliwal North, 450–500 feet at Sterkstroom and Indwe, 700 feet at Cala, and 1000 feet at Lady Frere.

The Indwe coal-seam is composed of a number of bands of coal and shale, which are constant in character throughout the Indwe mining area. The upper layers were in certain spots removed by contemporaneous erosion. The "wash-outs" must have been formed, according to Du Toit, by streams or currents of water flowing over the seam of coal and shale while they were in a soft incoherent state. The sandstone underlying the coal undulates, and thin layers of coal and shale were spread over the surface and perpetuated the irregularities beneath them. Erosion was most vigorous in the original gentle troughs of the seam, and thus the top coals in these troughs are no longer present, their place being taken by sandstone and grits.

In the Northern portion of Wodehouse near the top of the Beds is a hard fine-grained white sandstone with a few *Thinnfeldia* fronds. A similar bed is found at the same horizon in Elliot.

Aliwal North & Herschel. The thickness of the Molteno Beds in these Divisions is probably about 1000 feet. The Indwe Sandstone lies about 200 feet above the upper limit of the Burghersdorp Beds and forms a very prominent horizon, showing the same characters as in the south. The Indwe Coal is not present, except that it is represented in places by a hard black carbonaceous sandstone with thin streaks of coal. The Cala and Gubenxa coals are represented by 8 feet of mixed coal and shale. These lie 300 feet above the Indwe Coal.

The upper beds are very similar throughout and consists of coarse-grained pebbly sandstone, usually finer in texture than is the case further south at Indwe in the Transkei. Higher up are fine-grained sandstones with shales and mudstones, sometimes reddish in colour, followed by soft pinkish felspathic grits.

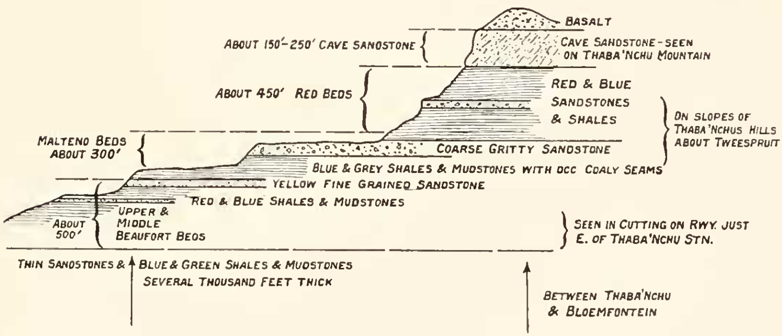


Fig. 48. Section in Thaba' Nchu District, O.F.S.

Orange Free State. Little detailed work has been done on the Stormberg Beds which lie in the Eastern Free State between the Orange River and Harrismith. It is certain that the Molteno Beds are absent at the latter place where the Red Beds rest unconformably on the Upper Beaufort Beds: and there is probably a gradual thinning out of the formation northwards from the Orange River, similar to that which has been traced by Du Toit in Natal. At Thaba' Nchu the beds are about 300 feet thick; the lower two-thirds, according to a section supplied by the Irrigation Department, consists of blue and grey shales and mudstones with occasional coaly seams, the upper third of coarse gritty sandstone. At Verkijkersberg, S.W. of Memel, in the extreme north-east of the Orange Free State, the Molteno Beds are also absent.

Transkei. In the Transkei the maximum thickness varies from 1800 feet in the south of the area to 1400 feet in the north. The Beds are essentially arenaceous. They consist of thick layers of coarse pebbly felspathic sandstone separated by bluish and grey softer weathering, fine-grained sandstones, mudstone, and shale. The sandstone contains a good deal of felspar, fragments of which are frequently $^1/_4$ in. in diameter, while the grains of quartz frequently exhibit partial restoration of the crystal faces, giving rise to "glittering sandstones". Small pebbles of vein-quartz are abundant in certain layers. Sporadic pebbles of granite, graphic granite, and white fine-grained quartzite occur, more commonly near the base of the series and frequently just above, or even resting on, a coal seam.

The Indwe Sandstone and Gubenxa sandstone are well represented. The top of the series here is a more than usually coarse pebbly sandstone.

Griqualand East. Du Toit has described the Molteno Beds in this area from the Divisions of Maclear, Mount Fletcher, Qumbu, and Mount Frere. The beds bear a close relation to those in the Transkei. In no place are they more than 1800 feet thick and are essentially arenaceous. Iron pyrites is found in irregular layers in the sandstones in a few localities.

Du Toit describes the beds as having the following characteristics. "The sandstones contain a good deal of felspar, usually rather decomposed. The pieces of felspar may, in cases, attain a diameter of half an inch, while in a railway cutting, about a mile south of Ugie Station, small pebbles of granite and graphic granite were observed in addition. The grains of quartz frequently show partial restoration of the crystal faces, and the light reflected from these facets gives the rock a sparkling appearance in the sunlight; hence the appropriate name of "glittering sandstone" given to them. Small pebbles of white or blue-black quartz up to an inch or thereabout in length are most characteristic of these sandstones, and some portions are so pebbly in character that they can almost be termed conglomerates."

Further to the north-east, in Mount Currie on the Natal Border. the thickness has diminished to about 1100 feet, even to 950 feet just over the border. The layers of coarse pebbly sandstone are thinner and spaced closer together than in Maclear. "Otherwise the formation is the same, e.g coarse-grained pebbly sandstones and grits — usually false-bedded and sometimes conglomeratic and crowded with smooth water-worn quartz pebbles — rather felspathic and passing into grey finer-grained types: most of the sandstone sparkles or "glitters" in sunlight owing to the reflection of light from the faces of quartz crystals". The pebbles in the Indwe Sandstone range from a few inches up to a foot in length. At one place there is a ferruginous conglomerate full of quartzite pebbles. Below the Indwe Sandstone bluish green and grey mudstones and thin fine-grained felspathic sandstones occur. The higher horizons of the Series consist of grits and pebbly sandstones, alternating with blue, grey and buff mudstones and shales.

Natal. Along the eastern slopes of the Drakensberg ranges du Toit has traced the Stormberg Series from the Cape Border to Van Reenen's Pass and Harrismith. At Hlatikulu Hill at the head of the Bushmans River in the Division of Estcourt he has measured a thickness of 140 feet of Molteno Beds consisting almost entirely of grits. At the base the beds are false-bedded with ferruginous nodules: at the top they consist of white coarse grits; and there are few thin shaly beds.

At Bezuidenhout's Pass on the Orange Free State — Natal border the Molteno Beds are absent: and they are similarly absent on the Platberg near Harrismith.

Red Beds.

Elliott. The Red Beds reach their maximum thickness in the neighbourhood of the Barkly Pass where they are about 1600 feet thick. The sandstones are fine-grained and irregularly distributed. Bands up to 30 feet in thickness are common and are usually red or purple in colour when unweathered. Conglomerate beds as a rule are absent: but in one or two localities beds of sandstone contain abundant white quartzite and quartz pebbles. The shales and mudstones which form the bulk of the Red Beds are red. purple, green or white, and occasionally violet in colour. It is noticed that the thicker sandstone bands very often lie upon eroded surfaces of the softer beds.

Wodehouse. The base of the Red Beds contains coarse "glittering sandstones" like those of the underlying Molteno Beds. The thickness in the district is very variable. Just north of Indwe there are 1500 feet of sediments: but 12 miles to the west the thickness diminishes to 650 ft. Further to the south it is again increased. Again, between Dordrecht and Jamestown the thickness is generally 650 feet, while to the north-east in the lower Waschbank it is 900 ft. to 1000 feet.

The lower portion consists of banks of rather coarse-grained gritty sandstone (pale yellow or bluish in colour) with interbedded yellow and buff mudstones and thin purplish red sandstones, shales, and clays. The sandstone beds are thicker, coarser, and closer together than in Elliot.

The upper 400 ft. or so are brillantly coloured shales and sandstones. Calcareous rocks are frequent, occurring usually as irregular nodules and concretions in mudstones.

Aliwal North. The thickness measured at Kraai River Poort is 900 feet, while to the north on the Herschel-Aliwal Boundary and at Lady Grey it has fallen to 600 feet. The general features are similar to those found further south. At the base of the beds a thick yellow sandstone separates the Molteno Beds from the overlying purple and red shales and mudstones. The succession is well displayed at Lady Grey, where Kynaston noted that the sandstones appear to become finer-grained as one ascended in the series. Occasional layers of calcareous concretions occur, which sometimes contain bone–fragments.

Barkly East. Only the top portion of the Red Beds is seen in this mountainous district. The beds have a general dip to the South, whilst to the north in Herschel, they dip in the opposite direction. Du Toit noted the presence of much silicified wood on the farm Glencoe, the tree stems being of considerable size.

Herschel. The Red Beds are well displayed along the north side of the Wittebergen. The thickness at Palmiet Fontein (near the Basutoland Border) and between Kromme Spruit and Majuba Nek is at least 900 feet.

At the base are red and purple mudstones, weathering to light blue, which have yielded a number of large Dinosaur bones. At the summit, at Dulcie's Nek, is a bed of limestone. Between, the strata are made up of very brillant red shales and clays with prominent red and occasionally buff sandstones. The sandstone band which occurs at about one-third the way up the succession as seen at Josana's Hoek appears to be persistent and will probably prove a useful "bench-mark" for palaeontological purposes.

Pebbles are very uncommon in the sandstones. During two fairly extensive collecting expeditions which examined most of the outcrops in the district only two reddish small semi-rounded pebbles of quartzite were seen.

Fossil wood is found in certain localities, occurring in the thin sandstones. Some of the trunks are large One section 9 feet long now in the South African Museum has a diameter of over 2 feet. It was found near the base of the formation at Kromme Spruit lying in a thin sandstone at a low angle to the bedding planes. Other specimens of similar and even greater diameter were obtained — also from near the base of the beds — at Blikana.

Orange Free State. The Red Beds are well exposed on the eastern border of this province, being especially well seen between Thaba 'Nchu and Modderpoort, around Ficksburg, and between Fouriesburg and Harrismith. Fossils have been collected at Fouriesburg, but no details of the Beds are available. Red colour predominates, but at Ficksburg the base of the formation consists of very thick grits — which, however, may prove to be a local excessive development of the Molteno Beds.

The Red Beds are exposed on the sides of the Thaba 'Nchu hills

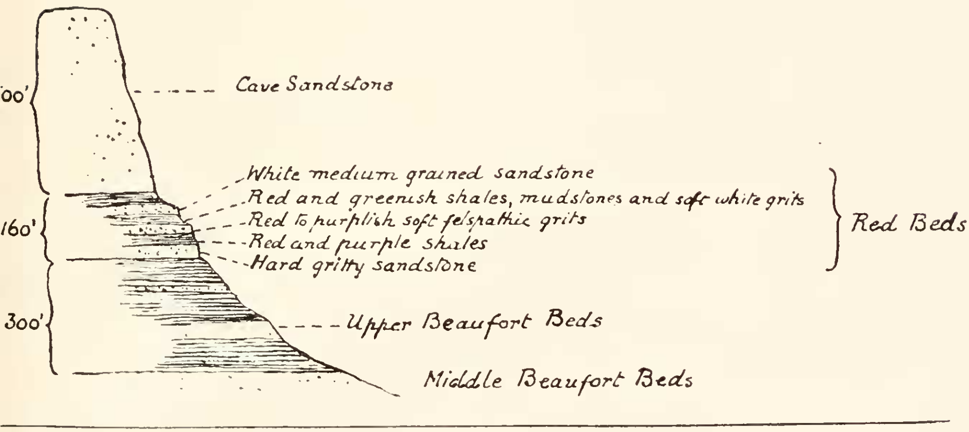


Fig. 49. Verkijkersberg. S.W. of Memel, O.F.S.

about Tweespruit. They are about 450 ft. thick and are predominantly argillaceous, consisting of red and blue shales with at least one prominent sandstone band.

Du Toit has studied the section shown by the Platberg, near Harrismith and he has kindly sent me details of this unpublished study. At the base of the mountain are red and purple shales with medium-grained sandstones, representatives of the Beaufort Beds — a slightly lower horizon of which has yielded a Middle Beaufort fauna on the Harrismith Commonage. Lying above these are 290 feet of strata which he assigns to the Red Beds, there being thus an unconformity between the Beaufort Beds and the Red Beds, the Molteno Beds being absent. At the base of the Red Beds is a thin but gritty sandstone. This is followed in succession by over 100 feet of soft purple shales, a massive fine-grained sandstone with thin soft bands, and at the top are red and purple shales. It must be pointed out that the unconformity is not evidenced by any apparent discontinuity in succession, nor is there any difference in dip between the two formations.

Further north, at Verkijkersberg, S.W. of Memel, the thickness of the Red Beds has fallen to 160 feet. The red clays of the Upper Beaufort Beds are succeeded by a hard gritty sandstone, often quartzose at the base and this in turn by a fine-grained sandstone. Then follows a series of red to purplish soft felspathic grits, red and greenish shales and mudstones and soft white and red grits. The top of the formation is formed of white medium-grained sandstones. The basal sandstone is variable in thickness and rests sharply on red mudstone:

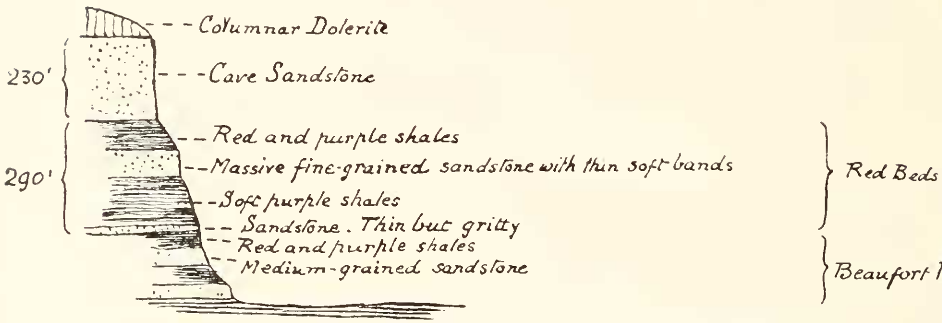


Fig. 50. E.S.E. corner of the Platberg, Harrismith, O.F.S.

portions of it, especially at or near the base, are quartzose grits and show false-bedding dipping in a South-Westerly direction.

Midway between Harrismith and Memel, on Tandjes Berg, the Red Beds are intermediate in thickness.

Transkei. In the Transkei the thickness is uniformly 1200 feet. The sandstones are gritty at the base of the series, occasionally carrying isolated boulders of quartzite: higher up they become finer-grained and yellow. The softer mudstones and sandstones and shales are of brilliant red, purple, and blue tints, weathering pale. Many of the so-called "buff" sandstones owe their colour to weathering, being red on a freshly-fractured face.

Griqualand East. In Maclear and the Divisions bordering it to the North and East the thickness of the Red Beds diminishes from South to North, having a maximum of 1200 feet. Du Toit has described a section showing the full succession shown in the ascent from

Pot River to Tent Kop in Maclear. This shows predominating purple and red shales, mudstones and soft sandstones often of remarkably brilliant colouring — which bleach on exposure. Coarse grits and occasionally pebbly sandstone occur at the base, and not uncommonly there are found boulders of quartzite like those of the Molteno Beds. The most prominent sandstones are usually white in colour, and in places contain nodules of iron pyrites or marcasite. Many of the sandstones when fresh are red; they are commonly full of porous patches which represent spots originally rich in calcareous material. Clay-pellet conglomerates are not uncommon at the base of certain sandstones. Fossil wood is occasionally seen. Vertebrate fossils are scarce.

In Mount Currie the thickness is only 400 feet. The beds, as else-

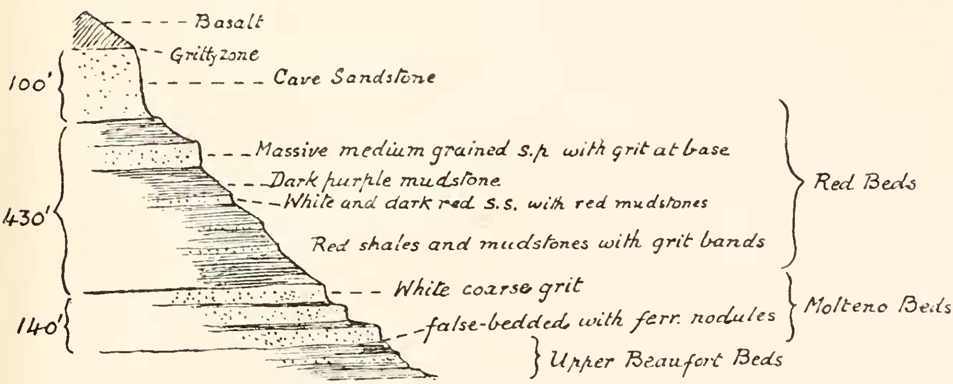


Fig. 51. Hlatikulu Hill, near Table Mountain, Natal

where, consist of several bands of fairly fine-grained sandstone alternating with blue, red, and purple mudstones and soft sandstones.

Natal. At Hlatikulu Hill the Red Beds have a thickness of 430 feet resting on the Molteno Beds. Shales overlie the top white coarse grit of the Molteno Beds, and contain one or two gritty bands. They are succeeded by white and dark red sandstone with red, purple and blue mudstones and soft sandstones; these by dark purple mudstones. Then comes a massive medium-grained sandstone with grit at the base, and between it and the Cave Sandstone are reddish shales.

Further north, at Bezuidenhout's Pass on the O.F.S. border the thickness has diminished to 400 ft. The formation rests directly on purple mudstones of the Upper Beaufort Beds and has at its base a bed of gritty and pebbly sandstone which, in its lower portion, has quartz-pebbles up to $^1/_2$ an inch in diameter as well as pellets of shale and some sandstone fragments. The mass of the Red Beds is made up of an alternating series of sandstones, which get finer-grained towards the top, and purple mudstones. The sandstones are white and the two uppermost bands contain flattened pellets of pale blue-green shale.

The junction between the Upper Beaufort Beds and Red Beds appears to be an unconformable one, but is without angular discordance.

Cave Sandstone.

Elliott. The Cave Sandstone here is a massive yellowish fine-grained felspathic sandstone of remarkable uniformity of texture. It is slightly stratified at its base, and sometimes more so at its summit; but lamination is usually absent. Some sections show false-bedding on

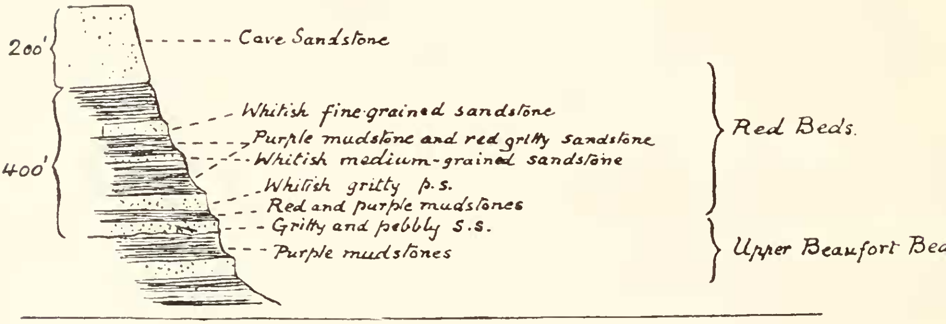


Fig. 52. Bezuidenhout's Pass, O.F.S. border.

an extensive scale. When fresh, the rock is pinkish or reddish in tinge.

Its maximum thickness, as displayed at the Barkly Pass, is 800 feet. Occasionally the sandstone is replaced over short distances by thin yellow sandstones and purple mudstones; similarly in Matatiele it is replaced locally by red clay, often mottled with green or alternating with light blue clay. At the top, the rock is sometimes interbedded with lavas and ash.

Barkly East, Wodehouse, Aliwal and Herschel. In these districts the rock is a fine-grained sandstone, usually pale yellow in colour, but varied by white, buff, pink, and blue. It is generally unbedded, but in places its upper portion is laminated. False-bedding is not uncommon, and is sometimes extensive.

In places the sandstone is split up by layers of ash and basaltic lava. The thickness is very variable, ranging from 150 feet to 800 ft. Du Toit, in his Report on these Divisions, compares the Cave Sandstone with the massive white Jurassic sandstone from the Grand Cañon region of Arizona.

Under the microscope the rock is very uniform in texture, chiefly made up of grains of clear quartz only slightly rounded. Angular fragments of orthoclase and microcline occur, as well as plagioclase, small grains of zircon, epidote, and sometimes tourmaline.

At Siberia, in Wodehouse, a shale-band near the base of the formation has yielded a fragmentary fish, many specimens of *Lepidurus*, numerous *Cyzicus* and Ostracods, and several forms of insect. In other places silicified wood is not uncommon.

Structurally, the sandstone is seen to be eroded and faulted before the main outpourings of the lava.

At Lady Grey, Aliwal North Division, where the Cave Sandstone is very well seen, the lower bed of sandstone is approximately 80 feet thick and is underlain by a few feet of soft reddish sandy shales. This bed is without sign of bedding planes, but exhibits well-marked vertical jointing. Above it is 400 ft. of sandstone clearly exhibiting a rude stratification in its upper portion and noticeable false-bedding at more than one horizon.

Orange Free State. Along the western border of the Drakensberg mass the Cave Sandstone constantly appears above the Red Beds. On Thaba'Nchu mountain it varies in thickness from 150 feet to 250 feet. Its thickness at Harrismith is 250 feet, where it is overlain by columnar dolerite, and at Verkijkersberg 500 feet. Its features are constant, a creamy or white massive sandstone forming the main body of the rock. At Fouriesburg the base of the formation is red and purple passing into white, so that it is impossible to draw a lithological distinction between the Cave Sandstone and the top of the Red Beds. From this level have come the types of *Gryponyx africanus* and *Massospondylus harriesi* as well as other lightly-built forms. A shale-band in the Cave Sandstone of Harrismith yielded *Cyzicus draperi* in various stages of growth.

Transkei. At the extreme North-east of the district the formation has a thickness of 800 feet; but a few miles away it thins to 50 feet. There is here an interruption of deposition caused by volcanic outbursts. At Tent Kop the Cave Sandstone is altogether absent, the lavas resting directly upon the Red Beds. These ashes dip beneath the Cave Sandstone of the neighbouring areas.

Lithologically the Cave Sandstone is uniform throughout the area — white to cream in colour, sometimes deep pink or red towards the base. It is almost invariably fine-grained and is composed of grains of quartz-sub-rounded to angular in outline — with grains of felspar and mica and small crystals of zircon, garnet, and rutile.

Griqualand East. The thickness in this area is very variable. In the North-East, near the Natal border, it has a maximum thickness of 800 feet, while westwards it thins in one place to 50 feet. In the Tsitsana Reserve its thickness is 300 feet yet at places near by falls to 100 feet. This variability is due in part to the outpouring of lavas before the close of the formation of the sandstone — in places sandstone is found intercalated with lava-flows.

The sandstone is generally uniformly white to creamy in colour occasionally being pink or red especially towards the base. The basal portion is well-bedded and at a few places rests unconformably on the Red Beds. The base frequently exhibits false-bedding.

Natal. At Hlatikulu Hill the Cave Sandstone is 190 feet thick, and at the top has a gritty zone overlain by basalt.

According to Churchill (1898) the thickness varies in the stretch between the head of the Bushman's River and Mont aux Sources from 200 feet to 600 feet, while at the south end of Thaba'Mhlope it is 800 feet thick. The rock there is compact, hard and gritty, usually cream or white in colour, but sometimes light red, and occasionally carries a "few round, hard sandstone nodules, often containing a little pyrites". At the base of the formation is a 6 – 10 ft. thick bed of a rather friable, light-coloured marly sandstone resting on a 5 – 15 ft. thick bed of nodular sandstone. This may be taken as the base of the Cave Sandstone as it rests on a "deep, pink, earthy layer".

Transvaal.

The Stormberg Series in the Transvaal is preserved as a number of outliers, forming the Bushveld Series, of which the most important occur on the Springbok Flats, the Komati Poort Coalfield, in the area North of the Zoutpansberg, and in the Limpopo Valley. The features of the series in each of the areas will be briefly outlined.

Springbok Flats. Mellor in 1905 gave an account of the sandstones of Buiskop and the Springbok Flats, which are overlain by the Bushveld Amygdaloid. He stated that the sandstones of the Springbok Flats are universally rather fine in grain and uniform in texture, rarely, if ever, gritty, and contain no conglomerates or pebblewashes except, possibly, at the extreme base. They are peculiarly massive and homogeneous and only rarely show traces of bedding planes, and then only at wide intervals. The colour varies from deep red to almost pure white or cream. The red sandstone is usually hard and quartzitic; where weathered and soft, it loses its red colour and

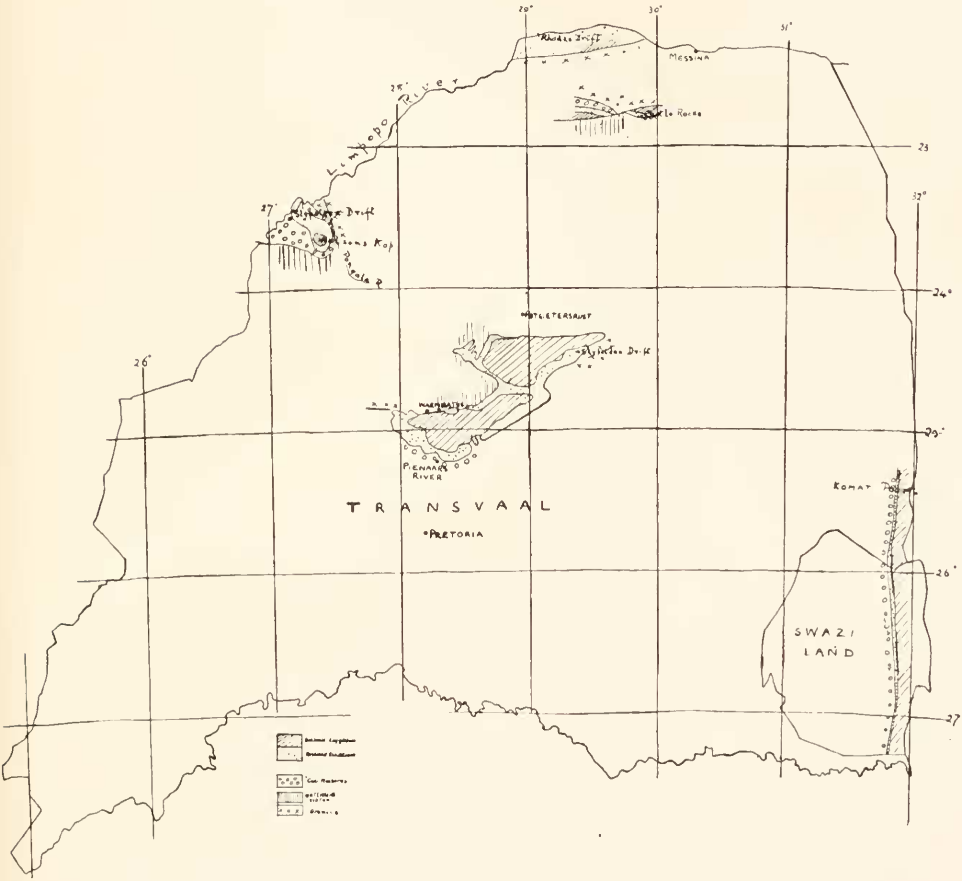


Fig. 53. Sketch-map of Transvaal to show distribution of Bushveld Series.

becomes yellowish or white. The sandstone is distinguished by well-marked vertical jointing.

West of Naboomspruit Station the sandstone rests directly on granite, but elsewhere upon the Coal-Measure Grits. It has a thickness there of about 30 feet. Its upper portion is massive, but towards the base it shows frequent traces of stratification, and the lowest beds consist of distinct bands of sandstones alternating with coarse gritty and conglomeratic beds which are composed of debris and fragments of granite. In places the fine-grained sandstones lie directly on the granite without intervening conglomerates.

At Slypsteen Drift the sandstones are even in texture, fine-grained and often massive; some beds show a tendency to lamination and are at times false-bedded. Wm. Anderson, in a paper published in 1912, described the occurrence of fossiliferous beds "exposed in the water-channel of the Compies River, in the vicinity of the store at Stypstee Drift, Springbok Flats, Waterberg District". "Stypstee Drift" is presumably a misprint, and should read "Slypsteen Drift". Regarding this occurrence Anderson writes "As this is the only postion in which I observed outcrops of these fossiliferous sedimentary beds, I have no evidence as to their probable lateral extent or distribution, because the country to the north-east, west and south-west chiefly consists of extensive areas of alluvial deposits, through which occasional outcrops of Recent calcareous rocks are not uncommon . . . . To the westward of Stypstee Drift, under the alluvials of the Springbok Flats, these fossiliferous sedimentary beds probably become associated with the amygdaloidal basalts, which form a portion of the Upper Karroo Series, and are well developed in the western and south-western portion of the Flats. It is, however, probable that this occurrence of fossiliferous Upper Karroo beds is not continuous with those of the west, but has been formed in an isolated basin. Similar, probably contemporaneous, sandstones and shales occur at the foothills of the western limit of the Springbok Flats, the sandstones occasionally attaining a considerable individual thickness, as at Buiskop, to the north of Warmbaths, where the rock has been extensively quarried for building purposes." According to Anderson, the beds at Slypsteen Drift rest unconformably on the Red Granite of the Bushveld. In the main section the lower exposed strata consist of practically horizontal exceedingly fine-grained, light grey, argillaceous shales. The sandstones above are markedly false-bedded and much jointed vertically. "In all cases the fossil bones occur as the nuclei of ferruginous nodules and not in a free state in the sediments. They occur more frequently in the nodules from the sandstones, but are more fragmentary than are those from the shale nodules. On all the exposed outcrops these beds do not show the slightest evidences of deposition under violent climatic conditions, although the presence of frequent bone fragments in the ferruginous nodules, which have evidently been much worn by attrition before they were deposited in the sediments, would rather incline one to the idea that there must have been around this lake-basin areas in which considerable erosion took place, in producing the material for these sedimentary beds. It is, however, difficult to explain why the eroded bones should find a place in these quietly deposited sediments, while the rock products of the same erosion are not present either as conglomerates or as isolated pebbles or boulders". Anderson saw no sign of plant remains; he pointed out that the ferruginous material segregated around the bones which varied in size from an inch to three feet in length. He considered that the bone-bearing nodules were confined to more or less distinct horizons on which the individuals are fairly plentiful. Large bones and small bones are mixed together indiscriminately — the two chief horizons being one amongst the lower shales and the other some distance higher.

Dr. Broom, who examined these remains, could not be certain of their specific identity. He considered it not improbable that they were all representative of one species, pointing out their resemblance to *Gressly saurus* and their possible identity with *Euskelesaurus browni* or *Euskelesaurus capensis*.

Neither Mellor nor Kynaston recorded determinable fossils, but in a bore hole at Ludlow 2355 specimens of *Cyzicus* (= *Estheria*) (?) were found in sandstone. Van Hoepen has described also a new genus of Theropod — *Gigantoscelus* — from bones in the Transvaal Museum which came from Haakdoornbult 344 in the district of Waterberg to the west of Pienaars River Station.

Komati Poort Area. The Bushveld Sandstone of the Komati Poort coalfield was described by Kynaston in 1906. In that area, fine-grained sandstones with distinctive features lie between the Coal Measures and the amygdaloidal basalts.

The sandstones are usually without signs of stratification. They are very fine-grained, even-textured throughout, soft, pale greyish or yellowish, sometimes pinkish in colour, sometimes mottled with darker spots. At one outcrop numerous spherical concretions up to 9 in. in diameter were seen, consisting of a hard shell around a softer interior.

Towards the base, the series becomes calcareous, and is often crowded with irregular lumps or nodules of finely crystalline limestone. Below this occur thin-bedded, soft, dark-red and greenish sandy shales and marls, the red colour predominating. The total thickness of the series is 300 feet. No organic remains have yet been discovered in the beds.

Northern Transvaal and Valley of the Limpopo. Mellor, in 1908, described the geology of the N.W. Zoutpansberg District in a Memoir of the Transvaal Geological Survey. He found that the Bushveld Sandstone series is especially conspicuous along the Limpopo Valley in the neighbourhood of Rhodes' Drift, from which point it extends east and west for many miles, forming prominent ridges rising 200 to 300 feet above the river. The sandstones vary in colour from red to yellowish white, are fine-grained, even in texture and sharp to the touch. They are usually extremely massive and frequently represented by a single bed from 30 ft. to 50 ft. in thickness without divisional planes. Occasionally, however, false-bedding on a very large scale traversing the full thickness of the rock and dipping at angles as high as 20 degrees is brought out by weathering.

Below the upper and harder portion of the massive sandstone and grading upwards into them there is almost invariably found about 15—20 ft. of sandy or marly mudstones, usually light green to purplish in colour, which contain numerous concretionary masses of limestone, varying from an inch to 2 or 3 feet in diameter. This lower marly portion of the sandstones usually weathers out into caves. Downwards the marly rock passes into red or purple sandy shales and soft sandstones, calcareous in places, and frequently mottled with light green patches. The average thickness of this lower series is about 200 feet.

"Where the sandstones form very prominent ridges and kopjes they are frequently found to have been much hardened by secondary silica, usually deposited along the numerous joint planes. In some cases the joint planes and fractures are so numerous that the whole rock becomes a breccia."

Dinosaur remains have been discovered in these beds. On the farm Wiepe 1258, Mr. Bowker found a number of bones which were described by Broom as *Gryponyx transvaalensis.*

In the west of the Waterberg Division of the Transvaal Bushveld Sandstones occur in the area between the Limpopo and its tributary the Pongola and apparently extend a little way across the river into the Bechuanaland Protectorate. According to information supplied by Dr. du Toit the sandstone rests on Coal Measures which themselves lie unconformably on Waterberg Beds or the Old Granite; and Nelson's Kop is capped with a volcanic flow. The Nelson's Kop sandstone — more fully described later — is an approximation to the Forest Sandstone type.

Dr. du Toit has recently presented to the South African Museum a few bones which he obtained from the beds at Slypsteen Drift on the Limpopo. They are, unfortunately, unrecognisable specifically, consisting of isolated phalanges and a portion of a caudal vertebra.

Their size, however, is comparable with that of similar bones of *Plateosaurus* or one of the larger genera of South African Theropoda.

Southern Rhodesia.

Molyneux (Quart. Journ. Geol. Soc. 1903, LIX, p. 279) gave the first provisional classification of the Upper Karroo rocks of Southern Rhodesia. He suggested the following: —

"Thaba 'Sinduna Series	200 ft.	Sandstones and volcanic rocks of Thaba 'Sinduna and Shiloh.
Forest Sandstones . .	1000 ft.	Fine sandstones of the forest-country, with sandy clay. Travertine on the surface. Bubi, Gwampa and Sikonyanla basalts. Conglomerate basement near the Djombi River.
Escarpment Grits . . .	400 ft.	Coarse red sandstones, with sub-angular pebbles, as seen in the great escarpment which stretches from the Mafungabusi Mountains to near Wankie."

Macgregor (in litt.) says that the beds classed here as Forest Sandstone are largely Kalahari, and therefore of more recent age than the Stormberg.

In an account of the geology of the region round Wankie, Lightfoot (1914) found 100 feet of Forest Sandstones — whose top was not seen — lying on 300 ft. of the Escarpment Grits. The "Forest Sandstone" of this area is said by Macgregor to be equal to his Nyamandhlovu Sandstone. Lightfoot conjectured a break at the base of his so-called Forest Sandstone and, if Macgregor be correct, this break would probably correspond in time to the formation of the Forest Sandstone of the Bulawayo area.

Macgregor (1916) described the Forest Sandstone of the typical area North of Bulawayo. He divides the sediments into four groups;

4. Nyamandhlovu sandstones intercalated in basalts.
3. White sandstone.
2. Red marls.
1. Basal beds, resting on old schists etc.

Maufe (1919) described briefly the Upper Karroo Rocks of the Amanxele Hills in the Bembesi basin north of Bulawayo. There buff-coloured sandstone lies unconformably on a floor of granite and greenstone schists.

The latest paper by Molyneux (1919) described the succession in the Pasipas area N. of Bulawayo. He divides the sediments as follows: —

Nyamandhlovu group	Arid climate . .	Basalt	30 ft.
		Sandstone	15 ft.
		Basalt	30-100 ft.
	Lava flows and Aeolian sands .	Transition sandstone	40 ft.
Forest Sandstone	Upper division .	Fine, pulverulent sandstone, interstitial clay. . . .	70 ft.
	Middle division .	Marls and sandstones	30 ft.
	Lower division .	Fine calcareous sandstone with calcrete. Limestone . . .	110 ft.
	Basal beds. . .	Partially sorted arkose	10 ft.

In petrological features, the Escarpment Grits consist throughout of a "coarse grey grit, containing banks of pebbles, which are often as large as eggs. It is not bedded very regularly, false bedding being common, and the rock usually breaks along a pebbly bed. The pebbles are all well rounded, and are mostly of quartz, but granite and gneiss pebbles occur occasionally. The rock is well jointed, and the joint faces are usually coated with a dark brown ferruginous skin." (Lightfoot)

The Forest Sandstone of the typical area shows the following features. The *Basal Beds* are conglomerates containing a large percentage of calcium carbonate, and are typically white in colour. Besides containing derived pebbles, siliceous concretions are very plentiful. The under surface of the beds is very irregular and in places the hollows are filled with a fine red marly sandstone lying beneath the conglomerates. In a specimen kindly sent me by Mr. Macgregor a small piece of bone was detected. This is the only fossil so far recorded from this conglomerate. The *Red Marls* have a maximum thickness of 4 feet. They are pinkish red to chocolate brown in colour, laminated, and very friable. Hitherto they have not been found to contain fossils. The *White Sandstone* follows the Red Marls. It is a massive white rock composed of angular grains of sand cemented in an opaline matrix. No bedding planes occur except just above the marls, where there is evidence of a minor unconformity showing contemporaneous erosion. In one place strong current bedding indicating currents from the south is to be seen. In another place an exposed surface is ripple-marked and apparently sun-cracked. Calcareous concretions and nodules are common. The upper part of the bed is usually dead-white, but it is sometimes stained pale pink. Fossils have only been found at two places. These were vertebrae and portions of a fibula of a small Dinosaur, belonging probably to either *Thecodontosaurus* or *Gyposaurus.* The *Nyamandhlovu Sandstone* is intercalated with sheets of basalt which overlie the preceding bed unconformably. The sandstone is false-bedded, of a deep-red to pale chocolate colour, and generally coarse-grained. It is well laminated and cleaves into broad flags. The grains of the sandstone are well rounded and of fairly uniform size. (Macgregor.)

The Forest Sandstones of the Wankie area, as described by Lightfoot, are much finer-grained than the Escarpment Grits, and contain pebbles only rarely. The sandstone is of a deep red colour and is very much false-bedded, forming flaggy bands. It rests on the Escarpment Grits in irregular patches, some of which are large, and these when viewed from a distance appear to be outliers. In thin section the rock closely resembles the slides made from the stone at Pasipas, near Bulawayo.

The rocks of the Pasipas area were described by Molyneux. He describes the sandstone as made up almost entirely of quartz grains of a common size of 0·2 mm. in diameter, a few reaching 0·7 to 1 mm. The rock is generally soft and easily excavated and, unless indurated by the process of silicification or protected by the sheets of overlying basalt, disintegrates rapidly. The normal rock is composed of fine grains of quartz joined by interstitial felspathic clay in the upper division and by carbonate of lime in certain lower beds. The basal beds generally represent the weathered state of the rocks of the Archaean complex: at other places there is a variable amount of sorting by the action of moving water (storm water). The lower division of Molyneux consists of unbedded deposits either with calcareous cement or lenticular beds of limestone, the deposits being mainly sandstones occasionally with calcareous balls and nodules, with a thin layer of pale brown or pink marl. The middle division consists of coloured marl interbedded with sandstones. The upper division is characterised by the non-calcareous nature of its interstitial clay.

Mennell (1904) says that the sandstone of Thaba 'Sinduna seen under the microscope shows sand grains that are often beautifully rounded and include fragments of perfectly fresh felspar (microline etc.) which indicates that it is largely of windworn material. A section made from a rock kindly supplied by Mr. Macgregor shows distinctly two sizes of grains — a large rounded grain of diameter about 0·5 mm., and a somewhat polygonal, smaller grain which is also rounded, of about 0·1 mm. diameter. The latter make up the bulk of the rock, which is from Esipongweni, about 20 miles N. of Bulawayo and about 30 feet below the first basalt. The larger grains are nearly all quartz. The smaller grains consist partly of fresh felspar, mainly microcline. Some of the quartz grains show strain shadows under crossed Nicols. There are occasional small grains of apatite and what is possibly tourmaline. The appearance of the grains is closely similar to those of the present-day Kalahari sand, save that there is no ferruginous coating.

Molyneux has pointed out that towards the top of the Forest Sandstone the beds contain increasing quantities of coarser rounded grains mixed with the others. As the Transition Sandstone is reached the grains are still coarser and dark grey in colour and are all well rounded, cohering together by oxide of iron.

Apart from the fragmentary Dinosaurs mentioned, the only Stormberg fossils found in S. Rhodesia are plant remains which have recently been discovered by Mr. Macgregor and have been sent to Professor Seward for determination. I am indebted to Mr. Macgregor for a preliminary note on this occurrence (in litt.). He writes "I had the fortune to obtain some fossils from the lower deposits (at Somabula). There are forms resembling *Thinnfeldia* and *Phyllotheca* so I take them to be Stormberg provisionally. I believe the whole deposit except a surface implementiferous rubble to be Karroo, but there are two types very distinct at Willoughby though interbedded at other places. The older deposits are red and pink mudstones and micaceous sandstones with white fossiliferous sandstones occurring as lenticles, and gravel with very well rounded pebbles at the base. The newer deposits cut channels through the older sometimes into the granite beneath. They are essentially coarse ill-consolidated arkoses with inbedded gravels. The chief point is that the base of the deposits resembles the base of the Forest Sandstone and the upper beds resemble the Escarpment Grits. There is nothing at all like the white Forest Sandstone. The fossils were at the bottom". Macgregor considers the Escarpment Grits to be probably of the same age as the Somabula gravels as they have the same highly rounded quartz and quartzite pebbles.

Finally, Molyneux has seen white sandstone with basalt on top overlying Escarpment Grits in the Mafungabusi district, 60 mile N.N.W.

of Somabula. If this white sandstone is Forest Sandstone, then the succession of the beds seems clear. The Escarpment Grits (with a white sandstone carrying *Thinnfeldia* below them in the Somabula area) are followed by the Forest Sandstone (seen at Mafungabusi), which is white in its lower part and red above, and this passes up by progressively coarser sandstones of more and more rounded grain through the Transition Sandstone into the Nyamandhlovu Sandstone. Where the Escarpment Grits are absent, as in the district north of Bulawayo, the base of the Forest Sandstone is a conglomerate followed by a Red Marl. If, on the other hand, the sandstone of Mafungabusi represents the top of the Forest Sandstone or the Transition Sandstone, then the Escarpment Grits of the Wankie area would seem to equal, in part at least, the Forest Sandstone of the type area. In any case, the correlation with the Stormbergs of the Cape seems clear. *Thinnfeldia* is characteristically a Molteno plant, although it occurs sporadically in the Red Beds; and the Dinosaurian remains are closely comparable with those from the top of the Red Beds or the Cave Sandstone. The lithological changes are also comparable with those seen in the Cape. Coarse pebbly sandstones typically give place to finer-grained sandstones with a local intermediate development of red marls: and the climatic changes are in the same direction as those in the south of the continent, although at any given time conditions seem to have been more arid in the north than in the south.

Writing of the Forest Sandstone Molyneux says "The rocks of the group show none of the usual planes of bedding of aqueous deposits, but are thick deposits of sand grains of uniform size without any sorting of coarser material . . . The basal beds are made up of debris resulting from the weathering of granite *in situ* or which may have been partially sorted into different sizes by storm waters, and in this manner the deeper hollows of the Archaean landscape were levelled up. From this stage onward there is evidence of climate of increasing aridity. The angular shape of the smaller grains in the rock shows that there has, in the lower division especially, been little abrasion or rounding in transport. The deposits are no doubt due to winds that carried dust and particles from a very dry area. To do this atmospheric movements need not have been different from those of to-day . . . The calcrete that occurs in the lowest beds of the Forest Sandstone points to a climate of semi-aridity, but as time went on desert conditions approached and there seems to have been progressive dessication of the whole country. The marls probably resulted from the deposition of fine material through the drying up of standing water — not a lacustrine condition in the manner of lakes connected with silt-bearing streams, but after the type still known in Africa as that of promiscuous pans or "vloers" described by du Toit. During the stage of the upper division aridity increased; there was not sufficient moisture to segregate the lime, but the vegetation that existed was still of sufficient growth to prevent the accumulation of dunes. But complete desert conditions were not long delayed, for during the transition period the wind-borne debris was sorted by wind rolling into sand dunes. The Nyamandhlovu epoch must have been one of complete desolation. Volcanism manifested itself in the flow of the sheets of basalt of great extent. Dust continued to fall and would be absorbed in the moving lava, but directly that flow ceased in any locality and the surface hardened the wind resumed its work of sorting and rolling, with the consequent formation of the interbedded sandstones." It is worthy of note that the "current-bedding" of the Nyamandhlovu sandstones is paralleled by similar phenomena in the upper portion of the Cave Sandstone, especially when it is interbedded with lava flows.

Maufe has shown that in places where the Forest Sandstone lies on granite and greenstone schist floors, the rock apparently fills up valleys in the old pre-Karroo floors, being in part banked up against the sides of those valleys.

Belgian Congo.

The basin of the Congo forms a gigantic depression which is formed of tilted and folded sedimentary rocks and schists of Palaeozoic and Pre-Cambrian age resting upon Archaean granites and gneiss. At the bottom of this hollow is a series of continental formations which rest unconformably upon the older rocks. These lie, in the main, horizontally or dip at feeble angles. They have been grouped by Prof. Jules Cornet into

3. Lubilache Beds ("Lubilash" of some authors)
2. Lualaba Beds
1. Kundulungu Beds.

The Kundulungu Beds are considered by Cornet to be of "Permo-Carboniferous" age; but the other two groups are thought by the same author to be the equivalents of the Upper Karroo Beds of South Africa, and it is these which must be considered here.

Ball and Shaler (1910) describe the whole series above the Kundulungu as the Lubilache Series with a vertical thickness greater than 1500 feet, while in the Kasai region their Lubilache rests on old rocks without the intervention of the Kundulungu series, and has a thickness of fully 700 ft. near Luebo and of 800 ft. on Lomani with a dip towards the centre of the basin. Mathieu hints that Ball and Shaler may be correct in surmising that the Lualaba and

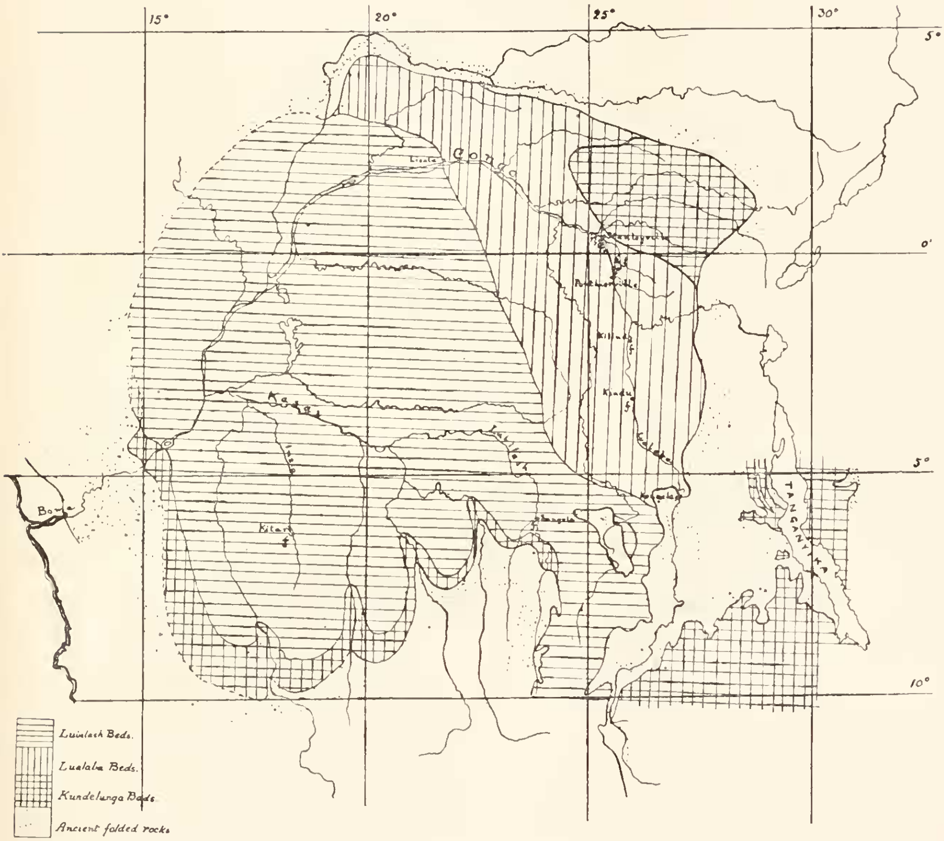


Fig. 54. Sketch-map of Belgian Congo to show distribution of Karroo System (from Revue Zool. Afric.).

Lubilache Beds may possibly be only phases of the one series. Passau, Horneman and others agree, however, with Cornet in separating the two series, and Passau has shown that Cornet separated the Lualaba from the Lubilache by means of a distinct carbonaceous shaley zone below the sandstone of the latter. These carbonaceous shales occur over a wide area, e. g. at Stanley Falls, the Lomani

Valley, at Lusuna and Lusambo along 5° Lat., and also in the east in Kasai.

Lualaba Beds. The Lualaba Beds have been described by Cornet as consisting of clays, grits, sandstones, limestones with little coherence and often oolitic, etc., and have been shown to cover a large area in the Congo Basin.

Studt in 1913 gave the following as an ideal complete section of the Lualaba Beds:

12.	Mottled clays & mudstones — black, white and red .	100 ft.
11.	Coarse red micaceous & felspathic gritty, pebbly sandstones	110 ft.
10.	Greyish calcareous shales & thin aragonite bands . .	10 ft.
9.	Black shales with pyritic coals, & coarse felspathic grits	140 ft.
8.	Light grey calcareous false-bedded & banded sandy shales	80 ft.
7.	Pyritic black shales and gritty sandstones	10 ft.
6.	Light grey calcareous banded & fluted sandy shales .	60 ft.
5.	Red pebbly sandstones, grits & conglomerates with intercalated beds of brown shale	160 ft.
4.	Light pink to grey sandstones & shales	80 ft.
3.	Pyritic black shales & coals with intervening felspathic grits.	120 ft.
2.	Light red to yellow medium-grained sandstones & shales	20 ft.
1.	Grey calcareous breccia.	80 ft.

Studt's bed no. 12 is not the carbonaceous shale mentioned by Passau, and it is possible that his beds 10, 11 and 12 may belong to the Lubilache series.

Passau in a paper on the beds in the area north of the Kasai along the Ulindi and Elila subdivides the succession as follows: —

Lubilache	5. Banded arenaceous shales with indeterminate plants.
	4. Clayey banded shales with nodules and pebbles.
Lualaba	3. Black clay shales — graphitic, carbonaceous and micaceous with plant fragments.
	2. Clayey shales with pebbles.
	1. Soft greenish clayey sandstones passing into conglomerate with very large inclusions generally of subjacent rocks.

He states that the Lualaba has a more restricted occurrence than the Lubilache, on account of the overlap of the latter on the former.

Hitherto, the Lualaba Beds have yielded only a few fossils — fish remains and Entomostraca — which have been briefly described by Leriche.

At Kilindi, at the junction of the Lualaba and Lindi rivers, fish remains were found in a soft, whitish argillaceous-calcareous sandstone which lies horizontally — the "middle calcareous shale zone" of Passau. This zone may correspond with bed 8 of Studt's classification. Leriche described the remains as *Peltopleurus maeseni.*

From white limestones at Kindu on the Lualaba two forms described as *Pholidophorus corneti* and *Lepidotus* (?) sp. by Leriche were obtained. In the latest paper on the Palaeontology of the Congo (1920) Dr. Leriche describes a large number of fragmentary fish remains under the name of *Lepidotus congolensis*, a species already described by Hussakof on material from the Congo basin. These remains are from calcareous clay from near the base of the Lualaba Beds in the vicinity of Stanleyville. He also describes a single scale attributed to *Colobodus* from just north of Ponthierville. Cornet also mentions the discovery of fish debris in bituminous shale in the neighbourhood of Ponthierville.

Entomostraca are common in some localities, e.g. at points on the railway between Stanleyville and Ponthierville, almost covering the surface of the layers on which they are found. Leriche examined them, and described a Phyllopod *Estheriella lualabensis* Leriche, and an ostracod *Darwinula globosa* var. *stricta* R. Jones. This latter variety occurs in the Rhaetic of Scotland and Leriche considers the Congo specimens to be indistinguishable from the Scotch form. The same form also occurs at Songa, 43 km. below Ponthierville, in bituminous shales; on the banks of the Oviatoku (a tributary of the Lualaba) in beds full of the ostracod *Metacypris passaui* Leriche; at Bamanga, 14 km. below Ponthierville; and at Kindu in clear limestones. From a study of these forms Leriche concluded that the Lualaba Beds were of Upper Triassic age. Cornet, on non-palaeontological grounds, correlated them with the Beaufort Beds of the Karroo System, considering, however, that the Lualaba Beds were a complex whole, in which one should be able to distinguish several zones.

Messrs. Ball and Shaler obtained fossils from several localities in the series (which they described under the name of the "Lubilache") viz., indeterminable plants from shale at Niangwe, 200 ft. above the base of the series; ostracods of the genera *Cypris*, *Candona* and possible other Cypridae, a valve of *Estheria*, and fragmentary fish-remains from limey shales 10 miles below Stanleyville and 150 (?) ft. above the base of the series; and a possible *Estheria* valve from soft sandstones at Sangula at the confluence of the Buschinmai and Sankuru rivers. (Of the organic nature of the last, Cornet is doubtful; and Leriche places the locality in the Lubilash formation). Ulrich, from an examination of these fossils says "The bed from which the fossils were procured is Mesozoic and Jura-Triassic, rather than later." Ulrich further states that if the fossils indicate anything concerning the climate it would be that it was relatively moist and cool, and that the water in which they were deposited was either fresh or brackish.

Lubilache Beds. Studt describes these beds as being "reddish to white friable sandstones and conglomerates containing numerous bands of concretions so penetrated by secondary silica as to have the appearance of pebbles or boulders of granular quartzite, flint, or jasper, while agate, onyx, and chalcedony are also common. The conglomerates "often contain black pyritic shale pebbles." Ball and Shaler also emphasise that "as a rule massive bedding predominates in the sandstones, as does a reddish colour; grayish and white beds are, however, not uncommon". Passau considers the thickness of the sandstone to be from 300–400 metres. In the Lubilash Beds at Kitari, a red shale has yielded numerous carapaces of a Phyllopod assigned by Leriche to *Estheria* sp. The same bed has also been said to yield ostracods "recalling *Darwinula globosa*", a variety of which is described from the Lualaba Beds. The *Estheria* is said to be sharply defined from *Estheriella* of the Lualaba Beds by the absence of radial ribs. The red shale in which the specimens were found occurs as a thin band in the thick sandstones of the Lubilash.

Correlation of the Lualaba and Lubilash Beds with South African zones is difficult on account of the paucity of the fossil remains from the Congo. Of the fish from the Lualaba the only genus found in South Africa is *Pholidophorus* which has been described from the Burghersdorp Beds (Upper Beaufort). *Lepidotus* is a Semionotid; *Semionotus* is a Cave Sandstone form. *Colobodus* is a Trias-Rhaetic genus. The phyllopod *Estheriella lualabensis* is apparently close to *Estheria greyi* from the Middle Beaufort Beds of Cradock. It seems possible, therefore, that part at least of the Lualaba Beds may be the equivalent of the Middle and Upper Beaufort Beds of the Union.

The lithological nature of the Lubilache Beds suggests instantly correlation with the Stormberg Beds. Cornet first suggested this correspondence, and Maufe and Molyneux both see resemblances between the Lualaba Beds and the Forest Sandstone group of Southern Rhodesia. Maufe writes, in criticism of Studt's later view that the Lubilache was of Waterberg age, "The author's description of the Lubilash Beds of Katanga might well be a description of the forest sandstones of

Southern Rhodesia"; while Molyneux says "I agree that the Lubilash series much resemble (in petrological features) the escarpment grit and forest sandstones. Thus it must be that the Lubilash are my escarpment-forest series, and of Upper Karroo age. The chalcedonic segregations, agates, and other silifications, and the friable nature of his fine sandstones are remarkably akin to features of the forest sandstones of Mafungabusi Mountains, where there is no doubt that they overlie the coal measures." As has been shown, the Forest Sandstone is almost certainly the equivalent of the Cave Sandstone. More palaeontological evidence is, however, greatly desirable, as similarity of petrological features merely means similarity of conditions of deposition and need not of necessity imply similarity of age. The *Estheria* sp. described by Leriche seems to have a fairly close resemblance to the Cave Sandstone form from the beds at Siberia C.P.; and their occurrence in a thin shaley band in massive sandstones is certainly significant when compared with the mode of occurrence of the latter.

Most writers on the geology of the Belgian Congo follow Cornet's original idea of the lacustrine origin of the Lualaba and Lubilache series. For example, Ball and Shaler picture their "Lubilache series" as having been formed in a lake which was probably subsiding in the middle, with low land to the west, north and south but hilly ground to the east — the hills possibly rising to a height of 2000 feet. Between these latter ran valleys, some deep enough and narrow enough to be worthy of the name of "fiords". No where was the lake deep. Cross-bedding was common, as well as abrupt changes from sandstone to shale. There was deep disintegration of the rocks of the shore-line due to weathering. Cornet, however, writing in 1910 remarked with regard to the "Lac Lubilachien" that his views had undergone modification since 1893. The conception of Lake Lubilache was a simple one and provisionally admissible at that time. But the Lubilache series, which is far from being limited to the stretch of the actual basin of the Congo, is much more complex than was at first supposed. It is possibly in part of lacustrine origin; but dunes and aeolian sediments generally play an important role in it. The "gres polymorphes", which are so characteristic of the system are certainly desert formations. Passarge follows Cornet in considering the Lubilache Beds as the products of a desert climate.

GENERAL CONSIDERATIONS.

Cape-Orange Free State-Natal Area.

Molteno Beds. The chief features upon which stress must be laid in considering the Molteno Beds of this area are as follows:

The formation dies out to the North, thinning from 2000 feet at its most southerly outcrop to 140 feet along the northern Natal-Basutoland border and disappearing altogether at Harrismith; so that its greatest North-South extent is just over 200 miles, an average diminution of 10 feet per mile. How much further south it once extended we cannot tell: the supposed occurrence of Molteno beds at the top of the Great Winterberg, on the Fort Beaufort-Tarka Divisional boundary has been disproved by a recent investigation undertaken by the author. But that they extended well south of their present outcrop is shewn by the occurrence on the coast near Port St. John's of a down-faulted patch at least 1600 feet in thickness.

The beds consist of sandstones, shales and mudstones which are gray, greenish or bluish in colour, and lack any prominent calcareous concretions or bands. In the south there is a great preponderance of arenaceous beds, but towards the north the argillaceous deposits play a more important, though still rather subsidiary part; it must be noted that in Natal also the shales are inconspicuous. The sandstones are coarse in grain, loose textured, and contain abundant felspar. In the south they are coarser than in the north. The sandstones occasionally contain nodules formed by the oxidation, and subsequent hydration in the outer layers, of iron pyrites. Occasional conglomerates occur, containing irregular boulders and pebbles which sometimes rest on coal-seams partly imbedded in overlying sandstones. Such pebbles are most abundant to the south-west.

The workable coal seams all occur in the lower portion. The coals are in thin layers alternating with thin black shales. They occupy detached areas, their absence from some areas being partly explicable by non-deposition and partly by contemporaneous erosion.

The only fossils are plants, which seem more abundant in the lower half of the formation. Animal remains have not yet been definitely identified, although Dunn has recorded the presence of bones at Molteno.

These features all point to deposition under deltaic conditions, either those of a true delta or of an aerial delta.

Barrell has pointed out that the determination of ancient true delta deposits from the study of the strata requires the demonstration of evidence that both subaerial and subaqueous sediments were deposited — the subaerial on the landward side of the strand-line and the subaqueous on the seaward (either marine or epicontinental) side. There can be no doubt that during the deposition of the Molteno Beds the land which furnished the rock-waste lay to the south and possibly in part to the east of the present outcrop; and, if a true delta had existed, subaqueous deposits would be expected towards the north. It would seem, however, as if the greater part of the features of the beds can be explained better by premising merely terrestrial conditions. At any rate, it can be said that terrestrial conditions will explain the features without calling in the aid of any large body of water.

Consider the features of aerial deltas in which purely terrestrial deposits are being laid down. Such features vary according to the nature of the climate, whether it be constantly rainy, intermittently rainy, semi-arid, or arid. The late Joseph Barrell worked out the criteria for each type, and to him we owe the following general survey.

In *constantly rainy climates* the deposits on piedmont slopes brought down by rivers and floods carry a large amount of humus and forest growth. The soil and subsoil are continually wet and drainage carries away the soluble elements. Thus deposits will contain little or no iron, magnesia, lime, potassium or soda and, on the other hand, will be rich in carbon. They will, on account of the diminished evaporation and constant saturation, be white, black, or gray in colour. Coal-seams will be abundant, moisture being necessary for their formation. Barrell says "It may be concluded that the broad association of carbon with sediments which are thoroughly decomposed and leached throughout is the mark of continuously rainy climates which are tropic or at least warm temperate; with sediments which are imperfectly decomposed and incompletely leached the mark of more or less continuously rainy climates which are in addition cool or cold."

When the climate is *intermittently rainy* much of the humus in the soil is yellow or red, and the clays are slightly calcareous. When yellow or brown flood-plain deposits are buried and lithified the upstream portions will be found somewhat more arenaceous, varying from red to brown sandstones and usually including red, green and occasionally black shales. Over the terminal land portions of the deposit, the sandstones should be finer-grained and the quantity of shales increase, becoming more gray, green and black. Thick widespreading coal beds are impossible: but in occasional swampy areas coaly shales will enclose and preserve the vegetation that grew in the swamps. Elsewhere vegetable growth, being alternately wet and dry, soon decays and is destroyed; casts of leaves and trunks in the lighter-coloured shales and sandstones being the only evidence that remains.

Under conditions of *semi-aridity*, the thorough seasonal oxidation of nearly all deposits except those made in permanent pools, lakes etc. results in the marked dominance of deep-red and brown shales and sandstones, a moderate amount of variegated shales and a few containing carbon. Lime will exist disseminated in noticeable amount through both shales and sandstones, and may occasionally give rise to markedly nodular or solid calcareous strata. The microscope should show a noticeable amount of felspar in the finer portions of the rock, as well as mica. "The most marked chemical distinction of sub-arid flood-plain deposits from those of truly arid regions is found in the small quantity of evaporation deposits of calcium carbonate, gypsum, and salt, but especially of the two latter. Lime may be quite abundant, as shown by the kankar of the Indo-Gangetic plain, its importance depending largely upon the quantity in solution in the river water". In river deposits of semiarid climates casts of logs are most likely to be preserved in the sands deposited in the neighbourhood of stream channels. Away from these channels wetting and oxidation would tend to destroy the logs.

In the flood-plain deposits of *arid climates* fluvial, pruvial and aeolian formations are all of wide occurrence. The most distinctive structures are: (1) the presence of mud-cracks filled with aeolian sands, the mud-flakes being usually polygonal plates upturned at the edges (cf. mud-flats of Orange River, at Kheis, as described by Dr. A. W. Rogers); (2) interbedding of fluvial and aeolian sands; (3) the presence of scattered and facetted pebbles.

It can be readily seen that the features shown by the Molteno Beds are intermediate in character between those postulated for flood-plain deposits laid down in constantly rainy climates on the one hand and intermittently rainy climates on the other. The southern more arenaceous facies represents the upstream portions; the northern the downstream terminal beds. Du Toit has shewn that the thinning northwards to the Natal border is due to actual thinning of the various members, while north of that some of the members (the upper) are missing. This is what would be expected from the supposition of a land to the south contributing rock-waste which was laid down in the form of a fan at the foot of the mountains, the amount of material becoming less as time progressed. The absence of red sediments and calcareous sediments precludes the possibility of any arid or very dry intervals.

The abundance of felspar in the sandstones proves that decomposition was not very complete, and argues a somewhat cool climate with discontinuous rainfall. The presence of boulders and pebbles can be explained by occasional torrential downpours following on periods of comparative quiescence in which vegetation was able to flourish.

It is possible that part of the lower Molteno Beds at least are formed of material that was accumulated on the land surfaces during Upper Beaufort times. During the comparatively cold periods of the Beaufort fairly deep disintegration of the rock-surfaces to the south took place, resulting in the formation of a mass of undecomposed felspar, quartz and other grains which, on the incoming of Molteno conditions accompanied by earth-movement, formed the material which built up the foundations of the Molteno Beds by transport northwards.

The nature of the coal-seams and of the fossil plants associated therewith is of considerable interest. The conclusion expressed by Rogers and du Toit as to the formation of the seams requires some modification. In the first place the often perfect preservation of the plants, which are mainly delicate and fragile fronds of ferns and fernallies, precludes the possibility of their having been transported far from their place of growth by river-torrents. There is little or no maceration shown by the fossils, except occasionally in the sandstones, and it is more reasonable to suppose that the plants were buried near to the swamps in which they grew and flourished.

Such swamps occupied discontinuous areas in the region; for, although contemporaneous erosion is the explanation of the lack of coal seams in certain parts, their absence in others is most likely due to an original absence of swampy ground. Such discontinuity in swamp conditions is a feature of flood-plains in an intermittently rainy climate rather than in continuously rainy regions. It is just possible that the conditions were nearly the same as those described by Davis from Turkestan where there is an alternation of inundations and drought. During the former, and following it, vegetation temporarily springs up, withers, and gives place to desert conditions until the next flood. Such alternation would possibly result in thin coal seams intercalated in thin sandstones or shales; but conditions of too great dryness would not be favourable to the formation and preservation of plant fossils.

Red Beds. The most striking feature of the Red Beds is the colouration of the sandstones, shales and mudstones which is predominantly red or reddish-purple. Even those sandstones which appear pale in the field prove, when freshly fractured, to have a decided red colour; and frequently, as along the northern face of the Wittebergen near the village of Herschel, and at Lady Grey, the mudstones are brilliantly crimson. In the Herschel division and in Aliwal North, the clays near the base are frequently blue or even grey; but only the few feet or so lying directly above the Molteno Beds show this characteristic; they soon give place to typically red deposits.

The climatic significance of red is a subject which has engaged the attention of several workers, especially in America, where the development of the Permo-Carboniferous Red Beds and the Triassic Red Beds has stimulated research. Barrell, discussing the subject in 1908, considered that red colours of sediments are due to oxidation at the time of origin of the sediments, ferric oxide being a component part of the accumulating deposits. He pointed out that in moist climates, heat and exposure all tended to the production of red soils, but that red was also a feature of some deserts. He concluded that the chief condition for the formation of red shales and sandstones is merely the alternation of seasons of warmth and dryness with seasons of flood, by means of which hydration is accomplished. This supplements decomposition at the source of the rock-waste and that which takes place in transportation in rivers. Wetting, drying and oxidation decompose the original iron minerals and remove all traces of carbon. Red shales and sandstones may thus originate in rainy, sub-arid or arid climates without any close relation to temperature, and typically as fluvial and pluvial deposits upon land; but the origin of such rocks is most favoured by climates which are hot and alternately wet and dry.

The same author in 1913 pointed out that redness in rocks is no criterion for the the separation of humid from arid climates, although red beds are frequently the accompaniments of aridity.

C. W. Tomlinson, in 1906, dealt with the conditions of origin of the Red Beds of Western U.S.A. He states "Where alternations of light- and dark-red strata occur, the more deeply coloured beds are in most cases of finer grain than the others. The occurrence of coarse-grained massive buff sandstones in a series of maroon or chocolate shales has been noted by many writers. This association holds true in many other Red Beds besides the group here under consideration. Thwaites reports it as an almost unfailing relation in the Lake Superior sandstone series of Northern Wisconsin, and Geikie mentions its existence in the Triassic New Red Sandstone of Gt. Britain". Further, "the colour of prevailing red strata in the Red Beds series is due to the presence of ferric oxide. A grey or green colour signifies a low proportion of ferric oxide, and usually a preponderance of ferrous over ferric compounds". Tomlinson considers the theories which propose respectively that the iron has subsequently been introduced into the sediments from igneous magmas, and that it is due to subsequent deposition from meteoric water; neither of these theories has much evidence in its favour. Wherever intrusions have affected Red Beds, their effect tends to be, not to heighten, but to destroy the red colour; while the more impervious strata are usually redder than the more pervious. The American beds, according to the same author, owe their colouration to the presence of ferric oxide which was transported as such and deposited almost wholly as a mechanical sediment, chiefly as a coating to sand-grains; but beyond saying that the inauguration and cessation of red bed sedimentation was probably connected closely with climatic and topographic changes involved in the orogenic history of the continent no definite statement as to climate is made.

Case has also considered in detail the formation of the Permo-Carboniferous Red Beds of Texas, and shows there is nothing in them to oppose the most generally accepted hypothesis that the red colour owes its presence to the mature weathering of iron-bearing rocks in a fairly humid region, with alternations of relative drought and humidity. The clays of Texas have a solidity and density which would not be present if the colouration were due to oxidation and dehydration of the iron subsequent to its deposition.

Again, in his latest work (1919) he says that flood-plain deposits of arid regions are marked by the presence of highly oxidised or carbonated minerals with a lack of hydrous oxides or sulphides. This is largely due to the normally low water-table, which permits the penetration of air deeply into the soil, and the exposure of the animal constituents to oxidation or carbonation. Also, the lack of vegetation on an arid flat means a lack of carbon. The common result is the prevalence of a red colour, the presence of gypsum associated with the remains of terrestrial animals, and a lack of plant remains.

There is thus a consensus of opinion with regard to the theory that the iron oxide, which gives the red colour, is due to the decomposition and oxidation of iron-bearing minerals and that it was deposited in the red strata mechanically in its oxidised condition; but its presence alone is not sufficient to make any pronouncement as to whether the climate was humid or arid. If the red is not associated with blue or grey or black, then the probability inclines towards the arid climate or, more nearly, the semi-arid.

Attention might be drawn here to the red sandy soil of Bechuanaland as described by Rogers (1906). The sand is often of a deep red colour, almost like brickdust, but on approaching an area in which calcareous tufa predominates the colour is seldom so intense. An examination of the material under the microscope shows that the grains are more or less rounded, especially those of quartz, and vary in diameter from a quarter to 1 mm. in diameter. The red colour is due to a coating of oxide of iron, which is removed by boiling with HCl. The great bulk of the material is composed of quartz grains, which show trains of inclusions and cavities. Plagioclase is not uncommon, and is present in the form of cleavage flakes, with the angles somewhat worn. Chalcedony and agate are rather rare; zircon and magnetite are abundant, while epidote is a common constituent. The composition of the sand shows that it has not been derived from the disintegration of the rocks of the district alone. The felspar and magnetite have been contributed by the disintegration of dolerites. It is probable that the quartz grains have been brought down from the Transvaal and the Orange Free State, Cape and Basutoland by the Vaal, Harts and Orange Rivers. The sand deposited along river-banks will be blown over the country by the prevailing N.W. wind. The decomposition of the diabase and dolerite and of pyrites in shales yield compounds of iron which can be taken into solution and deposited as oxide in the cracks and cleavages of the sand grains and around the grains themselves.

In the Red Beds of the Stormberg Series we find that save for occasional blue clays and whitish sandstones at the base, the various members are all red in colour. Carbonates occur, sometimes freely, as nodules, and in places form beds of limestone.

In the Maclear division, for example, the sandstone is commonly full of porous patches or small hollows representing spots originally rich in calcareous material, with here and there limestone nodules. Gypsum and salt are absent — a feature which distinguishes the beds from the Wichita Series of Texas. Conglomerates are rare, such as do occur being generally at the base of the formation.

At the base of the sandstone layers, however, bands of clay-pellet-conglomerate are not uncommon. Such bands indicate a certain amount of unconformity, the clay-pellets being formed by the rolling and rounding of the possibly dessicated upper layers of partly consolidated mudstone which lie beneath the sandstones. That the mud was dried by exposure before successive sediments were laid upon it is indicated by the occurrence of layers showing sun-cracks (cf examples in the South African Museum from Fouriesburg, O.F.S.):

while du Toit has collected and recorded mudstones from the Red Beds carrying worm-tracks, and the South African Museum possesses examples of large Dinosaur tracks from Morija, Basutoland.

There is a pronounced tendency for the sandstones to become finer in grain towards the top of the series. The author found in Herschel, near the head of Bamboes Spruit, a local development near the top of the Red Beds of a rock which has the appearance of being an ancient silcrete or surface quartzite; and from a slightly lower horizon a slightly reddish quartzite pebble was obtained, about an inch long, wich looked like a "dreikanter" whose edges had been somewhat rounded. Save for occasional silicified logs fossil plants are all but absent (*Thinnfeldia* and *Schizoneura* occur sparingly each having been found hitherto at one locality only): and the fauna is entirely a land one. Here it might be remarked that Tomlinson states "No actual remnants of organic matter are reported to have been found in red strata" — the tendency of organic matter is to turn red into green. It is not known whether this statement still holds good for America; but in the Red Beds of the Stormberg Series all the fossil reptiles, with the exception of some large bones from the base, have come from red clays and fine-grained soft felspathic red sandstones. In most cases the bones are found disarticulated; but at Blikana in Herschel, to mention one instance, a complete articulated skeleton of the smallish form *Massospondylus harriesi* was found lying on its side in red strata. The red muds especially are occasionally spotted, somewhat sparsely, with green; and bones from Fouriesburg, O. F. S. are surrounded by a thin layer of greenish rock; but there can be no doubt the green colour is due to subsequent reduction of the iron oxide by the agency of animal matter after deposition.

Moody (Quart. Journ. Geol. Soc. 1905), discussing the variegation in colour of the Keuper Marls in England, considers — mainly on chemical grounds — that "the variegation of marls is not to be explained by the assumption that bleaching of the red rock has occurred through reduction of ferric oxide and the loss of iron"; and he considers that the even distribution of ferric oxide in the English Triassic rocks is probably due to the action of chalybeate waters permeating the whole of the sandstone and part of the overlying marls. However, the intense colouring of the mudstones as well as the sandstones of the Red Beds of the Stormberg Series and the occasional association of green with fossil bones renders this theory a somewhat improbable one to account for the colouration in South Africa.

Microscopic study of the finer-grained sandstomes shows that the sand-grains are not of the "millet-seed" type, but are sub-angular in outline with their edges and corners slightly rounded. They are uniform in size; and the ferric oxide acts as a cementing material coating the grains. Mica is commonly present.

All these features agree closely with those postulated by Barrell for flood-plain deposits in a semi-arid climate; the basal portion of the Red Beds thus forming a link with the Molteno Beds — the climate gradually changing from an intermittently rainy to a semi-arid one, the aridity increasing as time went on.

A consideration of the horizontal and vertical distribution of the animal remains is of some interest. The base of the Red Beds has yielded fossils chiefly in the district of Herschel. They are all large, heavy-limbed forms such as *Euskelesaurus browni* and *Plateosaurus cullingworthi* while a little higher in the same area are still large forms such as *Melanorosaurus readi*. As far as we are aware, no small, lightly-built forms have been found at the base of the formation. As one ascends the forms become smaller and apparently much more agile. *Massospondylus* occurs from about half-way up to near the top, both in Herschel and in the north at Fouriesburg. At the latter place it is associated with the somewhat larger but still light-limbed *Gryponyx africanus* and a small *Thecodontosaurus*. The southern end of the mass has yielded little from the base of the Red Beds but large bones have been noted by du Toit in Elliot and Maclear: the small *Thecodontosaurus minor* is from the upper half, as are the extraordinary Cynodonts *Tritheledon* and *Lycorhinus*, while the supposed Predentate *Geranosaurus* is from the summit of the formation. *Erythrochampsa* is from the very top also, and is another very lightly-built small form, characterised by an armoured back.

Two features display themselves in this survey. The first is that the animal type became progressively more agile: the other that the majority of the fossils come from the centre and northern half of the present exposures. This latter feature may be disproved by subsequent finds; the southern portion of the area has not been searched to any appreciable extent: and the outcrops are frequently grass-covered and in bad condition for fossil-hunting. There can be no doubt, however, that the first is of some importance; and it gives assistance to the argument for a climate which gradually became more arid. As conditions became more rigorous, there would have been given an impetus towards agility and the ability to travel longer distances, in search of sustenance; and it is significant that deserticolous animals of to-day are long-limbed in structure.

It seems probable that the various animals did not live far from their place of entombment. Although complete skeletons are not common — one articulated skeleton only from the Red Beds is known to the writer — the majority of the described forms are known from a number of associated bones, some of which are frequently found still articulated. Isolated bones are rare, and few show signs of rolling or long transportation. At the base of the Beds, remains of several large animals were found together in bluish clay near Kromme Spruit, Herschel — apparently swamp-lovers whose remains were washed by moving waters into some quiet swampy spot: a supposition whose probability is increased by the discovery near by of a large silicified log. In general, the bones of an incomplete skeleton of a single animal occur together in one spot — a fact which would be difficult of explanation if transportion over a long distance be postulated.

Cave Sandstone. We have seen that the Cave Sandstone is a massive fine-grained rock of varying thickness with bedding planes but feebly developed, and that in the basal portion only. The rock is generally white or cream-coloured, but often it is pink or red and at its base is sometimes coloured as deeply as the underlying Red Beds. Athough the massive portion of the formation is unbedded it is often traversed by vertical joints.

The following description by du Toit of a specimen of the Cave Sandstone from Rocky Dell, Maclear, C. P., may be taken as typical of the bulk of the formation. (see Geol. Comm. Rept. 1910, p. 88).

"The rock is composed of grains from ·05 to ·08 mm. across of quartz and felspar, the former predominating. They vary in outline from sub-rounded to angular and are sometimes elongated splinters with sharp edges. Some of the quartz grains are quite clear, others contain needles of rutile and dusty inclusions. The felspar consists of orthoclase and plagioclase, either fresh or clouded — and kaolinised; microcline is absent There are flakes of somewhat altered biotite mica, muscovite mica, and a good deal of secondary white mica (sericite) in the felspar, around quartz grains, and sometimes within the quartz itself. A characteristic feature of the Cave Sandstone is the presence of grains of zircon and in the slide there are a number of worn crystals of this mineral, together with some colourless garnet, and some grains of rutile. The groundmass of the rock is fairly abundant, cloudy and dusty and probably for the most part kaolin; in places it has a pinkish colour corresponding to the pink mottling of the sandstone in the hand specimen". "Another section from the summit of the Hlankomo Mountain, Mount Fletcher, shows nearly similar features, but microcline felspar is present in addition and the rock contains somewhat more mica".

Two main views have been put forward as to the mode of origin of the Cave Sandstone. We will consider first that of Professor Schwarz as developed in a paper in the Trans. S. Afr. Phil. Soc. Vol. XVI (1905) p. 30.

Schwarz considers that the Cave Sandstone is a tuff, blown out of the volcanic vents which opened the period of Drakensberg volcanic activity, a portion of which still, in some cases, remains in the throats of the vents. "If" he says "the Cave Sandstone was formed before the production of the material in the pipe, then the latter ought to be made up of portions of all the rocks which the vent traverses, but we find that this is not the case, and that the material in the pipe is identical with that of the Cave Sandstone. The Cave Sandstone, however, contains 83·5 % of SiO_2, with grains of quartz, microcline, plagioclase, zircon, rutile, tourmaline, chlorite, garnet and epidote, while the lavas of the Drakensberg — some of which flowed out of the pipes — are basic in composition". Therefore, says Schwarz in effect, the pipes must have tapped deep-seated rocks such as the granites and crystalline schists — outcrops of which occur in Natal — and the triturated material from them forms the Cave Sandstone. The author of this theory does not believe that the Cave Sandstone was formed by ordinary denudation from land-surfaces, as no land surface of a requisite nature was near enough at hand. He agrees that the Molteno Beds are the detritus of a granitic region, presumably of the southern prolongation of the Madagascar ridge; but argues that the break in the deposition of the Molteno Beds marked the disappearance of the source of the supply. In conclusion he states "In the Cave Sandstone we have many peculiar features that could be explained by the supposition that it flowed from the crater mouths as a mud. It is hard otherwise to account for the immense thickness of the embedded mass; it is hard to explain the sudden change of great thicknesses of the white rock to a red clayey material; and still more mysterious is the pseudo-bedding that one can see at N'quatsha's Nek, where the stratification is just such as would be produced had the whole been stirred round in a gigantic pot like a pudding".

The same author, in his "Causal Geology" (1910) speaks of the Cave Sandstone as a "non-volcanic tuff": and in "South African Geology" (1912) says the Cave Sandstone" consists of rounded grains of quartz and felspar which have been corroded on the surface and enveloped with minute scales of talc; thus the ordinary aspect of a sandstone is entirely masked and the rock has the appearance of chalk. The sandstone is not an ordinary sediment for the fine coating of talc scales would have been soon rubbed off the sand grains if they had been dragged along the sea floor by currents, and the coating could not have formed after the sandstone was consolidated .... The non-volcanic material torn from the granite walls of the chimneys would issue as fine sand, and the corrosive action of the hot gases in the vent would account for the alteration of the grains on their surfaces".

The features shown by the Cave Sandstone, when considered with the other members of the Stormberg Series, do not seem to call for any such mode of origin as is outlined here. It seems that the presence of Cave Sandstone infilling some of the pipes led mainly to the formation of the theory. Du Toit has studied a peculiar pipe of this nature and has published the following description.

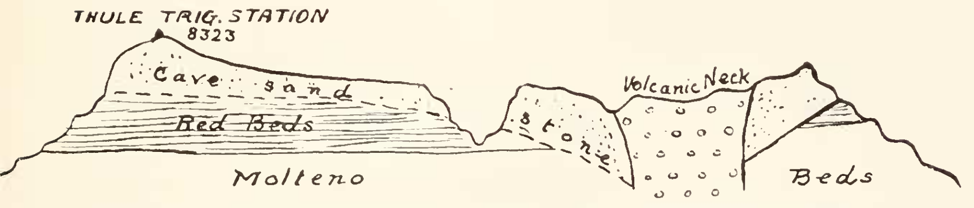


Fig. 55. Diagrammatic section through Volcanic Neck of Thule — after du Toit. Length about 4 miles.

"A very interesting occurrence in view of the information which it yields upon the conditions of deposition of the Cave Sandstone, is the large volcanic neck on the farm Thule (Griqualand East), almost on the crest of the Drakensbergen. It is nearly a mile across with somewhat irregular outline, and occupies a hollow hemmed in by Cave Sandstone, while several narrow ravines have trenched the area and laid bare good sections. The peculiar feature in this neck is that the Molteno Beds and Red Beds are lying quite undisturbed right to the very edge of the pipe, but the Cave Sandstone, on the other hand, commences to show an inward dip at a distance from the margin of the latter, varying from about a quarter of a mile on its eastern side to well over a mile on its west side. The sheet of sandstone curves downward over the denuded edges of the Red Beds, and in places possesses dips of as much as 40°, passing below dark greenish agglomerate at the extreme south-west end, but appearing to abut against the volcanic infilling at other points.

The material within the pipe consists of medium-grained agglomerate with fragments of basalt and amygdaloid of various kinds, but the bulk of the stuff is of sedimentary origin, and in places it passes into a pale yellowish-green sandy rock with few foreign fragments, some of this passing by degrees into Cave Sandstone. Fragments of Cave Sandstone and red and purple shales and sandstone are present, blocks of basalt up to 6 feet across and lumps of Molteno grit as much as 7 ft. in length.

The history of the pipe must have been somewhat as follows: — At the close of the period of deposition of the Red Beds a small volcano came into action on this spot and gradually enlarged its boundaries, portions of the margin (composed of Red Beds) slipping down at intervals into the vent. Then the Cave Sandstone commenced to be formed and was deposited at an angle over the denuded hollow encircling the agglomerate neck. Sediment would become mingled with the fragmental material within the pipe, while occasional volcanic explosions would account for the ashy streaks and patches in the Cave Sandstone at several points close to and outside the pipe. On the south-west margin the fragmental matter most probably represents an indipping patch of stratified ash overlying the sandstone".

This occurrence is by no means an isolated one: and the matter will be furthered discussed later in the section.

The other difficulties which stood in the way of Professor Schwarz's acceptance of the Cave Sandstone as a product of ordinary denudation seem to disappear if we consider that the climate underwent a further approach to aridity, and that from the onset of Molteno times there was a gradual secular climatic change in one direction throughout the formation of the deposits of the Stormberg Series.

We have seen that the base of the Cave Sandstone is generally red and often bedded — this indicating a continuance of the flood-plain deposits of the semi-arid Red Beds time. The massive portion of the Cave Sandstone has, however, as du Toit (1918) has pointed out, practically all the features of an aeolian deposit such as the Pleistocene loess of the Northern Hemisphere.

In its typical form the loess of Asia and Europe is a fine-grained deposit, consisting of minute particles of hydrated silicate of alumina, quartz, felspar, mica, and other minerals, more or less cemented by calcium carbonate, the segregation of which gives rise to concretions. It is also often impregnated with alkaline salts, and nearly always stained yellow with ferruginous matter. Its homogeneity of composition and structure contrasts it with all water-deposits. There is an almost complete absence of any stratification, and the particles of mica in it are uniformly distributed without orientation. A characteristic feature is its well-marked vertical jointing. Its fossils consist almost entirely of land animals, distributed evenly throughout its mass. Great numbers of bones of mammals occur locally — mostly belonging to forms abounding on steppes and grassy plains.

The consolidation of such a deposit would very conceivably result in such a rock as the Cave Sandstone. The grains in loess, like those of the Cave Sandstone, are not rounded as those of desert sands, but are described as "angular or sub-angular". One striking difference, however, is in the much greater abundance of hydrated silicate of alumina in the loess as compared with the Cave Sandstone: another in the number of tubules "marking the site of the roots of countless generations of plants": and a third in the absence of land-shells in the Cave Sandstone.

Taking into account its various peculiarities, von Richthofen concluded that the loess of China is the product of aeolian influences acting during periods of long duration and under different conditions of climate, of which three are distinguished in North China: (1) an erosion period, in which the surface of the country was sculptured by erosion and denudation into the figure it still retains beneath the covering of loess; (2) a Steppe period, in which the conditions of the saline steppes of Central Asia were extended over the whole of Northern China; (3) a loess period, now existing, in which the former Steppe-districts become converted into Loess-districts by the gradual accumulation of dust at the surface, the dust being held in place by the growth of vegetation. This theory of the formation of the loess can be accepted for Northern China: but it does not fit exactly all the requirements of Cave Sandstone formation.

In the first place there is the difference in composition between the two rocks. The Cave Sandstone is felspathic; but the felspar is but little decomposed and there is no such alteration product as hydrated silicate of alumina in any large quantity. Sand grains play the predominant part in the formation of the deposit. The chemical nature of the sandstone and the comparative angularity of its fragments indicate fairly arid weathering of the original land from which the material was derived. In this, there are not true "loess-conditions".

Secondly, there is no indication in the Cave Sandstone of the little tubes representing former grass-roots, nor any sign of extensive vegetation.

Silicified trunks of trees have been recorded from various localities in the Cave Sandstone, as for instance at Morija and Masitisi in Basutoland; but most of the occurrences, together with the doubtful occurrence of coaly material near Belmore, Barkly East, seem to be in the upper, sometimes laminated portion of the deposit.

This may also be looked upon as as mark of aridity. Richthofen considered vegetation necessary for holding in place the dust of which the loess is formed; but this is only so when the area of depositon is itself subject to constant winds. If the dust is deposited as a result of the slackening of the force of the wind which carried it, then vegetation is not a necessary adjunct; and the lack of vegetable remains argues conditions adverse to their growth.

The third difference is the absence of land-shells in the Cave Sandstone. Most terrestrial mollusca require moisture for their development and maintenance; and, although their absence from a land deposit is a piece of purely negative evidence, it lends additional weight to the theory of aridity when so many other facts point in the same direction.

In spite of these minor discrepancies, however, the "loess" seems to be the nearest among recent deposits to which we can liken the Cave Sandstone. It is of interest to note that near the base are highly irregular calcareous concretions similar to the "loess-dolls" figured by Wright.

The occurrence of mammalian bones in the loess is paralleled by that of reptilian remains in the Cave Sandstone. All the forms hitherto discovered are light-limbed probably cursorial forms — *Gyposaurus*, *Thecodontosaurus* and the like, together with *Notochampsa*. As has been shown, this latter was erroneously supposed to be a Crocodile, but is in reality a light-limbed long-snouted armoured Pseudosuchian. There is nothing of the water-loving, marsh-living type in this assemblage; they are all very conceivably the inhabitants of an arid or semiarid clime, adapted for comparatively rapid transit from place to place. In no case has a complete skeleton been found; but, on the other hand, isolated bones are rare and the usual occurrence is in the form of articulated portions of a skeleton. It should be noted that, in the case of *Notochampsa*, the skeleton is nearly complete, even some of the fragile bones of the fingers and toes being preserved. Had the conditions been moist, it is improbable that such would have been preserved in a sandstone-water percolating through the porous sediment would have rapidly dissolved the bones which have been preserved, as we believe, by the rapid accumulation of a dry wind-borne coarse siliceous dust.

That the climate was not absolutely arid is shown by 1) the fact that the deposit is in no sense a "desert-sandstone" in the Cape — O. F. S. area, and 2) the very rare local developments of greenish and bluish shales containing a water-fauna. Of these, the best-known is the shale-band in the Cave Sandstone at Siberia in the

Wodehouse Division. Here is a 20 feet zone of finely-bedded blue and green shale containing abundant fossils among which have been recognised one imperfect fish, several examples of insects and numerous examples of a small Ostracod, a *Cyzicus* in various stages of growth, and of an *Apus*-like Phyllopod, *Lepidurus*. The crustacean part of this fauna is all of a semi-arid facies, capable of living in damp or even dry mud for many months of the year even as they or their near relations do in the Karroo to-day. Fish are also found in what is supposed to be Cave Sandstone near Ficksburg, O. F. S., from which place slabs have been quarried with numerous specimens of *Semionotus capensis* on each, the occurrence seeming to indicate, from the fish point of view, a sudden catastrophic dessication of their living quarters.

Further, the Rev. S. S. Dornan has recorded that many fossil fish occur in the Cave Sandstone at Masitisi, Basutoland, as well as silicified trunks of trees.

It is of interest here to consider a little more closely the physical conditions of deposition, other than climate, of the Cave Sandstone in the Cape-O. F. S. area.

Although in places there is a gradual transition from the Red Beds to the Cave Sandstone indicating absolute continuity of deposition from one to the other especially in the North, in other places there is undoubted unconformity so that, while in some parts of the area deposition was going on, in other parts erosion was being effected at a greater rate than deposition.

As an extreme instance of this we may cite the fact that at Glenelg in the Maclear District the Cave Sandstone rests directly on pebbly grits of the Molteno Beds — the Red Beds having entirely disappeared. Here it does not seem certain whether the Red Beds were eroded subsequent to the deposition of the main mass of the formation and before the deposition of the Cave Sandstone, by means of a strong scouring agency, or whether the absence of Red Beds is to be explained by a continuous "contemporaneous erosion".

We have already referred to the unconformity which occurs in the neighbourhood of the ancient volcano at Thule. At Tent Kop, in the Maclear district, a bed of volcanic ash rests on the Red Beds and underlies the Cave Sandstone; while other examples might be cited showing that volcanic activity began, at any rate in the South, *before* the deposition of the Cave Sandstone.

At Tent Kop the sandstone overlying the Ash bed is full of small angular inclusions of indurated sandstone and shale.

That volcanic activity was rife during the formation of the Cave

Sandstone is evidenced by many examples, especially in the south of the region and towards the top of the formation. In Maclear two beds of sandstone are intercalated in the lavas. It is interesting, too, to note that the ash here contains fragments of Molteno Sandstone up to 5 feet across, and a few blocks of pre-Karroo quartzite. These have evidently been torn off from below and thrown out by volcanoes in the neighbourhood.

Further north, in Barkly East and the neighbouring districts, in a few places the Cave Sandstone is entirely absent, the volcanic flows resting directly on the Red Beds. In the Barkly East Division the formation is split up by numerous beds of lava and ash, both of which are sharply defined from the sandstone. At Siberia in Wodehouse, three bands of sandstone are intercalated in the lavas. At the head of Bamboes Spruit in Herschel there are four such bands. Near the large Belmore volcano in Barkly East the Cave Sandstone contains numerous masses of vesicular lava up to four feet across, the lower surfaces of which consist of pipe amygdaloid. Du Toit has described a section near Barkly East Township showing pinkish sandstone resting on a bed of ash and abutting at one end against a sheet of doleritic lava; in the sandstone are embedded rounded masses of altered doleritic lava. At Waterfall in the Barkly Division there is a section showing alternation of volcanic and sedimentary material, both the sandstones and the lavas having a lenticular character; there are pipe-amygdaloids at the base of some of the lava-flows and rounded portions of lava in the beds of sandstone.

It is important to notice that in all the occurrences cited in the last paragraph the intercalation of sandstone and volcanics occurs above the main mass of the Cave Sandstone; also that the sandstone in this upper portion of the formation is usually well laminated. This fact, coupled with the occurrence of pipe amygdales in the lavas where these rest on the sandstone, seems to show that the conditions of deposition of the sandstone were somewhat different from those of the main mass and were somewhat moister and less arid. However that may be, it is apparent that the Cave Sandstone was not deposited uninterruptedly; in places the deposition was hindered by outbursts of ashes and of lavas from the many volcanoes of the area. Du Toit remarks "While the Cave Sandstone accumulated freely in the north and was followed by lava flows, the ejection of ash in the south was so considerable that full development of the sandstone was prevented in that region, and it was only at a slightly later period that lavas commenced to be erupted there".

The large Modderfontein volcano in Aliwal North came into existence while the Cave Sandstone was being laid down, for in an outlier of Cave Sandstone near by the rock is full of small fragments of shale and sandstone that were blown out from the volcano.

Very little, or no, work has yet been done upon the area north of the Orange River, but it is probable that the Cave Sandstone there will be but little affected by volcanic flows — the volcanoes seemingly having come into being progressively from south to north in point of time.

The work of du Toit in the south and centre of the area has shown that, presumably in connection with the outbreak of volcanic activity, there was a certain amount of faulting and folding which has affected the sediments but not the overlying lava flows.

In Maclear, the dips of the Cave Sandstone show that folding took place during, and probably also somewhat previous to its deposition and that they had ceased by the time that the area became flooded with lavas. There are local disturbances of both the Red Beds and the Cave Sandstone, but the overlying lavas are undisturbed. A certain amount of subsidence caused the formation, too, of local hollows which were filled with ash.

At Siberia, in Wodehouse, faulting on a small scale affects the Red Beds and Cave Sandstone, but not the volcanics. In the Barkly East Division the main bed of Cave Sandstone and the ash-bed are affected by small folds, producing domes and basins in the strata, and — according to du Toit — there is clear evidence of a great zone of subsidence formed during the eruption of the earlier lavas. A generalised section along the Kraai River shows the Red Beds and the main-body of Cave Sandstone with the ash-bed bent into an asymmetrical undulating trough, while the lavas with the thin intercalated sandstone beds lie horizontally and undisturbed except in the east.

It is of interest briefly to consider the probable changes which took place during Stormberg times in the land area from which these sediments were derived.

That a land mass lay to the south and probably partly to the east of the present area occupied by the Stormberg beds cannot be doubted. How far to the south it lay we cannot say: but the occurrence of a fair thickness of Molteno Beds near Port St. John's indicates the presence of a land-mass to the south of the present continent. Of its petrological characters little can be said. The constituent minerals of the Stormberg sandstones indicate derivation from granitic or granitoid rocks in part. The lithological character of the original rock from which sediments are derived is always, however, a matter mainly of speculation unless the sediment is near the region of erosion and other conditions are favourable for preserving the mineral constituents of the original rock or rocks in an unaltered condition. Chief interest centres around the probable physiographic changes of the parent land-mass.

A general survey of the Stormberg sediments reveals a sudden interruption of deposit of shales and fine-grained sandstones which took place throughout Upper Beaufort times and the displacement of that type of sediment by a series of grits, coarse-grained sandstones, conglomerate bands, and somewhat irregular large lenses of shales (sometimes coaly). This type was followed by a series of sandstones, reddish in colour and becoming progressively finer-grained, interbedded with red clays: and that by the fine-grained Cave Sandstone. This succession can be profitably contrasted with that of the Siwaliks of the Himalayas as described by Medlicott and Blanford (1879). They say "Sandstone immensely preponderates in the sub-Himalayan deposits, and is of a very persistent type from end to end of the region and from top to bottom of the series. Its commonest form is . . . of a clear pepper and salt grey, sharp and fine in grain, generally soft, and in very massive beds. The whole Middle and Lower Siwaliks are formed of this rock, with occasional thick beds of red clay and very rare thin, discontinuous bands and nodules of earthy limestone, the sandstone itself being sometimes calcareous and thus cemented into hard nodular masses. In the Upper Siwaliks conglomerates prevail largely; they are often made up of the coarsest shingle, precisely like that in the beds of the great Himalayan torrents . . . The mountain torrents are now in many cases engaged in laying down great banks of shingle at the margin of the plains, just like the Siwalik conglomerates: and the thick sandstones and sandy clays of the Tertiary series are of just the same type of form and composition as the actual deposits of the great rivers." They conclude that the Siwaliks were laid down as a fluviatile outwash from the rising Himalayas.

We see here that the succession in the Siwaliks is the exact opposite of that shewn by the Stormberg Beds — at least to the top of the Red Beds. In the Siwaliks fine-grained sandstones and red clays give place to coarse-grained sandstones, conglomerates and coarse shingle-beds. If Medlicott and Blanford are correct in assigning the Siwaliks to fluviatile deposition from a rising mountain mass, then it may be presumed that the Stormberg Beds are possibly sediments derived from a land-mass slowly lessening in altitude.

This presumption is further buttressed by certain theoretical considerations which have been fully set out by Barrell (1908) and which will be briefly noticed here.

In youthful topographic stages rock-breaking dominates over rock-decay; in topographic old age the reverse is normally true. In arid climates, however, and to a lesser extent in cold climates, where chemical action plays a less important part than in humid and wet climates, there is dominance of disintegration over decomposition even in topographic maturity or old age. Again, in the youthful stages of topography the waste is carried away from the higher ground as soon as disintegration frees it from the rocks, in arid and subarid climates by the streams arising from torrential rains, and is deposited in inland basins or on piedmont slopes. Under arid and subarid conditions this waste is coarser, less decomposed and has less true clay than similarly situated waste of more pluvial climes. Even in maturity, the mountains of arid regions retain their nakedness, roughness and sterility and give rise to disintegrated waste rather than decomposed material. As, however, the difference in altitude between the parent mass and the sediments formed from it diminishes, so will the transporting power of the torrents lessen, and the sediments will tend to become finer in grain — the larger fragments of disintegrated matter being unmoved by the slower and less powerful streams.

In the old age of arid regions wind erosion becomes increasingly more important than water erosion, so that the products of erosion in old-age, when the desert surface is approximately flat, are chiefly wind-borne loess and dune-sand.

A number of instances might be cited of present-day regions in which one or more of these stages is seen; it is enough to quote the Eastern Persian area described by Huntington, the aerial deltas arising from the decaying high-lands of Arizona, and the sand-filled valleys and "island mountains" of Namaqualand in South Africa. It would seem that the evidence afforded by the nature of the sediments, coupled with these theoretical considerations and present-day examples, tends to point to the conclusion that the land-mass from which the Stormberg sediments were derived, suddenly rejuvenated at the end of Beaufort times, was in process of planation during the deposition of the beds until the intense volcanic activity put an end to sedimention in the area.

On the other hand, there is little or no direct evidence of local or regional earth-movement such as would have caused sudden rejuvenation at the end of Beaufort times; and the sudden onset of the conglomeratic and coarse type of sedimentation which characterises the Molteno Beds may have been due to more intense precipitation of moisture resulting in torrential downpours and a consequent rush of swollen streams at certain seasons. Even if that be a partial explanation of the phenomenon, it is certain that the land to the south must have had a marked elevation above that upon which the sediments were deposited. No intensity of rain-fall would cause pebbles and coarse sand to be washed from one area on to another at approximately the same level; in other words, subaerial conglomerates are not features of wellmatured or senescent stream-deposits.

Transvaal Area.

The correlation of the various outliers of the Bushveld Sandstone with one another and with the Stormberg Series of the Cape has been based mainly upon petrological grounds and upon the fact that they underlie the amygdaloidal lavas. It has been supposed that they are but remnants of a once extensive mass; but, however that may be, it is certain that they were laid down upon an uneven surface.

In the Springbok Flats area, north of Pretoria, the series is bent into a double basin, and rests either directly on the Red Granite or upon highly inclined and sometimes much broken and faulted sediments of the Waterberg System. The basal beds of the Bushveld Series here are frequently composed of debris and fragments of granite, felspar, and quartz with interstitial partly decomposed felspathic material — derived from the Granite — and occasionally of large rounded quartzite pebbles, probably from the Waterberg Conglomerate. These coarse beds are confined to the edge of the Series. Above them are in general, layers of red marl or shale; and they are followed by the true Bushveld sandstone. In the west and south of the area, however, the red marl overlies the so-called "Coal-Measure Grits".

In the Komati Poort area the beds dip to the east, sometimes at an angle of 10 degrees; and this dip has been held to account for the occurrence of the series at a level so much below that of the Springbok Flats. Here the "Bushveld Sandstone" lies, apparently conformably, upon the "Coal Measure Series" — which lie themselves upon the older Granites, schists, and altered sediments of the Swaziland System in the following order: — Pale, hard, often coarse felspathic grits, often massive with pebbly bands, at the base, followed by sandy micaceous shales, carbonaceous shales, grits and sandstones. Between these latter and the fine-grained sandstone yellow shales occur at one or two points. The upper portion of the Coal-Measure Series carries *Glossopteris.*

Garrard has traced this series in a north-south belt through eastern

Swaziland to within 25 miles or so of the Zululand coal-field. In the latter (St. Lucia field) the coal-bearing beds are separated from the Basalts by horizontal beds of calcareous sandstone. At Somkele the coal is considered by du Toit to be of Beaufort age, overlain by red and purple shales which he thinks are Middle or Upper Beaufort.

In the N. W. Zoutpansberg the Bushveld Sandstone rests either on the old gneisses and schists or upon a variable thickness of Coal Measures underlain in places by Glacial Conglomerate.

The palaeontological evidence seems to bear out the correlation of the Zoutpansberg and Springbok Flats members with the Red Beds and Cave Sandstone of the Cape Province area. Two questions remain to be settled definitaly — 1. Is the fine-grained sandstone of the Komati Poort area really Bushveld Sandstone? 2. Is there any Transvaal representative of the Molteno Beds? Kynaston has already covered most of the ground, but the questions can be briefly discussed.

1. The only recorded fossil from the Komati Poort area is *Glossopteris* sp. from below the fine-grained sandstone. Here, in the southern extension of the belt in Swaziland, and in Zululand upper coal-seams occur near the top of the "Coal-Measures". In the St. Lucia coal-field the following plants have been found: — *Glossopteris browniana* var. *indica*, *G. browniana* var. *angustifolia*, *G. damudica*, *G. retifera*, *G. acuta*, *G. spatulo-cordata*, *Phyllotheca* sp. and *Taeniopteris spathulatum*. This flora was held to be an Ecca one by Etheridge jun.; but there seems little doubt that the assemblage is, as a whole, typically Lower Beaufort. These beds are, however, separated by a wide belt from the amygdaloidal lavas at Somkele, a belt which is not yet at all known. If the coal-bearing beds at Komati Poort are the equivalent of those at St. Lucia then two possibilities arise: — (a) that the fine-grained sandstone at Komati Poort is true Bushveld Sandstone and lies unconformably on the Beaufort Beds — just as the Red Beds lie unconformably on the Beaufort Beds in the N. E. Free State; or (b) that the fine-grained sandstone is itself of Upper Beaufort age. The general nature of the sandstone, its mode of weathering, its non-variability over a large district, and the known unconformity at Harrismith and in the neighbourhood lend strong support to the former alternative. The matter awaits further treatment based upon more detailed field work; but it is important to note that the similarity of the sandstones in the different areas points to formation under similar climatic conditions; and these conditions do not seem to have occurred in the southern area until the onset of Red Beds times.

2. This question has been partly answered above. In the Cape the Molteno Beds are a local phase corresponding to a certain type of climate and certain geographical conditions which enabled coarse pebble-beds, finer sandstones, and carbonaceous shales to accumulate in a huge subaerial delta over a plain situated at the foot of an upraised land mass to the south. In the High Veld of the Transvaal there is no corresponding mass of sediment. During the deposition of the Beaufort Beds in the south of the Union, the Transvaal area was subjected to erosion and denudation (deposition only taking place within certain basins), the sagging of the geosyncline in the south possibly being compensated by a rising of the northern area. This period of erosion, however, came to an end at some point during Stormberg times; and in some of the basins formed on the unequal land surface debris accumulated, to be soon covered by thin shales and the Bushveld sandstone. There is evidence to show that warping and sagging took place in the region north of Pretoria during Karroo and post-Karroo times, which would account for the overlaps round the margins of such basins as have been preserved. The basins, in fact, owe their preservation to the sagging which took place. In spite of minor differences visible in specimens from different places the Bushveld Sandstone is of so uniform a character that it is reasonable to suppose that the patches that remain are but relics of a once more widely-spread layer that stretched up into Southern Rhodesia. Like the Cave Sandstone it was subaerial and probably mainly aeolian; and once the basins were filled up by the driven and blown sand, the material spread out to cover a larger and larger surface. We cannot estimate its maximum extent, nor conjecture what peaks of older rock stood up above the sandy levels. We shall note later that there seems to be a lateral change from a fine-grained "loess-like" deposit to a somewhat coarser, rounded desert-sandstone. In this area the basal conglomerates may be the equivalent of the Molteno Beds — they are equally the result of the action of torrential rains able to produce temporarily streams strong enough to carry fair-sized pebbles; while in the basal part of the reddish clays north-west of Pienaars River Station the occurrence of a very thick compound seam of coal lends colour to this suggestion.

The climatic conditions which gave rise to the Red Beds of the Cape were shortlived in the Transvaal; and the climate rapidly changed to one comparable with that reigning in Cave Sandstone times further south; the onset of such conditions was possibly earlier in the north than in the south. As a general conclusion, the further north one goes from the Cape area the greater is the evidence of aridity furnished by the Bushveld and Forest Sandstones; and it is of interest here to examine the .evidence afforded by a microscopic examination of the rocks from the various localities.

The closest approximation to the true Cave Sandstone is possibly afforded by the fine-grained sandstone from Komatipoort. This was described by Kynaston as follows: — The rock "shows numerous small quartz grains, of a generally uniform size, and on the whole angular and sub-angular rather than rounded, embedded in an exceedingly fine-grained matrix, in which individual grains are barely distinguishable. Grains of plagioclase felspar may occasionally be noted..... The microscopic characters agree very closely with those of the fine sandstones from the Springbok Flats, the proportion of matrix to individual quartz grains being somewhat higher in the latter."

The Buiskop sandstone is of fairly fine grain, and there are very few grains which are coarser than the general texture of the rock. A considerable amount of ferruginous cementing material is present in the red varieties; and the grains of quartz, although not splintery, are polygonal in outline with rounded corners. The red variety is very similar to the sandstones of the Red Beds.

A specimen of sandstone from Nelson's Kop, in the west of the Waterberg District near the Limpopo and Pongola Rivers, contains two types of quartz grains — a larger and a smaller. The larger grains are less prevalent than the other; they are rounded without any trace of angularity and they vary in size from a grain having diameters of 0·3 mm. and 0·22 mm. to one with diameters of 0·6 mm. and 0·4 mm. The smaller grains, of a diameter of 0·15 mm. and under, are not so obviously rounded, but none of them are splintery, although thin sections are somewat polygonal. Most of the grains are coated with a thin reddish-brown layer of iron oxide, while there are scattered grains of the same material. Felspar is much less common than in the Forest Sandstone. The whole section is reminiscent of that figured by Molyneux as a typical section of the Nyamandhlovu Sandstone. For the sample I am indebted to Dr. du Toit, who also supplied me with a piece of Bushveld Sandstone from Castle Kopjes, on the main road from Louis Trichardt to Messina.

The Castle Kopjes rock is light in colour and consists of equidimensional grains of quartz with a very occasional grain of plagioclase. The grains are fairly well rounded, smaller than those of the Nelson's Kop stone and similar in size to those of Buiskop.

Reviewing the features of these Transvaal specimens, it would appear that, in general, they are intermediate between the true Cave Sandstone of the South and the Forest Sandstone and Nyamandhlovu Sandstone of Rhodesia — the more southerly outcrops partaking more of the nature of the former, the westerly and northerly ones more of the character of the Rhodesian rocks. Thus we can picture the loess-like formation of the south giving place gradually to the true desert sands of the north, the fragments of the Transvaal deposits which now remain to us representing the transition stage between the two types and shewing an intermingling of the fine-grained angular fragments from the south with the rounded desert sands of the north.

Age of the Stormberg Series.

Until fairly recently the age of the Stormberg Series was accepted as ranging from Rhaetic to Lower Jurassic; within the last few years, however, there has been a tendency to throw back the age along the time-scale and to consider the Cave Sandstone as no later than Rhaetic.

The evidence in favour of the older view was mainly two-fold, based on the nature of the plants of the Molteno Beds and that of *Notochampsa* from the Cave Sandstone. The latter was thought by Broom to be a true crocodile allied to *Pelagosaurus*; and as crocodiles did not appear until the Jurassic in other parts of the world the Cave Sandstone was deemed Jurassic. The Molteno plants were considered by Seward to be of Rhaetic age; and the Series was thus spaced between those limits.

Detailed examination of the evidence leads, however, rather to the acceptance of the later view. In the first place the Rhaetic age assigned to the Molteno plant forms is based upon what is by no means clear evidence and in view of recent discoveries the conclusion may need considerable revision. Dr. du Toit is studying a large amount of material mainly collected by himself, and although his results are not ready for publication he has permitted me to say that the undoubted association of *Glossopteris*, *Chiropteris*, *Pterophyllum*, *Callipteridium* and apparently *Rhexoxylon* with the typical Molteno genera *Baiera*, *Thinnfeldia*, and *Taeniopteris* give a very pronounced Keuper appearance to the flora.

The vertebrates which it should be remembered come from still higher horizons, when studied in detail, also bear a Triassic aspect.

The three Cynodont forms are specialised relics from the Upper Beaufort Beds. These latter, which underlie the Molteno Beds, have yielded the Stereospondyls *Capitosaurus* and *Trematosaurus*, forms which are found in the Bunter (L. Triassic) of Germany.

Among the Archosauria the crucial *Notochampsa istedana* has been shown to be not crocodilian but a Thecodont lying apparently between *Aetosaurus* and the Crocodilia. The former occurs in the Keuper of Germany, the latter first appear in the Lower Jurassic; this would denote a Rhaetic age for the Cave Sandstone which has yielded the intermediate form.

Erythrochampsa from the Red Beds has a crocodilian pelvis; but too little is known of the form to be certain of its affinities, and it has thus no bearing on the discussion. *Sphenosuchus* from the Red Beds is a Pseudosuchian of somewhat specialised form. It is probably somewhat later than *Aetosaurus* (Keuper), although it should be noted that the highly specialised *Schleromochlus* is found in the Lettenkohle (Upper Muschelkalk) of Scotland.

In Europe, *Thecodontosaurus* ranges from the Lower Muschelkalk to the Middle Keuper: the larger *Gresslyosaurus* and *Plateosaurus* occur in the Upper Keuper and Rhaetic. In South Africa the order of appearance is reversed. The larger *Euskelesaurus* and *Plateosaurus* are lower Red Bed forms while the lighter-limbed *Thecodontosaurus*, *Massospondylus*, *Gyposaurus* and the like occur in the Upper Red Beds and Cave Sandstone. *Massospondylus* has been shown to have retained a primitive form of shoulder-girdle; and it seems probable that these light-limbed animals migrated to the Stormberg region only when conditions became sufficiently arid for them in the south. In spite of the slight differences between the detailed succession of the Saurischia in the European and South African regions there is no doubt as to the general similarity of the fauna; and since none of the European genera survived beyond the Rhaetic additional weight is lent to the theory that the Stormberg Series is not later than Rhaetic.

The occurrence of *Geranosaurus* is paralleled by that of the Predentate *Nanosaurus* in the Rhaetic of North America; while the Cave Sandstone fish *Semionotus* occurs in the Keuper of Europe.

Finally, the general aridity which, as we have seen, prevailed increasingly through Stormberg times is a characteristic of the Triassic epoch; and in the absence of any evidence to support the theory of the Jurassic age of part of the Series we must conclude that Stormberg sedimentation began in Middle Triassic time and ended in the Rhaetic.

Professor Schwarz considers that the Stormberg Beds should be divorced entirely from the Karroo System and that, if they are not sufficiently important to warrant their promotion to a system of their own, they should be grouped with the Uitenhage System. His reasons for this view, as stated in Proc. Geol. Soc. S. Africa 1919, are open to question. "The most important of all faunal changes, the passage of the vertebrate remains from reptilian to mammalian" is not yet proved to be a feature of the Stormberg Beds; the fauna is a reptilian one, with members of the Beaufort Theriodontia still living; the Dinosaurs are, as we have seen, Triassic and not Jurassic nor Cretaceous forms; and *Glossopteris* is still a feature of the Molteno Beds.

Important evidence bearing on the age of the sediments has recently been forthcoming from South America. The beds of Karroo age in the State of Parana, Brazil, show the following succession:—

6.	Eruptivas da Serra Geral		600 metres.
5.	Arenito de Botucati		200 ,,
4.	Serie Rio Rasto		100 ,,
3.	Serie Passa Dois	Calcareo Rocinha	3 ,,
		Grupo Estrada Nova	150 ,,
		Grupo Iraty	70 ,,
2.	Serie Tubarao		180 ,,
1.	Serie Itarare		350 ,,

The Itarare Series is glacial, and its upper portion contains a marine fauna of Lamellibranchs and Gasteropods.

The Tubarao Series contains a *Glossopteris* flora.

The Iraty Group contains the reptiles *Mesosaurus* and *Stereosternum*.

The Rio Rasto group has yielded the reptiles *Scaphonyx fischeri* and *Erythrosuchus* sp. and is presumably approximately equivalent to our Upper Beaufort Beds. Recently Holdhaus (1918) has described from the same Series the lamellibranchs *Solenomorpha similis*, *S. intermedia*, *S. altissima*, *S. deflexa*, and *Sanguinolites elongatus* — an assemblage which has led him to class the beds definitely as Permian.

The Botucati sandstone, sandwiched as it is between the beds containing *Erythrosuchus* and the thick volcanic outpourings which, like those of the Stormberg, made an end of sedimentation, can but correspond to the Stormberg sediments of South Africa. Following as it does conformably upon strata now classed as Permian there can be little doubt that it is not later than Triassic in age — a result in accordance with that now obtained from our consideration of the South African deposits.

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