GEOLOGY AND PALAEONTOLOGY

OF THE

JURASSIC AND CRETACEOUS BEDS OF SOUTHERN TANGANYIKA

BY

WILLIAM G. AITKEN

S U M M A R Y

SUMMARY.

Part I of the thesis describes the geology of an area of about 400 square miles in the hinterland of Kiswere in the coastal region of southern Tanganyika. More detail is available of the Mandawa - Mahokondo region, where the sequence is most complete, than of the remainder.

The greater part of the area is occupied by Mesozoic rocks with marine Paleogene sediments in the extreme east. The exposure of Jurassic and Lower Cretaceous strata is due largely to the erosion of once continuous plateau-forming beds of Upper Aptian age or younger. Unconsolidated continental Neogene sands cap the plateaux and Neogene gravels appear on some of the lower watersheds. The Neogene sediments have not been mapped in detail.

All stages of the Middle and Upper Jurassic and of the Cretaceous are represented, though the succession is not continuous. The Jurassic and Lower Cretaceous strata (the Mandawa - Mahokondo and the Tendaguru Series) are largely of littoral or neritic facies and estuarine and continental rocks are present towards the west. Below the oldest exposed Jurassic beds (the Pindiro Shales), which contain massive gypsum at surface, drilling has proved a thick evaporite series including halite deposits.

There is a notable easterly thickening of almost all of the individual units of the Jurassic and Lower Cretaceous sedimentary column. The Tendaguru Beds, which in their type area are only about 400 feet thick, total over 2,500 feet in the north of the Mandawa - Mahokondo area (including about 500 feet of Lower Cretaceous strata) and the total thickness of the Jurassic above the Pindiro Shales there approaches 5,000 feet.

The marine Upper Aptian occurs in two facies, dominantly calcareous (Kiturika Beds) along the east of the Ngarama Plateau and mixed arenaceous/argillaceous/calcareous to the east of the Mandawa - Mahokondo area. No marine Upper Aptian occurs in the west of the area mapped, and the continental Makonde Beds, which have previously been described as equivalent to the Kiturika Beds, cannot be demonstrated to be other than younger than them in the area concerned. The Albian - Senonian sequence forms a series of overstepping, dominantly argillaceous subdivisions, still in part at least of fairly shallow water origin, nowhere extending west of the Upper Aptian limestone outcrop.

Below the Callovian, fossils are not abundant or diagnostic but rich fossil horizons occur in the sequence between the Callovian and the Lower Aptian. There is generally a clear palaeontological distinction between the marine horizons of the Jurassic and the Lower Cretaceous, and palaeontological evidence on the basis of Trigoniids is advanced for correlations within the Kimmeridgian - Tithonian strata. Otherwise, local correlations are in part on lithological grounds.

There are two outstanding structures in the area, the Mandawa - Mahokondo and the Makangaga - Ruawa anticlines en echelon, both in part diapiric, of which the axes lie approximately NNW.- SSE. To erosion of these is due the exposure of the older Jurassic strata. The former has two distinct culminations. Outside the vicinity of these structures dips are generally low. The greater part of the movement, which was to some extent independent in the two structures, was completed by the end of the Jurassic but, locally, faulting and some minor uplift affected Upper Aptian beds. A number of unconformities occur; some are due to local diapiric uplift in the anticlinal areas, but those below the Upper Neocomian and below the Upper Aptian appear to be of more widespread significance.

The geological history of the area is outlined and a brief comparison is made of some of the faunas present with others in the Ethiopian Province and elsewhere.

Part II of the thesis gives an account of Trigoniids collected during the survey of the Kiswere Hinterland. A total of 11 new species have been named and described and at least a further 5, of which only poor material is available, are also regarded as new. The genera *Linotrigonia*, *Laevitrigonia* (as emended by Cox, 1952) and *Opisthotrigonia*, and the subgenus *Pleurotrigonia* are reported for the first time from East Africa. Of these, *Opisthotrigonia* was previously regarded as monotypic. Biometric analysis of variation in communities of *Indotrigonia* from successive horizons in the Middle Kimmeridgian - Tithonian sequence has been attempted.

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PART I - GENERAL GEOLOGY

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I. INTRODUCTION

General.

This account is of the geology of an area of about 400 square miles, lying in the Kiswere hinterland in the southern coastal region of Tanganyika about mid-way between the townships of Lindi and Kilwa (see Plate I). The greater part of the area is occupied by Mesozoic strata; all series of the Middle and Upper Jurassic and of the Lower Cretaceous are represented, though there are breaks in the sequence. Apart from doubtful occurrences of Kimmeridgian strata near Tanga (Arkell, 1956, p.326) and on the Central Railway (Hennig, 1924, p.113), higher Jurassic strata have not been recorded in Tanganyika outside the area bounded by the Matandu and Lukuledi Rivers in the Southern Province. Within these limits no pre-Kimmeridgian strata are known other than the occurrences in the area mapped. The Neocomian is not known in Tanganyika to the north of the Matandu River. The Kiswere hinterland, therefore, contains the most complete Jurassic and Lower Cretaceous sequence exposed in Tanganyika. It appears to be the most complete in the whole of East Africa.

A summary account of the geology of the Mandawa-Mahokondo area has already been given (Aitken, 1954; 1956a,b) and of the Makangaga-Ruawa area (Aitken, 1958). The relation of the Cretaceous to the Jurassic in the area has also been discussed (Aitken, 1956c). The present account, however, is complete in itself and refers to the others only where modification of views previously expressed has been necessary.

The lower beds of the Jurassic are exposed in two anticlinal structures <u>en echelon</u> (the Mandawa-Mahokondo and Makangaga-Ruawa anticlines) in which the greater part of the movement was completed before the Upper Aptian. Elsewhere, the upper part of the Jurassic sequence and the Neocomian and younger rocks are essentially undisturbed except by faulting, though local angular unconformity between Jurassic and Cretaceous beds has been observed. Previous published work (e.g. Dietrich, 1933a) has shown that there is a palaeontological break at this junction. The Jurassic and Neocomian-Lower Aptian strata are exposed by partial erosion of the once continuous cover of Upper Aptian or younger plateau-forming beds. To the west these are the continental Makonde Beds and to the east, the limestones of the Kiturika Beds. Below the north-eastern edge of the Ngarama Plateau, however, and in a lower topographic position on the east of the Mandawa-Mahokondo anticline, the Upper Aptian occurs in a partly argillaceous facies. This began a cycle of essentially argillaceous deposition extending through the Upper Cretaceous, of which the sediments are exposed in the east of the mapped area. The Cretaceous is overlain by Paleocene strata in the east, and apart from unconsolidated sands which cap the plateaux (probably entirely derived from the Makonde Beds), there are scattered occurrences of Neogene sands and gravels at lower levels.

Method of survey.

When geological survey of the Mandawa-Mahokondo area was commenced, no other topographical base-map was available than that produced during the period of the German administration of the Territory, on a scale of 1:300,000. This compilation was quite inadequate for recording detailed traverse lines. It was believed that air photography of the area would be carried out before the investigation was far advanced, and no attempt was made to produce a detailed topographical map by plane-table or other means. Instead, a series of compass and stadia traverses were carried out, with a small amount of levelling. The traverses were mainly of tracks and stream-beds and it was anticipated that when air photographs were obtained, data collected could be transferred to an air-photograph mosaic before the second field season's work was commenced. Traverses were plotted initially on a scale of 1:10,000 and a pantograph reduction made (see Plate III), to produce a sketch-map on which geological boundaries could be inserted. Air photographs were not in fact forthcoming until the greater part of the field-work in the

Mandawa-Mahokondo area had been completed in parts of three field seasons. Time was available for traversing only the major streams, therefore. Subsequent study of air photographs allowed more detail of the fault pattern to be inserted, but the main stratigraphical and structural information had been obtained before the photographs were available.

The map presented (Plate II), however, is based on topographic sheets recently supplied by the BP-Shell Petroleum Development Co. of Tanganyika, Ltd., constructed from air photographs. The maps were originally printed on a scale of 1:100,000 but were photographically enlarged to 1:50,000 before addition of geological data. The reduction in scale from the original plotting has necessitated selection of the structural data presented. A reduction of the original traverse plan (Plate III) indicates the closeness of traversing in different parts of the Mandawa-Mahokondo area, and shows the positions of traverses named in the locality lists (Appendices I and II).

Some preliminary work in the Makangaga-Ruawa anticline involved compass and stadia traversing, but the bulk of the observations there and elsewhere in the area mapped, apart from the Mandawa-Mahokondo area, were plotted directly on air photographs and transferred to the 1:50,000 topographic map.

Observations in some of the peripheral areas of the map were scanty and information has been exchanged with Mr.R.

Stoneley of the BP-Shell Petroleum Development Co.Ltd., with a view to determining boundaries. The dating of the post-Aptian Cretaceous is due to this Company.

Fossil collections.

During field work, large fossil collections were made. The bulk of the Cephalophoda have been examined by Dr. W.J. Arkell, F.R.S., and his determinations of ammonites have provided a firm basis for dating of the Jurassic sequence. Mr. C.W. Wright determined several Neocomian forms. The majority of the cephalopod specimens are housed in the Sedgwick Museum, Cambridge. Dr. L.R. Cox, F.R.S., has commented on molluscs from the ?Bajocian Pindiro Shales. The bulk of the lamellibranch specimens have been deposited in the Hunterian Museum, Glasgow University, and other groups have been accepted for determination by the following authorities:-

Echinoids - Dr. E.D. Currie (The Hunterian Museum, The University, Glasgow).

Brachiopods - Dr. H.M. Muir-Wood (British Museum (Natural History)).

Corals - Dr. H.D. Thomas (British Museum (Natural History)).

Gastropods - Dr. L.R. Cox (British Museum (Natural History)).

The localities from which specimens of the various groups came are indicated in Appendix I.

Unless stated otherwise, the present author is responsible for determinations of lamellibranchs collected in the course of field work and named in this paper. An account of the Trigoniids forms Part II of the thesis.

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II. PHYSICAL FEATURES

Topography.

Some impression of the topography of the area is gained from examination of the "print lay-down" reproduced as Plate IV. The area is dominated by the Ngarama and Mbalawala plateaux formed mainly of continental sandstones of supposed Aptian age, with Upper Aptian marine limestones flanking the eastern and southern parts of the former.

The elongated dome structure of the Mandawa-Mahokondo area to the east of the Ngarama Plateau is outlined by a strong escarpment feature of Kimmeridgian-Tithonian oolites and associated strata. Below the escarpment is a belt of low lying ground corresponding to the outcrop of a Lower Kimmeridgian marl unit; an elongated ridge with high areas at the north and south corresponding to geological culminations, forms the core of the structure.

Between the Ngarama and Mbalawala plateaux, escarpment features are formed similarly of Kimmeridgian-Tithonian oolites, etc., along the exposed eastern flank of the Makangaga-Ruawa anticline and at the northern pitch of this structure, forming the Namgango-Ndondonga Ridge. The core of this anticline, occupied mainly by the Pindiro Shales, is an area of fairly gentle over-all slopes. Apart from the strong Namgango-Ndondonga ridge in the north, there are low, south-facing scarps and northerly dip slopes to the north of the Matarawe Stream, due to alternating hard and soft Callovian-Kimmeridgian strata.

In the Mbemkuru Valley a broad alluvial area to the west is barred by a fault-line scarp (the Kikundi-Mchinjiri Fault) formed of Kimmeridgian-Tithonian strata topped by oolite, with the high ground of Minyoka and Ukulinga to the east. This escarpment extends southwards forming the eastern wall of the Mchinjiri Valley. Further to the west, there is another less prominent bar across the Mbemkuru Valley where the extension of the high ground of the Itukuru area and a ridge east of the Mtapaia Stream approach close to the river from the north and the south respectively. The high Cretaceous plateaux south of the Mbemkuru River do not enter the area mapped, though the northern end of Mbambala Hill is an extension, formed of marine Upper Jurassic rocks, from the plateau area further south. Rather similar is the Turikira Ridge which extends southwards from the Ngarama Plateau, capped by Lower Cretaceous beds.

South of the Mandawa-Mahokondo area and east of the Turikira Ridge, is low, rather broken country of Neocomian and Aptian strata. A little to the west of the Lindi-Kilwa road in this area, however, and lapping the eastern side of the Mandawa-Mahokondo anticline further north, is an extensive area of rolling country formed mainly of Upper Cretaceous marls. To the east of this belt along the eastern margin of the area mapped, is an almost continuous escarpment capped by Paleocene limestones.

Drainage.

The main drainage way is the Mbemkuru River, a stream with its headwaters 120 miles WSW. of its point of entry into the area mapped. West of the Kikundi-Mchinjiri scarp, the Mbemkuru flows through a broad alluvial area, but at the fault line enters a gorge. The valley sides remain steep throughout, for some distance to the east of the area mapped. Hennig (1914a, p.21) described river terraces at 10m, 20-25m and 40m above the river near the entrance to the gorge, but air-photograph interpretation suggests that the features observed are erosional, marking eastward dipping bedding planes. The course of the river follows a large semicircular curve southwards, shortly after entering the steeply incised section. It seems probable that the Mbemkuru is an ancient drainage line, and as such, might be antecedent in this part, the main features of the present topography in the areas of Jurassic and Lower Cretaceous rocks representing an exhumed land surface below the strata making up the plateaux to north and south. On the other hand, the drainage could be superposed. This would be more readily admissible if the early German contention (e.g. Bornhardt, 1900), supported by Spence (1957, p.39), was accepted, that the sequence forming the

Inland Plateaux, where the river rises, are of the same age as, and were once continuous with, the sediments of the Coastal Plateaux. Staff (1914a, p.97) has commented on the alignment of the upper course of the Mchinjiri (south of the area mapped) with the lower course of the Mbemkuru, and of the Mbemkuru upstream of Minyoka with a stream entering Kiswere inlet. He preferred to suppose that the Mbemkuru formerly entered the sea at the Kiswere inlet rather than at the insignificant indentation of the coast at its present mouth. This conception might favour a superposed origin of the drainage with the river capture after the removal of the later cover. This point cannot be adequately discussed on the basis of the area mapped.

The main tributaries of the Mbemkuru from the north in the area mapped, are the Kikundi and the Kihimbwi - Ruawa - Pindiro drainage. The headwaters of the Kihimbwi and Ruawa lie in large erosion embayments in the western flank of the Ngarama Plateau, but no such features are present on the Mbalawala Plateau. The minor drainage in the Makangaga - Ruawa area reflects the geology. Nowhere in the shale country is strike control of streams apparent and in the block of country bounded by the Pindiro, Kihimbwi - Ruawa and Matarawe streams, the minor drainage is nearly radial. Elsewhere the strike of the underlying beds controls the drainage to a greater or less extent. Fault control is probable in the case of the Pindiro and Kikumiru streams.

The main southern affluents are the Mchinjiri, the Lipogiro and the Mtapaia.

Almost all the drainage in the Mandawa-Mahokondo area joins the Mandawa River, which forms the only breach in the eastern flanking ridge of the structure. The main tributaries of the Mandawa rise on the flanks of the Ngarama Plateau, cross the Kimmeridgian-Tithonian ridge and the low lying area of Lower Kimmeridgian marls on the west, and break through the central ridge of the anticline. Others rise on the Kimmeridgian-Tithonian ridge and follow similar courses. There is a concentration of these streams in the saddle between the stratigraphical (and topographic) culminations, through which flow the Namakumbira-Nchia, the Lonji-Mandawa, the Runjo and the Namakambi-Namakangoro streams.

The Mkomore, its headwaters deriving both from the plateau edge and from the Kimmeridgian-Tithonian ridge, actually breaks through the northern culmination. The Mahokondo-Manyuli Stream, although crossing the Lower Kimmeridgian marl area close to the northern pitch of the structure, also enters the area of the core of the anticline. The Nunga Stream, a tributary of the Manyuli, with its headwaters in the Kimmeridgian-Tithonian ridge to the north-east of the structure, is exceptional in entering the core of the structure from the east. The marl area on the east flank of the structure is occupied by strike sections of the Nunga Stream, the Manyuli Stream and, south of the Mandawa, by the Ndolera drainage.

The only drainage in the area of the anticline which does not flow into the Mandawa, is the Lihimaliao. This stream descends from the edge of the Ngarama Plateau over the western ridge of Kimmeridgian-Tithonian strata near its southern end. It follows, for the most part, the outcrop of the marl unit round the southern nose of the central ridge. Even this stream enters the "core" in the Namakambi area and cuts into it at several points lower down. The Lihimaliao takes advantage of a break in the eastern ridge of Kimmeridgian-Tithonian beds due to faulting at the south-east of the structure, to escape eastwards. The only considerable tributary entering the Lihimaliao from the southern culmination of the anticline, is the Mbaru, though numerous small watercourses descend the semi-circular southern "nose" of the central ridge.

The breaking-through of the central ridge by the numerous watercourses suggests that in part the drainage is superposed. The strike valleys of the Manyuli and the Ndolera in the eastern belt of marl could be recent or exhumed, as could that of the Lihimaliao.

North and north-east of the anticline the drainage flows into the extensive creek system south of Kilwa, either direct or <u>via</u> the Mkondadye, a consequent stream to the north of the area mapped. South of the Kikundi Stream on the east of the anticline, numerous small consequent streams enter the strike valley of the Nanycheri, a northern tributary of the

Mandawa. Similarly to the south as far as the Ngirito area small consequents join the Kimbarambara, also a strike stream for most of its length, flowing into the Mandawa from the south.

Immediately south of the anticline, the Mloweka-Kindole Stream is probably controlled by the system of ring-faulting there. Much of the drainage east of the Turikira Ridge is tributary to this major stream, which joins the Lihimaliao and flows to the northern part of the Kiswere Creek. The stream which Staff (1914a, p.97, see p.11 above) suggested marked the old lower course of the Mbemkuru entering Kiswere inlet, is joined by some of the drainage from the Turikira Ridge north of Mtande. South of Mtande all the drainage is tributary to the Mbemkuru.

Water supplies.

Flowing water is confined to parts of the Mbemkuru River and several of its tributaries. Elsewhere, small springs and seepages, and standing pools in a few of the larger streams provide water supplies, and water is often obtained from wells dug in the sand of larger stream beds. Occasionally water is obtained from shallow wells in surface sands, as at Njenga, but these are not permanent.

The Mbemkuru River is not permanently flowing to the west of the area, but receives perennial inflow from a number of streams rising at the lower slopes of the Cretaceous plateaux. Most notable is the Kihimbwi Stream, which is joined by the Ruawa. The Pindiro, the other main tributary of the Kihimbwi in the Makangaga-Ruawa area, contains permanent water in places but no continual flow. Other permanent inflow to the Mbemkuru is derived from springs on the southern side of the Itukuru area, notably Mto Nyangi. The permanent streams are the main source of water supplies, but seepages in the Kikundi, Turikira and Mohinjiri are notable.

There are no perennial streams outside the Mbemkuru Depression. The main permanent seepages or small springs are in the following water courses:-

Bathonian/Oxfordian strata	Kimmeridgian/Tithonian strata	Neocomian/Aptian strata
Mkomore	Mahokondo	Namitambo
Mchia	Nandenga	Mpilepile
Lonji	Lihimaliao (near Njenga)	Kikundi
Namakangoro	Mpilepile	
	Mkomangoni	
	Mandawa	
	Ngirito	

There are small springs near Mirumba and Ntande villages.

Climate, soils and vegetation.

Rainfall probably averages about 35 inches per year, mainly concentrated in the months of December to May with a maximum in April and a rapid fall-off in May. There are occasional showers in the intervening "dry months" especially in late September or early October. Early morning, valley-bottom mists may occur throughout the dry months.

The following remarks on soils derived from the various members of the sequence mapped (Plate II) are generalizations. Apart from those of alluvial origin, the soils are largely lithogenic and generally thin. The Pindiro Shales give a characteristic, brown, loamy clay soil. In the Mandawa-Mahokondo area, soil in the core of the structure, apart from the areas of Pindiro Shales and the area of an outlier of Septarian Marl, is usually a dark brown, loamy sand, but locally there are red sand soils and grey sandy clays. The grey, sandy, clay soils occur in the Makangaga-Ruawa area on rocks of the same age and type, except south of the Matarawe Stream, where dark brown, loamy sand occurs. The Septarian Marl, both on bottom lands and on ridges, gives a black clay soil often with white pellets of calcareous material. In the Makangaga-Ruawa area the arenaceous unit (? Middle Kimmeridgian) above the equivalent of the Septarian marl there, gives a grey, silty soil and loamy sands. A dark, grey-purple, clay soil with limy pellets is derived from the succeeding marl unit. Dark brown or grey, clayey sands, with small rock fragments and limy pellets, is derived from the Middle Kimmeridgian-Tithonian sequence, but a sandy superficial cover modifies this in many places. Light brown or slightly reddish, loamy sands are characteristic of the arenaceous facies of the Lower Cretaceous, with grey, loamy sands more common in the eastern areas. The Ngarama and Mbalawala plateaux have sandy soils, derived from the superficial cover which masks both sandstone and limestone areas. Around the peripheries of the plateaux, outwash sands give rise to similar soils.

The marls outcropping below the Upper Aptian limestones around Nalwehe produce soils very like those of the Jurassic Septarian Marl, and on the Upper Aptian country to the north-east of the Mandawa-Mahokondo area, black clay soils and grey, sandy loams occur. The Albian and Upper Cretaceous marl country towards the east of the area has crumbly, black, clay soils; and more coherent, black, clay soil caps the Paleocene limestones at the eastern border.

The vegetation supported by the different soil types is fairly characteristic. The plateaux have a forest cover with heavy undergrowth on the tops but only patchy undergrowth on the slopes. At the other extreme, is the rolling grassland with small areas of thicket, especially in the low ground, occupying the areas of Upper Cretaceous clay soils and some of the eastern Lower Cretaceous areas. The clay soils in the Jurassic Septarian Marl and the Pindiro Shales have been heavily cultivated, but only areas accessible to water (for example, between Mbinga and Mtande) have been put under cultivation in the more extensive Upper Cretaceous clay areas. Thicket vegetation is characteristic of areas of old cultivation.

Generally open woodland with some thicket occurs over most of the remainder of the area except the uncultivated stretches of alluvian where high grasses grow. The largest of such areas are in the Mbemkuru Valley, particularly the Makangaga Swamp.

III. PREVIOUS GEOLOGICAL WORK

(a) General.

The area described forms a part of the Lindi-Kilwa Hinterland, the geology of which has attracted interest since the beginning of the century. Much of the previous work done in the Lindi-Kilwa Hinterland, outside the limited area protrayed on the map (Plate II) is pertinent to the present study. Summary accounts of the area appear in a number of general stratigraphical works: (Krenkel (1911b, 1925) Koert (1913), Behrend (1918), Gregory (1921), Reed (1921/1939), Gregory & Barrett (1931), Teale (1936, 1938), Wade (1937), Brennich (1937), Stockley (1948), Arkell (1956), Quennell, McKinlay & Aitken (1956), Aitken (1957).

The classification of the Jurassic and Lower Cretaceous strata in the area, put forward by Hennig (1914a, p.14) based on the work of the German Tendaguru Expedition, remains the standard. The character of the various strata was summarized as in Table I by Behrend (1918, p.115) after descriptive notes by Janensch (1914c, p.227):-

TABLE I - The Tendaguru Beds and Aptian Strata of the Lindi-Kilwa Hinterland (after Behrend, 1918).

	Tendaguru region	North and East (Urgonian facies)
Aptian	7. "Makonde facies" (Makonde Beds): Unfossiliferous, reddish and variegated sandstones and marls with layers of Newala Sandstone.	7. "Kiturika facies" (Kiturika Beds): Coral reef and gastropod limestone (including Bernhardt's _Nerinea_ bed of Kilamela (=Kikomolela).
Neocomian	6. _Trigonia schwarzi_ Bed: 5 m. thick. Fine-grained, brown, calcareous, fossiliferous sandstone with strong jointing, with bands of whitish, coarse, calcareous sandstone.	6. Partly Urgonian limestone (Makangaga region) with _Toucasia carinata_.
Wealden	5. Upper Saurian Bed: 40 m. thick. Red and grey sandy marl and a sandstone band. Bones of saurians.	5. Partly shell conglomerate, oolite or clay facies.
Tithonian and Upper Kimmeridgian.	4. _Trigonia smeei (beyschlagi)_ Bed: 20 m. thick. Yellow and grey sandstones generally with calcareous cement, usually fine-grained. Individual bands coarse to conglomeratic.	
Kimmeridgian	3. Middle Saurian Bed: 15m. thick. Red and grey, sandy, usually calcareous marl with saurian remains.	3. Partly oolite and _Nerinea_ limestone.
Upper Oxfordian	2. _Nerinea_ Bed: 25 m. thick. Only exposed at Tendaguru. Fine to medium-grained, usually grey, soft calcareous sandstone.	
	1. Lower Saurian Bed: 20 m. (+) thick. Grey and reddish, sandy, usually calcareous marl with saurian remains.	

Work done previous to the German Tendaguru Expedition is of some consequence, however, and has a bearing on the "Tendaguru controversy" in which German, British and American authors engaged during the period between the Wars.

The history of research is treated in three sections dealing respectively with the Mbemkuru River depression and adjacent areas; the Mandawa-Mahokondo area; and the Makangaga-Ruawa area.

(b) The Mbemkuru River Depression and Adjacent Areas.

The first account of the geology was given by Bornhardt (1900), whose fossil collections were described by Müller (1900), Weissermel (1900) and Potonié (1900), and on whose specimens of oolites Rothpletz (1900) commented. Bornhardt's work was accomplished on two excursions. The first took him from Lindi _via_ Mchinga to the Namgaru Valley and the Noto Plateau, returning by way of the Kikomolela Plateau to Lindi. This was entirely outside the area now under consideration. On the second excursion, Bornhardt entered the Mbemkuru area from the direction of the Noto Plateau and spent several days there before proceeding to Kiswere and thence to Kilwa (see below, p.34). Bornhardt's mapping has been largely superseded by the work of the German Tendaguru Expedition and some of the age determinations of fossils supplied to him, led to confusion. Bornhardt believed that overstepping Cenomanian was present in the _Nerinea_-bearing strata of the

Kikomolela Plateau and that the Makonde Beds (including the Newala Sandstone), which he named, were a transgressive Upper Cretaceous formation. This conception was amended by Hennig (1914a) as discussed below. Bornhardt's fossil collections, especially those from the "Tshikotsha-Bache" and from Ntandi (both of which were dated as Neocomian) are important.

Fraas (1908a,b) visited the Mbemkuru area to investigate a report of fossil bones in the vicinity of Tendaguru Hill, about six miles south-west of Mtapaia in the area recently mapped. Apart from vertebrate remains which he himself described, he made collections of invertebrates which were examined by Krenkel (1910a), particularly from Niongala, Mikadi, Tendaguru and Matapwa, all of which were at the time regarded as Lower Cretaceous. Fraas revised Bornhardt's supposition that the oolites in the Matapwa area represent the same horizon as the ? Bajocian oolites of the Ruvu River area in east-central Tanganyika. His supposition that they are Cretaceous, however, has been amended, and the strata placed in the Upper Jurassic (Hennig, 1914a, p.17). Fraas gave the sequence in the area as follows:-

	(8. Newala Sandstone
Terrestrial Upper Cretaceous	(7. Red sandy marls
	(6. Dinosaur Horizon

Marine	? Cenomanian	5. "*Nerineenkalke*" 4. Niongala Beds
	Neocomian	3. Calcareous sandstone with *Trigonia schwarzi* 2. Ntandi Beds 1. *Trigonia* Beds

This sequence was very largely revised by Hennig (1914a, p.14) and for the most part, the stratigraphical terms used are superseded. The *Trigonia* Beds are equivalent to the "*Trigonia smeei*" Bed of the Tendaguru Series, which is of Upper Jurassic age. The Ntandi Beds, the "Calcareous sandstone with *Trigonia schwarzi*" and the Niongala Beds have all been linked under the name *Trigonia schwarzi* Bed in the Lower Cretaceous part of the Tendaguru Series. The "*Nerineenkalke*" has been shown by Hennig to include two very different horizons, the Jurassic *Nerinea* Bed of the Tendaguru Series and *Nerinea*-bearing limestones of the Upper Aptian, which Müller (1900, p.571) described as Cenomanian. The Dinosaur Horizon is equivalent to one or more of the three Saurian Beds of the Tendaguru Series, which are Upper Jurassic in age. It is suggested later (p.149) that further work is likely to enable the subdivision of the *Trigonia schwarzi* Bed when revival of Fraas' terms Niongala Beds and Ntandi Beds may be convenient.

Also preceding the publication of the German Tendaguru Expedition's first major work (Branca *et al*, 1914), were papers by Dacqué and Krenkel (1909), Janensch (1912a,b), Krenkel

(1910b, 1911a), Hennig (1912a,b,c,d; 1913a,b,c), and Staff (1912a,b), all of which can be regarded as largely superseded.

Included in the first comprehensive series of publications relating to the German Tendaguru Expedition were general accounts of the work done (Branca, 1914a,b,c, Janensch, 1914a, b,c,d, Janensch and Hennig, 1914), and a discussion of the geomorphology of the area (Staff, 1914a,b).

Various fossil groups were described and, for convenience, other work relating to the fossil collections of the German Tendaguru Expedition is listed here along with the 1914 publications, though some are mentioned more specifically below:-

INVERTEBRATA

Beurlen	1933	Crustacea
Böhm & Riedel	1933	Cephalopoda
Dietrich	1914	Gastropoda
	1925a	Cephalopoda (Mahokondo area)
	1925b	Foraminifera
	1926a	Corals
	1933a	Cephalopoda, Gastropoda, Lamellibranchia
Fahrion	1937	Foraminfera
Hennig	1914b	Cephalopoda, Lamellibranchia, Gastropoda
	1916a	Lamellibranchia, Gastropoda, Brachiopoda
	1916b	Lamellibranchia, Brachiopoda, Foraminifera
	1937a	Cephalopoda, Lamellibranchia, Brachiopoda, Crustacea
Janensch	1933	Crustacea

Lange	1914	Brachiopoda, Lamellibranchia, Annelida
	1917	Lamellibranchia
Sieverts-Doreck	1939	Crinoidea (including a collection made by Professor Hennig in 1934)
Zwierzycki	1914	Cephalopoda

VERTEBRATA

Branca	1911, 1914d, 1916a,b, (Reptilia)
Dietrich	1926b, 1927b (Mammalia)
Hennig	1914c (Pisces) 1915a, b, 1916c,d,e, 1924b, 1925, 1936 (Reptilia)
Janensch	1914b, 1920, 1922, 1924, 1924/25, 1925a,b, 1926, 1929a,b,c,d, 1931, 1932, 1935a,b, 1936a,b, 1947, 1950a,b,c (all Reptilia)
Nopsca	1916 (Reptilia)
Pompeckj	1921 (Reptilia)
Stromme	1916 (Reptilia)
Virchow	1919, 1921 (Reptilia).

PLANTAE

Gothan	1927	A conifer.

Janensch (1914c) did not regard the Makonde Beds and their equivalents as part of the Tendaguru Series, but included the Makonde Beds and Kiturika Beds along with the Tendaguru Series in the Lindi Formation, a term introduced by Dacqué and Krenkel (1909). He discussed the origin of the Saurian Beds, showing that they are not entirely terrestrial, since occasional marine invertebrates are associated with skeletons of reptiles.

Hennig (1914a) in his account of the stratigraphy of the Tendaguru Beds, emphasised their essential unity, holding that there is no major break in the sequence from the Lower Saurian Bed to the Makonde/Kiturika Beds (see Table I). The re-dating of the strata implied that the three previously supposed transgression in the Jurassic, the Lower Cretaceous and the Upper Cretaceous, were not substantiated. It will be shown later that certain horizons are, in fact, strongly transgressive, though the dating of these is not as suggested by the earlier authors. The entire series was regarded as being essentially flat-lying and undisturbed, and faulting, that Bornhardt (1900) had assumed must exist, was thought to be absent. The only faulting suggested in the area was invoked to account for the occurrence of Lower Cretaceous strata in the low-lying area close to the Mbemkuru River. The "Niongala-Scholle", supposed to be due to "trap-door" faulting, is discussed later (p.168), and it is suggested that the Lower Cretaceous occurrences are susceptible to an alternative explanation.

Since the earlier publications relating to the work of the German Tendaguru Expedition, different opinions have been advanced regarding details of succession and correlation within the Tendaguru Series. Schuchert (1918) summarised (in English) the stratigraphical results of the expedition. On account of the identity of dinosaurs in the Middle and Upper Saurian Beds, he suggested that both should be assigned to the Upper Jurassic, and considered that a break in the sequence below the Trigonia schwarzi Bed was likely, and another below the Middle Saurian Bed. He thought the German work indicated that the Makonde Beds are an overlapping formation towards the south-west, and that in the Tendaguru area at least, there is probably a break in sedimentation below them. Hennig (1918) gave a general account of the area examined by the German Tendaguru Expedition, and Arldt (1919) and Reck (1924a,b) discussed its work. Staff and Hennig (1922) described aspects of the geomorphology of the region.

Dietrich (1925a, p.19) correlated with the Nerinea Bed, the oolites and calcareous sandstones near the Mandawa River (see p.35, below) and also regarded the Middle Saurian Bed as equivalent to the Septarian Marl (his "Perisphinctes - Aspidoceras - Schichten") of the Mandawa-Mahokondo area which provided a dating for the Middle Saurian Bed (Dietrich, 1925a, p.22) as Middle - Upper Kimmeridgian. The latter correlation has been shown to be in error (Spath, 1927/1933, p.820; Arkell, 1956, p.335).

Lull (1915), Mathew (1934) and Simpson (1926) discussed the reptiles of the saurian beds of the Tendaguru Series in relation to the forms occurring in North America and Simpson pointed out that the faunas of the Middle and Upper Saurian Beds are essentially identical and agreed with Buckman's suggestion (in Schuchert, 1918) that the Upper Saurian Bed cannot be other than Upper Jurassic. Simpson (1928, 1933) discussed mammalian fossil remains from the Tendaguru Beds.

Kitchin (1926, p.468) strongly criticised the age interpretations of the German Tendaguru Expedition in respect of Jurassic invertebrates determined by Hennig (1914b), Zwierzycki (1914) and Lange (1914), and upheld the previous views of Müller (1900) and Krenkel (1910a) that the Trigonia-bearing beds of the Tendaguru Series are all Neocomian (see also Part II, pp. 52-54). To account for what he considered to be anomalous associations of lamellibranchs and ammonites in the "Trigonia smeei" Bed Kitchin thought "It is evident that something has gone seriously amiss either in the collecting or the recording". He suggested that "the base of the local marine Neocomian strata rests immediately upon a bed of Middle Kimmeridgian age, at some level in the series situated just beneath the 'Upper Saurian Horizon', and that the unconformity was not detected" by the later German authors.

The terms of Kitchin's criticism evoked spirited comment from the German side (Hennig, 1927; Dietrich, 1927a). Hennig expressed complete confidence in the view that there was uninterrupted sedimentation in the Tendaguru area and Dietrich proposed the following modification in dating the various subdivisions of the Tendaguru Series:

Trigonia schwarzi Bed	Neocomian
Upper Saurian Bed	Purbeckian - Portlandian
"Trigonia smeei" Bed	Portlandian - Kimmeridgian
Middle Saurian Bed	Kimmeridgian

<u>Nerinea</u> Bed Kimmeridgian - Oxfordian

Lower Saurian Bed Callovian

[These differ slightly from Dietrich's (1925a) datings which were: "<u>Trigonia smeei</u>" Bed - Upper Kimmeridgian - Lower Tithonian; Middle Saurian Bed - Middle-Upper Kimmeridgian; <u>Nerinea</u> Bed - Lower-Middle Kimmeridgian (see also pp.26,36)]

The Dinosaurs of the Tendaguru area were mentioned by Hobley (1925) and Migeod (1927), and Parkinson (1928, 1930b) gave some account of work done by the British Museum Tendaguru Expedition of 1924-1929, but a complete description of the collections made by this Expedition is not yet available.

Kitchin (1929) answered Hennig's and Dietrich's comment in detail. He again criticised the German assumption that there is an unbroken succession, pointing out that there was no certain evidence of post-Middle Kimmeridgian Jurassic ammonite faunas. He admitted that his previous suggestion (Kitchin, 1926, p.468), that an unconformity exists between Lower Cretaceous and Kimmeridgian strata somewhere in the "<u>Trigonia smeei</u>" Bed could not be upheld on account of the evidence that the Middle and Upper Saurian Beds are very close in age, but did not agree with Simpson (1926) that the Saurian Beds are Jurassic. So convinced was he that the lamellibranch fauna of the "<u>Trigonia smeei</u>" Bed is lower Cretaceous in age by comparison with similar faunas in Cutch and South Africa, and that it is of a type that could not have survived unchanged from the Jurassic, that he was prepared to suppose that associated Jurassic ammonites must have been derived into the bed. On the same basis, he considered that part at least of the Nerinea Bed is Valanginian or Infra-Valanginian. Gregory and Barrett (1931, p.178), while stating the alternative age determinations of the Tendaguru Beds, appear to have favoured Kitchin's views. Spath (1935, pp.184-185) and Cox (1940, p.3) commented on Kitchin's insistence on the Cretaceous age of the lamellibranch faunas concerned (in their occurrence in Cutch) and showed that they are, as Kitchin himself had supposed earlier (Kitchin, 1903), of Jurassic age.

Parkinson (1929, pp.358-360, 1930a) discussed the correlation difficulties in the Jurassic part of the Tendaguru Series due to the lack of distinctive lithological features. He did not observe the Lower Saurian Bed at all. He suggested (1929) "that the Nerinea Bed is a lower and local phase only of the Smeei beds", amplifying this later (1930a, p.10) to suggest that the Nerinea Bed, the Middle and the Upper Saurian Beds are "only local estuarine intercalations in the otherwise continuous marine Smeei Beds". He believed "That in ascending from the Nerinea bed to the top of the Upper Saurian bed, estuarine conditions became increasingly prevalent until finally marine deposition ceased, or almost ceased, and that during the part of the sequence represented by the German Smeei Bed fresh or brackish water conditions alternated with local marine episodes; in fact the two co-existed in adjacent neighbourhoods. That is, the two

Saurian beds of our predecessors are one". He suggested "That a disconformity occurs above the so-called Upper Saurian Bed of an importance which palaeontologists must decide", and regarded this as the junction between Jurassic and Cretaceous. He believed that this disconformity could account for the distribution of Jurassic and Cretaceous in the area of the "Niongala-Scholle", the existence of which he doubted. He suggested that the Makonde Beds, as they are indicated by Hennig (1914a) may be, in part, the much younger Mikindani Beds (Neogene).

Spath (1925, pp.159-160) had referred the Nerinea Bed and the "Trigonia smeei" Bed to the Middle Kimmeridgian but later (Spath, 1927/1933, p.820) revised this opinion and assigned them, along with the remainder of the series up to and including the Upper Saurian Bed, to the Portlandian. He showed that the correlation of the Septarian Marl of Mahokondo with the Middle Saurian Bed by Dietrich (1925a) was unacceptable on a revision of the ammonite evidence. He observed (Spath, 1930, 1927/1933) that the Tendaguru Series does not represent an uninterrupted succession up to the Aptian, noting that there is a considerable palaeontological break below the Trigonia schwarzi Bed, this bed being Hauterivian to Aptian in age. Spath remarked (1939, p.140), that the succession within the Trigonia schwarzi Bed itself was not likely to be unbroken, though earlier (1930, p.135) he had suggested that it was uninterrupted.

Dietrich (1933a,b) discussed the stratigraphy of the Tendaguru Series and monographed the faunas (mainly lamellibranchs) of the "*Trigonia smeei*" Bed and the *Nerinea* Bed, and added some information on *Trigonia schwarzi* Bed faunas. He supported Parkinson's stratigraphical conclusions on palaeontological grounds, and proposed the following subdivision of the Tendaguru Series (excluding the Lower Saurian Bed)[1]:-

1). The fauna of the Lower Saurian Bed appears never to have been discussed in detail. The only form noted as being recorded from it, *Megalosaurus* (?) *ingens*, occurs also in the Middle and Upper Saurian Beds.

Aptian		Urgonian
Lower Aptian to Hauterivian and Upper Valanginian	*schwarzi* stage	(Sandstone with *Trigonia bornhardti* (Sandstone with *Trigonia schwarzi*
	GAP	
Lower Portlandian to Kimmeridgian and Sequanian	*smeei* stage	(Upper Dinosaur Bed (Littoral deposits with *Cyrena* and *Mytilus* (Sandstone with *Trigonia smeei* (Littoral deposits with *Cyrena* and *Mytilus* (Middle Dinosaur Bed (Littoral deposits with *Cyrena* and *Mytilus* (Sandstone with *Trigonia dietrichi*

Dietrich's work was summarised and discussed by Schuchert (1934).

Hennig (1935, p.221; 1937c, p.294) dealt with the structure of the southern coastal region of Tanganyika, and Hennig (1937b, p.518) outlined current work in the area.

Hennig (1936, 1937a), after further field work in southern Tanganyika, upheld the original (1914) lithological subdivision in all essentials, and also the view that no major gap exists between the Jurassic and Cretaceous horizons, though, from the nature of the deposits, small breaks might be expected throughout the sequence. He set out in tabular form (see Table II) the various correlations that have been made of the Tendaguru Series.

Much of the work described by Hennig (1937a) was done outside the Mbemkuru area but he gave several profiles in the Tendaguru area and elsewhere, and a block diagram of the Mbemkuru River depression. He still upheld the concept of the "Niongala-Scholle", though he modified its boundaries. Hennig (1937a, pp.108-109) showed that there is an increase in thickness eastwards of the subdivisions of the Tendaguru Beds; the Trigonia smeei Bed for example, was said to thicken from 20 m. at Tendaguru to 50 m. at Matapwa. He pointed out, however, that there is lateral transition eastwards of the Saurian Beds into their marine representatives, so that the precise limits of the "Trigonia smeei" Bed cannot be defined in the eastern areas. He touched on the role of oolites in

TABLE II. Previous correlations of the Jurassic and Lower Cretaceous in Southern Tanganyika (after Hennig, 1937a).

	Bornhardt-Müller 1901	E. Fraas-Krenkel 1908	Tendaguru-Expedition: im Felde 1909/11	Tendaguru-Expedition: Bearbeitg. 1912/14	Tendaguru-Expedition: Nachkriegszeit (Dietrich 1925)	Schuchert Mook 1916 Simpson 1926	Kitchin 1926	Kitchin 1929	Parkinson 1930	Dietrich 1933	Spath 1933/35	Hennig 1934/37	
	Ob. Kreide		Untere Kreide (Wealden)									Albium	Marin
Makonde-Sandsteine		Neokom		Urgo-Apt					z. T. Mikindani-Schichten			Ob.-Apt	Kontin.
(Kalk-Zone)										Untere-Apt		Urgo-Apt Urgo-Barr. Hauterive Ob.-Val.	Marin
Schwarzi-Bornhardti-Zone				Barrème Hauterive		Neokom	Neokom	Barrème Hauterive	Neokom	Barrème Hauterive Obere-Valendis			
Ob. Dinosaur.-Mgl.	Neokom			Valendis-Wealden / Purbeck	Wealden	Purbeck?		Valendis	mariner Malm mit Aestuar-Einlagerungen	(Unt. Portld.)	Portland	Weald. Purb.-Portld.	Kontin.
Smeei-Zone				Tithon	Tithon	Portland	Valendis			Smeei-St. =Kimmeridge		Ob. Kimm. Mitt. „	Marin
Mittl. Dinosaur.-Mgl.		„obere Kreide"		Kimmeridge	Ober. / Mittl. Unt. (Kimmeridge)	Oberes / Mittleres (Kimmeridge)	Mittleres Kimmer.					Mitt. Kimm.	Kontin.
Nerinellen-Zone				(?) Oxford	? Sequan	Unteres		Infra-Val.		(Sequan)		Sequan	Marin
Unt. Dinosaur.-Mgl.				?	?				nicht beobachtet			(? Oxford)	Kontin.

the succession, saying they were a regular occurrence in the sequence and not so restricted as previously thought. He supposed that oolite sedimentation lasted progressively longer towards the east and north, being at its maximum in the Mandawa-Mahokondo area, while elsewhere the marls of the Upper Saurian Bed were being formed contemporaneously. It is shown later that the position of the oolite in the sequence and the correlation on which Hennig based his figures of thickness, are subject to review.

Hennig (1937a, pp.112,113) observed an occurrence of a bed rich in "Trigonia smeei" above the Upper Saurian Bed in the south of the Mbemkuru Depression and near Matapwa. He considered that this species occurs in the Cretaceous as well as in the Jurassic - a contention previously made by Lange (1914, p.228) which Dietrich (1933a, pp.29,30) doubted. Hennig believed that the Jurassic - Cretaceous boundary lies within the Upper Saurian Bed. He considered that the two horizons rich in "Trigonia smeei" represent marine interdigitations in the continental sequence represented by the Middle and Upper Saurian Beds, and showed his "Vor-Smeei-Schicht" of the Mandawa area to the north, as a similar arenaceous interdigitation in the marine septarian marl sequence of that area as indicated in his correlation table reproduced in Table III.

Table III. Correlation of the Tendaguru Series according to Hennig (1937a).

Lower Aptian	*Trigonia schwarzi*
Barremian to Upper Valanginian	*Trigonia bornhardti*
Lower Valanginian or Wealden	"*Spät*-smeei-*lager*" Upper Saurian
.....(Jurassic-Cretaceous Boundary).....	....
Purbeckian	Bed
Portlandian	"*Haupt*-smeei-*lager*"
Kimmeridgian	Middle Saurian Bed (or Upper Septarian Marl) ."*Vor*-smeei-*lager*"

Both Dietrich (1933a, pp.36,78) and Hennig (1937a, pp.114, 116-117) attempted to distinguish between the strata characterised by "Trigonia" bornhardti and "Trigonia" schwarzi, but they did not agree on the order of superposition. Hennig (1937a, p.114) noted that the bornhardti Zone is not marine in its lowest parts (which leaves doubt as to how its base is defined) and he stated (1937a, p.115) that the upper limit of the stage has not been determined. The relation of strata with "T." bornhardti and "T." schwarzi is discussed elsewhere (p.148).

Arkell (1956, p.333) briefly outlined the Tendaguru controversy and gave some nomenclatural revision of ammonites figured from the Jurassic part of the Tendaguru Beds. He concluded that the "Trigonia smeei" Bed forms are Upper Kimmeridgian and the Nerinea Bed forms not much older, and thus agreed with Spath (1927/1933) that the Middle Saurian Bed could not be correlated with the Septarian Marl of Mahokondo, the fauna of which he showed is Lower Kimmeridgian. He also suggested that the name Tendaguru Beds is best restricted to the Jurassic portion of the sequence, a proposal that seems unnecessary.

(c) The Mandawa-Mahokondo Area.

As in the case of the Mbemkuru area, the first account of the geology of the Mandawa-Mahokondo area is due to Bornhardt (1900, p.276), but he did not recognise its anticlinal structure. He collected fossils from ?Bathonian-

Oxfordian, Lower Kimmeridgian and Upper Kimmeridgian strata, and presumably saw the Pindiro Shales as he recorded gypsum in the Mahokondo area. The localities dated as "Dogger" by Müller (1900, pp.515, 517) at the Mandawa River and at 1.2 km. to the north, both near the present Lindi - Kilwa road and the "Cretaceous" locality (Müller, 1900, p.546) 0.6 km. south of the river, all apparently belong to the Upper Kimmeridgian - Tithonian part of the sequence as now recognised. The first two were mentioned by Gregory (1921, pp.280,281,368) who appears to have been confused as to the dating, as between Bathonian and Callovian, in the case of the strata including pisolitic limestones exposed at the Mandawa River (his "Mandawa Beds"). These limestones were equated by Dietrich (1925a, p.19) with the Nerinea Bed of the Tendaguru Series, but Hennig (1937a, pp.109-110) regarded them as equivalent to oolites which he believed to occur at the top of and above the "Trigonia smeei" Bed of the Tendaguru Series. It is now believed that Dietrich's correlation is the more nearly correct since both sets of oolites are believed to be older than the "Trigonia smeei" Bed in its type area.

Müller (1900, pp.520,531,568) also described fossils from three localities which must lie in the inner part of the Mandawa-Mahokondo structure, at 2.2 km. and 1.5 km. west, and 0.4 km. east respectively, of the Mahokondo Stream, 25 km., 24.5 km. and 23.5 km. north-west of Kiswere. The first of these, originally ascribed to the "Upper Dogger", is apparently in the Lower Kimmeridgian Septarian Marl of the present classification. Dietrich (1925a) described these marls as the "Perisphinctes-Aspidoceras Schichten" and regarded them as of Middle - Upper Kimmeridgian age, equivalent to the Middle Saurian Bed of the Tendaguru Series. He described a large collection of ammonites from them (see p.70), and referred briefly to other fossils. Dietrich's name for the strata was superseded in Hennig's (1937a) account of the area (see below), and again amended by Aitken (1956a, p.10).

Dacqué (1910a, p.53; 1910b, p.159) referred the fauna from the locality 1.5 km. west of the Mahokondo Stream, which did not contain identifiable ammonites, to the Callovian and not the Kimmeridgian as Müller had supposed. He compared it to faunas in the Ruvu Beds in the hinterland of Dar es Salaam. The locality 0.4 km. east of the Mahokondo Stream, is also probably in pre-Kimmeridgian rocks and not Cretaceous as Müller tentatively suggested.

To the north-west of the anticline, from a locality 0.8 km. north of the Mkundi Stream, 29 km. north-west of Kiswere, Müller (1900, p.541) described as Neocomian a fauna, including *Trigonia beyschlagi* and "*T. ventricosa*". This locality, now believed to be Tithonian, has been discussed by Kitchin (1903, p.121), Lange (1914, pp.269,282), Dietrich (1933a, p.34), Hennig (1937a, p.113) and Cox (1952, p.115). It is further discussed in Part II, p. 105.

Hennig (1914a, p.40) who had not then visited the area, assumed that the Jurassic reported by Bornhardt and Müller in the area must indicate a "horst-like residual" of strata older than are represented in the Tendaguru Series. After visiting the area, Hennig (1937a) recognised the anticlinal structure (which he related to a monoclinal flexure along the eastern side of the Coastal Plateaux) and produced a sketch map of part of the anticline. He gave the following succession and correlation:-

<u>smeei</u> Oolite	= oolites at the top of and above the <u>Trigonia smeei</u> Bed of the Tendaguru Series of the Mbemkuru River depression.
<u>smeei</u> Bed ("<u>Haupt</u>-Smeei-<u>Zone</u>")	= <u>Trigonia smeei</u> Bed of the Tendaguru Series.
Transition Sandstone	
Upper Septarian Marl	= Middle Saurian Bed of the Tendaguru Series.
"<u>Vor</u>-Smeei-<u>Schicht</u>"	
Lower Septarian Marl	
<u>Nerinea</u> Bed	= <u>Nerinea</u> Bed of the Tendaguru Series.

He could not accept Spath's (1927/1933, p.820) contention that the ammonite faunas of the septarian marls are older than the Middle Saurian Bed of the Tendaguru succession.

Unfortunately, there is some confusion between Hennig's sketch map and the text of his paper as regards the position of the Transition Sandstone. The former indicates it between the Upper Septarian Marl and the "Haupt-Smeei-Zone" and the latter between this and the "smeei" Oolite. Some confusion has also arisen (see below pp. 52/71) between fossil localities indicated in the sketch map and cited in the text. Recent mapping in the area and the study of fossil faunas obtained, especially in the lower part of the sequence, have shown that Hennig's conception of the succession and the correlation of its component parts with members of the Tendaguru Series, requires modification.

Arkell (1956, p.331) outlined the sequence in the area, basing his account mainly on reports of field-work by the present author[1)] and on a study of ammonite fossil collections made during this field-work. These determinations are given later (pp. 61/63, 70).

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1) As stated above, this account supersedes an earlier paper (Aitken, 1956a) on the Mandawa-Mahokondo area. Arkell (1956, p.331) cited this as the source of a quotation of the sequence in the area, which it is not. It is believed that the quotation is from an unpublished report by Dr. P.E. Kent of the BP-Shell Petroleum Development Co., Ltd.

(d) The Makangaga - Ruawa Area.

Hennig (1914a, p.50) gave the first account of the "Pindiroschiefer", now termed the Pindiro Shales, which occupy a large part of the Makangaga-Ruawa area. He described the occurrence as "reaching up into the base of" the Tendaguru

Beds, which he believed to be undisturbed, and considered that the "Trigonia smeei" Bed was the first member of the younger series to transgress discordantly across the steeply inclined Pindiro Shales. He was not able to accept a local disturbance of Mesozoic strata as accounting for this appearance of highly disturbed beds and concluded they were of Palaeozoic age. Also mentioned by Hennig (1914a, p.24) was the occurrence of the Trigonia schwarzi Bed in the Runjo area at the south-east of the Ngarama Plateau, the exact locality of which is not known. Hennig encountered the Runjo occurrence while traversing the western side of the Ngarama Pleateau to determine if pre-Kimmeridgian strata, such as Bornhardt (1900) had recorded in the Mandawa-Mahokondo area, outcropped there. He did not observe such strata but it is now believed that they do in fact occur in the Ruawa area, and also that the gypsum-bearing strata recorded by Bornhardt near Mahokondo are the equivalents of the ?Bajocian Pindiro Shales. Hennig also mapped the Trigonia schwarzi Bed at the southern end of the Itukuru area and the "Trigonia smeei" Bed in the Pindiro-Kihimbwi Valley.

Hennig (1916a, pp.181-200) gave a further account of the geology of the Pindiro Valley with some description of rock types encountered. He mentioned occurrences of gypsum in the Pindiro Shales and described fossils supposedly derived from them, which would indicate their age as "Dogger" - Middle Jurassic, possibly including Callovian. The locality from which most of the fossils came is not now believed to be in the shale sequence, but (see below pp.65,66) in beds correlated with parts of the fossiliferous Bathonian-Oxfordian strata in the Mandawa-Mahokondo area.

Krenkel (1925, p.295), apparently having overlooked Hennig's (1916a) dating of the Pindiro Shales, suggested they might be correlated with the "Kinga System" (Younger Algonkian).

Hennig (1937a) further discussed the geology of the Pindiro-Kihimbwi Valley and gave a sketch map and two sections relevant to it (his figures 1, 6 and 18). As regards the faulting present and the attitude of the beds, the map and sections are difficult to correlate. Hennig made particular reference to the Pindiro Shales, of which he described the stratigraphy and palaeontology. His account is examined in some detail below (pp.42 et seq.).

STRATIGRAPHY

General

The oldest unmetamorphosed rocks exposed in the Southern Kilwa and Northern Lindi Districts are the ?Bajocian Pindiro Shales. All stages of the Jurassic above this are represented, together with Lower and Upper Cretaceous strata, and in the east, Paleogene rocks.

The older part of the Jurassic succession crops out only in the cores of the Mandawa-Mahokondo and the Makangaga-Ruawa anticlines. It is best developed in the former and this is the type area of the Mandawa-Mahokondo Series (Quennell, McKinlay & Aitken, 1956) which includes Bajocian to Lower Kimmeridgian strata. The overlying Tendaguru Beds (Hennig, 1914a) are more widespread, occupying the remainder of the lower ground, except in the east, and exposed by erosion of the sediments forming the plateau areas. The plateau-forming sediments are the Kiturika Beds (Upper Aptian) and the Makonde Beds, which have been claimed as their continential equivalents, with a capping of unconsolidated sands probably derived largely from the latter.

Marine Upper Aptian strata form the base of a series of overstepping Cretaceous horizons in which (*fide* R. Stoneley of the BP-Shell Petroleum Development Company, Ltd.) Aptian, Albian, Vraconian, Cenomanian, Turonian and Senonian representatives have been recognised. The Cretaceous is overlain by Paleocene strata within the area shown on the map; and apart from the sands capping the plateaux there are Neogene sands and gravels at lower levels.

A summary account of the geology of the Mandawa-Mahokondo area has already been given (Aitken, 1954; 1956a, 1956b) and of the Makangaga-Ruawa area (Aitken, 1958). The relation of the Cretaceous to the Jurassic in the area has been discussed by Aitken (1956c). The present account, however, is complete in itself and refers to the others only where modification of views previously expressed has been necessary.

Reference should be made to Plates II, V-VIII in following this account.

THE MANDAWA-MAHOKONDO SERIES.

Table IV includes an outline of the sequence exposed in the type area of the Mandawa-Mahokondo Series. The thicknesses are estimated from exposures on the eastern flank of the Mandawa-Mahokondo anticline, for the most part in the Mkomore Stream. Table V outlines the corresponding sequence as exposed in the northern part of the Makangaga-Ruawa structure. There are minor amendments in the thicknesses of strata estimated to those previously given.

?Bajocian (Pindiro Shales).

The lowermost unit included in the series was first described from the Makangaga-Ruawa area (Hennig, 1914a, p.50).

TABLE IV.—STRATIGRAPHICAL SEQUENCE IN THE MANDAWA-MAHOKONDO AREA

System	Stage	Lithology	
CRETACEOUS	ALBIAN - SENONIAN	Green marls with fine, brown-weathering sandstone bands especially near the base.	
CRETACEOUS	UPPER APTIAN	Massive, white, reefal limestones and calc-arenites. Grey-green marl at base (near Nalwehe) [Western area]	Grey-green marls, calcareous silts and fine or medium-grained sandstones. Thin intercalations of sandstone and sandy limestone with <u>Orbitolina</u>. Calc-arenites in upper part of sequence. [Eastern area]
		UNCONFORMITY	
CRETACEOUS	NEOCOMIAN TO LOWER APTIAN	Grey, medium-grained sandstones. Gritty, calcareous sandstones (pebbly in places). Fine, buff sandstones.	
		White, reefal limestone with intercalated sandstones. [Western area]	White, coralliferous limestone [Eastern area]
		? UNCONFORMITY	
JURASSIC	UPPER KIMMERIDGIAN TO LOWER TITHONIAN	Fine, silty, yellowish and buff sandstones with resistant, grey, calcareous grits and gritty sandstones sometimes pebbly.	
		White and grey-white, oolitic limestones with variable sand and grit content, associated with white, sandy limestones and calcareous sandstones. Interbedded, fine, silty, yellowish or buff sandstones.	
JURASSIC	MIDDLE TO UPPER KIMMERIDGIAN	Fine, soft, buff, somewhat calcareous sandstones with resistant bands of grey, sandy limestone and calcareous sandstone, especially in the upper part.	
JURASSIC	LOWER KIMMERIDGIAN	Grey and buff marls with thin intercalations of fine, yellowish marly sandstones. Septaria locally abundant.	
JURASSIC	CALLOVIAN TO OXFORDIAN	Fine or medium-grained, green, brown or buff, calcareous sandstones (partly de-calcified) with hard ribs of grey, sandy limestone and fine, calcareous sandstone (highly fossiliferous in part).	
JURASSIC	BATHONIAN TO CALLOVIAN	White, oolitic, sandy limestones interbedded with medium-grained or coarse, white, calcareous sandstones and sandy limestones, and soft, fine-grained, buff sandstones.	
		Grey and greenish, hard, fine calcareous sandstones and sandy limestones with bands rich in <u>Nerinella</u>. Interbedded fine and medium-grained, soft, greenish and buff sandstones. (Sandstone bands with botryoidal weathering surfaces common).	
JURASSIC	? BATHONIAN	Grey and greenish grits and sandstones (occasionally garnetiferous). Friable, whitish sandstones and pebbly grits. Fine, buff and green, soft sandstones. Reddish and green marl. Calcareous grit with limestone pebbles and cobbles (mainly at base).	
		? UNCONFORMITY	
JURASSIC	? BAJOCIAN	Grey or buff, calcareous shales and silts, occasionally fossiliferous. Calcareous nodules derived from shales contain small fossil molluscs in places. Interbedded platy limestone bands. Thin ironstone bands. Massive gypsum and halite (the latter not exposed).	

TABLE V.—STRATIGRAPHICAL SEQUENCE IN THE MAKANGAGA-RUAWA AREA

System	Stage	Lithology	
CRETACEOUS	UNDATED (? UPPER APTIAN) AND UPPER APTIAN	? Upper Aptian: Brick-red to purplish, medium-grained sandstones and purple mudstones. (Makonde Beds) ⁄⁻Western area⁄	Upper Aptian: White reefal limestones. (Kiturika Beds) ⁄⁻Eastern area⁄
	HAUTERIVIAN TO LOWER APTIAN	Coarse, white calcareous sandstone; sandy, gastropod limestone; fine, hard, whitish and buff, calcareous sandstones and marly sandstones. Fine to medium-grained, buff, calcareous sandstone, sometimes pebbly. ⁄⁻Western area⁄	Conglomerate and sandstone. ⁄⁻Eastern area⁄
		(*Trigonia schwarzi* Bed)	
	UNCONFORMITY		
JURASSIC	UPPER KIMMERIDGIAN TO TITHONIAN	Whitish, oolitic, often sandy limestones; grey-white, calcareous, sometimes pebbly grits and sandstones; fine and medium-grained, soft weathering, buff sandstones. (Top not exposed).	
	MIDDLE - UPPER KIMMERIDGIAN	Grey-buff, soft, marly sandstones with bands of fossiliferous, concretionary limestone; medium-grained, whitish, calcareous sandstone; thin, grey, sandy limestones.	
	UNCONFORMITY		
	? MIDDLE KIMMERIDGIAN	Purple marl with occasional concretionary limestone bands and concretions.	
		Fine, whitish and buff, friable sandstones and harder, medium and coarse-grained, whitish sandstones.	
	? LOWER KIMMERIDGIAN	Grey marl, with calcareous concretions.	
	? BATHONIAN TO OXFORDIAN	Fine, soft, buff, marly sandstones; whitish medium-grained, hard sandstones; grey, sandy limestones; grey-green, lumachelle limestone. ? *Nerinella*-bearing sandstone.	
	? BATHONIAN	Purple marl; Conglomerate (position in doubt)	South Ru Fa
	? BAJOCIAN	Fine, greyish-buff, calcareous sandstone; brown, pisolitic limestone and white and pink, porcellanous limestone.	
		Brownish, calcareous, sandy shales; fine, calcareous, brownish sandstones and sandy limestones; finely banded, sometimes shaly limestone; massive gypsum and halite (the latter not exposed). (Pindiro Shales)	

Here, the Pindiro Shales occupy most of the valley-floor between the Ngarama and Mbalawala plateaux to the south of the Matarawe Stream, as far as Tunduru Village, near the confluence of the Pindiro and Kihimbwi Streams. In the Mandawa-Mahokondo anticline there are two distinct culminations, and the Pindiro Shales crop out only at the northern and southern ends of the core of the structure.

The application of the term Pindiro Shales has been restricted as compared with Hennig's usage. The strata north of the Matarawe Stream in the Ruawa area from which Hennig (1916a) appears to have collected many of the fossils on which he based his dating of the Pindiro Shales, are correlated with beds much higher in the sequence in the Mandawa-Mahokondo area.

Hennig (1937a) described the Pindiro Shales as sandy shales with intercalated sandstones, limestone bands, layers of limestone nodules, and gypsum. Some of the limestones to which he refers may be in strata overlying the shale sequence proper, but there are thin, ferruginous, argillaceous limestones (occasionally fossiliferous) in the sequence, and in the Mkomore Stream section, apparently near the top of the succession there are thin bands of whitish, argillaceous limestone. To Hennig's account it may be added that the shales are invariably ferruginous and highly calcareous and that some of the material that has the appearance of shale is, in fact, finely laminated, slightly ferruginous limestone (of which one sample contained as little as 2.8% of insolubles). Occasionally the shales and fine sandstones in the type area contain small flakes of graphite, suggesting short transport from the area of origin of the sediment. Light-coloured, silicified, oolitic limestones occur as boulders in the Itukuri and Luero areas, associated with the shale sequence. Such rock has not been seen in place. Associated with shaly sandstones of the shale sequence to the north of Luero Village on the Ruawe path, is a very coarse, whitish, friable, pebbly calcareous grit with fresh felspar pebbles and small, rotted, gneiss pebbles. This is a very similar rock to that common in the ?Bathonian subdivision of the Mandawa-Mahokondo Series exposed in the Mkomore Stream section, but is apparently older. An outcrop of similar rock has been observed in the southern culmination of the Mandawa-Mahokondo anticline, in the outcrop area of the Pindiro Shales there, and probably also belongs to the Pindiro Shales sequence, as do greenish calcareous pebbly sandstones close by. Especially in the southern culmination too, thin clay-ironstone bands occur. Rather common are cobbles of a rock formed of an irregular network of veins of calcium carbonate (about 1/16 - 1/8 inch spacing) infilled with brown, ochreous material. On a rather different scale, a more regular box-work of veins at ½ - 1 inch spacings sometimes occur in ferruginous silty limestones, in which solution has left the cavities partly filled with similar ochreous material. Darkcoloured calcareous concretions and narrow, concretionary ferruginous limestone bands (distinct from the fissile limestones) sometimes occur; in the Mandawa-Mahokondo area these have yielded small molluscan fossils.

In both culminations of the Mandawa-Mahokondo anticline and at several localities in the Makangaga-Ruawa area, massive gypsum is exposed. In the type area of the Pindiro Shales, Hennig (1916a, p.185) reported gypsum just east of Bwatabwata Village and later (Hennig, 1937a, p.103), to the east of the Kihimbwi-Ruawa confluence. The gypsum in this area outcrops in the low escarpment overlooking the Kihimbwi Stream between Pindiro Village and Lake Mbuo. Although gypsum outcrops at much the same level at numerous places on the escarpment, it is clear that several distinct bands are present. The beds are highly disturbed and deformed; at the northern end of the outcrop they are in a near-vertical attitude. Gypsum has also been observed near Luere Village, to the west of Ruawa on the path to Mikarawanje, and in the Mikarawanje Village area. Hennig (1916a, p.186) mentioned a further occurrence below the scarp forming the western side of the Minyoka area, but did not observe the shale sequence itself. Hennig (1937a) did not mention this occurrence, and it has not been observed since. In the northern culmination of the Mandawa-Mahokondo anticline there are a number of small exposures in the Mkomore Village area and further to the south.

Recent drilling by the BP-Shell Petroleum Development Co.Ltd., into the Pindiro Shales has penetrated a thick evaporite series (anhydrite/gypsum/halite) with shale intercalations. A similar situation occurs in the Makangaga-Ruawa area. In the southern culmination of the Mandawa-Mahokondo structure in the Mbaru Stream, the outcrop of numerous bands of gypsum separated by shale, extends for over 300 feet along the valley sides, dipping 55° - 65° at ± 15° from due east, except at one point where reversal occurs probably due to drag folding. Gypsum also occurs, poorly exposed, upstream, and some hundreds of yards to the west a sink-hole has formed in it. The total thickness of exposed gypsum-bearing strata in this section must exceed 200 feet.

The gypsum occurs as a massive, grey-white material that has formed as an evaporite. It varies from nearly pure gypsum (one sample analysed 97.8% gypsum, though most ranged between 80% and 90%) to a rock with considerable contorted inter-lamination of silt or fine sand. Occasionally it shows distinct interbanded layers of shale or fine sandstone up to about ½-inch thickness, and such material may appear as disoriented fragments within the rock. The appearance of contortion and the breaking-up of intercalated shale bands that occurs within individual beds of gypsum is presumably due to expansion on conversion of original anhydrite to gypsum, or to "flow" of the evaporite.

The relation between the gypsum exposed at surface and the anhydrite encountered at depth in boreholes is not clear. However, since no gypsum has been noted in such cores as have been taken (most of the drilling was non-coring) and all samples taken at surface have been gypsum, it may be suspected that conversion of anhydrite to gypsum has taken place near surface.

The Pindiro Shales are the most highly disturbed of the strata in the area. High dips, rapid dip reversals and minor puckering occur, so that both in strata immediately associated with gypsum and above, estimation of the thickness from surface data is not practicable. In the Mkomoro Stream section there is evidence of unconformity above the shale sequence and a varying thickness must therefore occur.

It is not now believed that all the fossils described from the Pindiro Shales by Hennig (1916a, 1937a) came from strata that can be included in the shale sequence, and the application of the term "Pindiro Shales" has been amended (see above, p.43).

Hennig (1937a, p.104) described as definitely from the shale sequence, a bed consisting almost entirely of closely packed shells of a small Astarte, likening them to the volsi-pumila-minima-pulla-parkinsoni-fimbiata group which he considered to be not clearly separable.

From the shale sequence half a mile east of Bwatabwata Village (Loc. WA.2273) a brownish-yellow, argillaceous limestone yielded (Dr. L.R. Cox *in litt.* to W.G. Aitken, 8 Nov. 1955) *Protocardia* sp., ?*Gervillia* sp., a Cyprinid and *Promathildia* sp.. From three quarters of a mile west of Ruawa Village on the path to Mikarawanje (Loc. WA.2275), a thin streak of sandy, shelly limestone in a specimen of fissile yellow-brown, calcareous, sandy shale yielded to Dr. Cox, shell fragments including *Gervillia* sp. or *Pteria* sp..

Hennig (1916a, p.192) described fossils from a blackish limestone nodule from a locality north of the Matarawe Stream and hence, apparently, not in the Pindiro Shales as now understood. However, he later described (Hennig, 1937a, p.155) "dark to blackish limestones, previously mentioned as host-rock to some fossils" in a section just above gypsum, and thus apparently in the shale sequence. Though not noted in the Makangaga-Ruawa area, dark nodular limestones and calcareous nodules with fossils (including, *fide* Dr. L.R. Cox, cf. *Procerithium*, *Gervillia* sp. and Astartids) have been collected from the Pindiro Shales in the Mandawa-Mahokondo anticline (Loc. WA.2349). This type of occurrence is probably similar to that recorded by Hennig in the type area of the Pindiro Shales. A fauna of thin-shelled lamellibranchs, usually crushed, in which small Astartids are prominent has been found in a greenish-brown, shaly clay underlying the topmost exposed bed of gypsum in the Mbaru Stream.

The localities of the other fossils named by Hennig (1937a) from the Pindiro Shales are not stated and may not have come from the shale sequence itself. The fossils recorded, however, are Astarte sp., Ceratomya concentrica, Gervillia cf. aviculoides; Cryptaulax armatum, C.echinatum and Pseudocerithium undulatum. Of these, Ceratomya concentrica is common in the Callovian of the Mandawa-Mahokondo area and Cryptaulax armatum was previously described by Hennig (1916a) from the strata now believed to be Callovian.

Hennig regarded the Pindiro Shales as "Dogger", i.e. Middle Jurassic possibly including Callovian. The fossils determined by Dr. L.R. Cox were not sufficient to give a more precise dating. There is evidence to suggest that the oldest beds overlying the shale sequence proper - the Pindiro Shales in their amended connotation - are Bajocian. This therefore is the youngest dating possible for the shale sequence and part of it at least may be older.

?Bajocian (Post-Pindiro Shales).

The Pindiro Shales are overlain by strata of different ages at different places. The oldest of these are also tentatively ascribed to the Bajocian. They lie to the south of the Matarawe Stream west of its confluence with the Ruawa, in the Makangaga-Ruawa area. On the air photographs they are seen to form two linear features parallel to the strong ridges of the Kimmeridgian-Tithonian oolite sequence. Palaeontological dating is on scanty evidence. Immediately to the east of the Pindiro Shale outcrop on the Ruawa-

Mikarawanje path, on the westerly of the two linear features, fine greyish calcareous sandstone occurs from which a specimen of Myophorella (Orthotrigonia) sp. nov. closely related to M. (Orthotrigonia) duplicata (Sowerby) was obtained (Loc. WA.2274). The dating is on the basis of this specimen (see Part II, pp.130-134). Other, mainly fragmental, belemnite, lamellibranch, gastropod, brachiopod and echinoid fossils from here (Loc. WA.2545) have not been determined. Overlying this sandstone on the back-slope of the same feature, a thin limestone occurs. In the boulder spread of limestone, brownish pisolitic rock and white and pinkish porcellanous types are found.

?Bathonian.

Strata that can be assigned with some confidence to the Bathonian, outcrop in the Mandawa-Mahokondo anticline, and there are possible equivalents in the Makangaga-Ruawa area. In the northern culmination of the Mandawa-Mahokondo structure is a heterogeneous sequence of almost unfossiliferous strata, exceeding 500 feet in thickness, overlying the Pindiro Shales. It is best exposed in the Mkomore Stream and extends to the Namakumbira area, but has not been definitely recognised further south. Its base is taken at a distinctive conglomerate band of which about five feet is exposed, but soft-weathering, grey-buff, rather fine sandstones occurring above and immediately below the conglomerate are much alike. The matrix of this conglomerate is a calcareous grit and it contains rounded masses of porcellanous, sometimes oolitic, white, pink, brownish and grey limestone. The masses of limestone, which is the dominant rock type, vary from pebble to small-boulder size. Pebbles, generally angular, of quartz and felspar up to about 1¼ inch across also occur, and there are occasional fragments of brownish calcareous shale apparently derived from erosion of the Pindiro Shales, and of rotted metamorphic rocks. What is presumably the same band gives rise to a spread of boulders in the northern part of the Mkomore cultivated area. The presence of limestone pebbles and cobbles in calcareous grits has been noted at a number of levels in the Bathonian sequence. Their origin is uncertain; possibly they are derived from the thin limestone bands near the top of the Pindiro Shales (see p.43). Otherwise, the only limestone of similar appearance known in the southern Kilwa District is that described as ?Bajocian near Ruawa. Possibly a limestone series, of which this forms part, was subject to erosion during the deposition of the ?Bathonian sequence exposed in the Mkomore section.

The lower part of the ?Bathonian sequence in the Mkomore Stream is not well exposed, and due to irregularity of dip, and probably faulting, it is not readily decipherable. Two main rock types occur, which presumably alternate. There are exposures of fine and medium grained, buff and dark greenish buff, micaceous, calcareous sandstones, sometimes with harder, more calcareous ribs. The sandstones are often finely current bedded. The other main rock exposed is coarse, often friable, whitish pebbly grit, often with cobbles of gneiss and porcellanous limestone occurring irregularly in it. Not seen exposed, but occurring as occasional small loose masses, is marly reddish sandstone.

The upper part of the ?Bathonian sequence in the Mkomore Stream is better exposed and the dip is fairly constant. The apparently unbroken sequence probably totals over 500 feet. The same two main elements occur as in the section upstream, but the whitish grit members are often finer grained. An horizon of reddish, greenish and mottled marl occurs about the middle of the regularly dipping sequence. About 25 feet is exposed but the total thickness presumably much exceeds this as loose boulders of similar material occur in an unexposed part of the stream section upstream.

The upper limit of the ?Bathonian sequence is arbitrarily fixed above a thick band (over 20 feet in thickness) of strongly cross-bedded, grey-green, medium-grained, calcareous sandstone with a two-foot band of highly garnetiferous sandstone at the base. The strata immediately above and below this - grey-green, medium-grained, calcareous sandstones- are not dissimilar, but those above are usually finer-grained. Close below the strong sandstone band are occasional thin streaks of oolite in the sandstones, and the uppermost of several bands of whitish, calcareous grit (about two feet in thickness) containing white limestone pebbles, is not far beneath it. The bands of _Nerinea_-rich sandstones and sandy limestones that are a feature of the succession close above the strong sandstone band, do not occur below it. A pronounced topographical feature, visible on the air photographs, crosses the Mkomore Stream at about this junction and can be traced for some distance to north and south. The extent of the ?Bathonian sequence in the Namakumbira Stream is much less than in the Mkomore section, and air-photograph interpretation suggests that it may be over-stepped by the overlying ?Bathonian-Oxfordian sequence.

On the western flank of the northern culmination of the anticline, the ?Bathonian has been faulted out.

In the southern culmination of the Mandawa-Mahokondo anticline and in the Makangaga-Ruawa structure, the ?Bathonian subdivision has not been definitely identified. Occurrences of coarse, pebbly grits in each of these areas have been mentioned above, but are apparently associated with the Pindiro Shales. Immediately east of the post-Pindiro Shale ?Bajocian outcrop, in the Ruawa area there occurs a surface spread of large pebbles of broken vein quartz and cobbles of pegmatite. It is not clear whether these are derived from a conglomeratic rock such as is known in the ?Bathonian in the Mkomore section, or if they represent a surface gravel. Also in this area, lying between the ?Bajocian marine strata and the Middle-Upper Kimmeridgian outcrop, is a purple marl that might belong to the ?Bathonian succession. Alternatively, it could be correlated with a ?Middle Kimmeridgian purple marl unit (see p.73) that outcrops to the north of the Matarawe Stream. A pre-Middle Kimmeridgian dating of the marl has been assumed, however, though it is not necessarily Bathonian.

Hennig (1937a, p.144) mentioned the occurrence of large boulders of gneiss in the Tunduru Village area, which he suggested were derived from Oxfordian gravels overwhelmed by the Kimmeridgian transgression over the Pindiro Shales. The gneiss boulders were not observed during recent work, but it is suggested elsewhere (p. 66) that post-Pindiro Shale strata older than Kimmeridgian are present near Tunduru Village and derivation of the boulders from the ?Bathonian conglomeratic grit sequence is an alternative possibility.

Neither of these possible representatives of the ?Bathonian sequence are indicated as such on the map, though the former lies in an area described as ?Bajocian-Oxfordian.

?Upper Bathonian-Oxfordian.

In the type area of the Mandawa-Mahokondo Series the ?Upper Bathonian-Oxfordian sequence is divisible into three units. These have not been individually dated except for the topmost, in which ammonites of Middle or Upper Callovian and Upper Oxfordian age occur. The lowest may reach down into the Bathonian. All three lithological subdivisions can be recognised at numerous points along the whole length of the ridge forming the core of the Mandawa-Mahokondo anticline. The sequence includes resistant strata and forms country of quite marked relief. Mapping has not been sufficiently detailed to enable the boundaries between the subdivisions to be traced, more especially in view of the faulting that has affected them, but the sequence at the northern end of the structure is clear and apparently unbroken. Thicknesses given in Table IV were obtained from the section in the Mkomore Stream and the adjacent part of the Manyuli Stream (see Plate V), and are slightly higher than those previously estimated (Aitken, 1956a; Quennell, McKinlay and Aitken, 1956) in this area.

Throughout the sequence, fine to medium grained, buff and greenish, soft weathering, calcareous sandstones occur. It is the intercalated, generally harder strata that allow the subdivision of the sequence.

In the lowermost subdivision, hard, grey and greenish, fine, calcareous sandstones and sandy limestones are intercalated and form a considerable, almost uninterrupted sequence in the lower part. These hard bands are often fossiliferous, with generally small, thin-shelled, fragmentary lamellibranchs; the only ammonite found has been an unidentifiable Perisphinctid. Very prominent are bands made up largely of specimens of Nerinella, which presumably gave rise to Hennig's error in correlation of beds in the core of the structure with the Nerinea Bed of the Tendaguru Series. A characteristic of the subdivision is the "botryoidal" weathering surfaces frequently present on the bands of hard, fine, calcareous sandstones. This is very prominent in the Nchia Stream section. The thickness of the subdivision is estimated as about 380 feet in the Mkomore Stream. No complete and apparently undisturbed section has been observed elsewhere. That in the Nchia Stream is faulted.

In the middle subdivision most of the harder members of the sequence are white, oolitic, sandy limestones and medium or coarse-grained, white, very calcareous, sometimes shelly sandstones or whitish sandy limestones. The sequence is not very fossiliferous except in occasional bands of white, calcareous, sandstone with much fragmentary, molluscan shell material and a few complete shells. These have not been examined in detail. In the lower part of the subdivision in buff, calcareous sandstone, both in the Manyuli and Mkomore sections, large shells of Astarte sp. have been noted (Locs. WA. 2068, 2209) and a specimen of Myophorella (Orthotrigonia) sp. nov. aff. duplicata Sowerby (Loc. WA. 2244 - see Part II, p.130). No ammonites have been found. The age cannot be directly established but the beds lie not far below Middle or Upper Callovian strata and a Lower Callovian age is suggested. The thickness of the subdivision is estimated as about 180 feet.

The uppermost subdivision is not unlike the lowermost, but there are fewer hard intercalations; these do not usually have "botryoidal" weathering surfaces, the Nerinella-rich bands are absent and there are numerous highly fossiliferous beds present, usually of greenish, sandy limestone. At the base of this subdivision in the Nchia Stream is a strong band of dense, hard, medium-grained, green, water-bearing sandstone exceeding 30 feet in thickness. A similar rock is seen in what may be the same position in the sequence in the Lonji Stream and at the Namakumbira Stream crossing of the Ndolera-Lonji path, but has not been recognised in the Mkomore-Manyuli section. The distinction from the overlying Septarian Marl is sharp by reason of the topographic expression and the soils to which the two groups give rise. The thickness of the subdivision is estimated as about 370 feet in the Manyuli Stream.

It was probably in this subdivision that Bornhardt (1900, p.279) collected the specimens described by Müller (1900, p.531) as Kimmeridgian (Callovian according to Dacqué, 1910a, p.53) from "1.5 km. west of the Mahokondo Stream". Müller's (1900, p.563) locality 0.4 km. east of the Mahokondo Stream is presumably also in this subdivision. Hennig's (1937a) "Vor-Smeei-Schicht" also appears to correspond to it.

The subdivision includes many richly fossiliferous horizons. Dr. W.J. Arkell has examined the ammonite collection, but for the most part, other material is as yet undetermined. Arkell (1956, p.333) listed determinations of specimens collected during the earlier part of the survey by the present author, whose lists of fossils from this part of the Mandawa-Mahokondo Series (Quennell, McKinlay and Aitken, 1956) include further determinations by Dr. Arkell. These lists are appended, with locality numbers shown for specifically determined specimens collected during the recent survey (see Appendix I and Plate III).

Müller (1900) reported the following:-

BRACHIOPODA.

Rhynchonella lacunosa

R. subnobilis (= Somalirhynchia africana: see Weir, 1929)

LAMELLIBRANCHIA.

Astarte sp. (= A. mülleri: see Dacqué, 1910a)

Ceromya aequatorialis (= Ceratomya telluris: see Cox, 1935)

Cucullaea lasti (? = Grammatodon (Indogrammatodon) virgatus: see Cox, 1940)

Cucullaea texta

Exogyra bruntrutana (= E. nana: see Weir, 1930 and Cox, 1940)

Goniomya cf. trapezina

Isocardia sp.	) All included in his new species
	) Isocardia substriata by Hennig
Isocardia striata	) (1924a), but Weir (1929, p.33)
	) considered that more than one
Isocardia subtenera	) species is covered by this name
	) according to the synonymy Hennig
	) gives, and suggested that the
	)"Isocardia" striata of Müller

(which Weir assigned to the genus Ceromyopsis) required a new specific name. Cox (1935, p.189) also agreed that this form had been mis-identified.

Machomya n. sp.

Ostrea pulligera (= Alectryonia pulligera: see Hennig, 1937a)

Pinna sp. cf. constantini

Pleuromya tellina

Venus sp.

SCAPHOPODA

Dentalium cf. entaloides

GASTROPODA

Natica suprajurensis

Nerinea credneri (= Nerinella credneri: see Dietrich, 1914 and Hennig, 1924a: = Nerinella muelleri: see Cox, 1954)

Pterocera cf. oceani

Straparollus suprajurensis

From the "Vor-smeei-Schicht" of Hennig (1937a), supposed to represent part of the Callovian-Oxfordian portion of the sequence, Hennig recorded the following:[1]

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1) This list takes into account discrepancies between Hennig's fossil lists, his locality map and his palaeontological descriptions, where it seems certain that the fossils concerned are from the Callovian-Oxfordian strata.

LAMELLIBRANCHIA

Alectryonia aff. pulligera (= Ostrea pulligera of Müller, 1900)

Arcomya robustissima

Astarte

Homomya

Modiola aff. cuneata (or tulipa)

Pecten

P. (Camptonectes) aff. lens

Pinna lanceolata (or constantini)

Trigonia

Velata aff. inaequivalvis

BRACHIOPODA

Rhynchonella sp.

R. inconstans

R. aff. astieriana

R. sparsicosta

MISCELLANEOUS

Pleurotomaria

Serpula

Belemnites

Epismilia n. sp.

The ammonites in the recent collections determined by Dr. W.J. Arkell, which are either directly dated or occur in association with datable forms are as follows:-

Upper Oxfordian (plicatilis Zone)

Perisphinctes (Arisphinctes) maximus (Young & Bird) [tending somewhat to P. (Arisphinctes) cotovui Simionescu]: Loc. WA.1818.

P. (Arisphinctes) orientalis Siemiradzki: Locs. WA.2159, 2298.

P. (Arisphinctes) orientalis Siemiradzki [tending towards P. (Arisphinctes) aff. maximus (Young & Bird)] Loc. WA. 2159.

P. (Arisphinctes) cf. ingens (Young & Bird): Loc. WA.2159.

P. (Dichotomosphinctes) antecedens Salfeld: Loc. WA.2159.

P. (Dichotomosphinctes) wartae Bukowski: Loc. WA.2159.

P. (Dichotomosphinctes) cf. dobrogensis Simionescu: Loc. WA.2159.

P. (Dichotomosphinctes) cf. buckmani Arkell: Loc. WA.2159.

Euaspidoceras depressum (Futterer): Loc. WA.2159.

Mayaitid sp. indet [Epimayaites cf. subtumidus (Waagen) or possibly a Paryphoceras]: Loc. WA.2159.

Middle and Upper Callovian

Phylloceras kudernatschi (Hauer): Loc. WA.2245.

Calliphylloceras demidoffi (Rousseau) [= disputabile Zittel ?] Locs. WA.835, 1813, 2161, 2204, 2259, 2302, 2303, ?2309.

Holcophylloceras zignodianum (d'Orbigny) [? = mediterraneum Neumayr]: Locs. WA.2019, 2161.

Ptychophylloceras euphyllum (Neumayr): Locs. WA.1005, 1186, 1591, 2204, 2226, ?828.

Lytoceras adeloides Kudernatsch: Loc. WA.835.

Hecticoceras (Sublunuloceras) dynastes (Waagen): Loc. WA.2219.

H. (Sublunuloceras) paulowi de Tsytovitch: Loc. WA.1186.

Sindeites sp.: Loc. WA.1004.

? Subkossmatia discoides Spath: Loc. WA.1226.

Indosphinctes pseudopatina (Parona & Bonarelli):
Loc. WA.1005.

Indosphinctes cf. indicus (Siemiradzki): Loc. WA.835.

Choffatia aff. difficilis (Buckman): Locs. WA.1195,
1218, 2019.

Choffatia aff. balinensis (Neumayr): Loc. WA.1634.

Grossouvria cf. gracilis (Siemiradzki): Loc. WA.2016.

Grossouvria spp. indet. : Locs. WA.1346, 1634, 2226, ?1004.

Poculisphinctes aff. poculum (Leckenby): Locs. WA.2303,
?1004.

Obtusicostites cf. ushas Spath or buckmani Spath:
Loc. WA.1004.

Kinkeliniceras subwaageni Spath: Loc. WA.832.

K. discoideum Spath: Locs. WA.835, 1183, 2019.

Kinkeliniceras or Obtusicostites sp. juv.: Loc. WA.2204.

Sivajiceras aureum Spath: Locs. WA.831, 2303.

S. aff. kleidos Spath: Locs. WA.835, 2247, 2259.

S. cf. fissum (Sowerby): Loc. WA.2309.

Sivajiceras sp. juv.: Loc. WA.2019.

Hubertoceras omphalodes (Waagen): Loc. WA.828.

H. arcicosta (Waagen): Locs. WA.835, 1004, 1220.

H. dhosaense (Waagen): Loc. WA.1191.

Peltoceras ngerengerianum Dacqué: Loc. WA.2245.

Probably Callovian

Lytoceras sp. nov.: Loc. WA.2308.

ny) Partschiceras cf. viator (~~d'Orb~~) or aff. subobtusum (Kudernatsch): Loc. WA.2203.

Dr. E.D. Currie (Hunterian Museum, Glasgow University has identified the following echinoids:-

Psephechinus aff. microclyphus (Wright): Loc. WA.1634.

Hypodiadema aff. guerangeri (Cotteau): Loc. WA.1226.

The following lamellibranchs (author's determinations) occur:-

LAMELLIBRANCHIA

Astarte mülleri Krenkel: Locs. WA.835, 982, 1004, 1182, 1219, 1226, 1229, 1815, 2161, 2219, 2221, 2225, 2227, 2244, 2259, 2267, 2303, 2309.

Ceratomya concentrica (Sowerby): Locs. WA.1105, 1216, 1345, 1346, 2013, 2230, 2297, 2302.

C. telluris (Lamarck) [= Ceromya aequatorialis of Müller: see Cox (1935)] Locs. WA.835, 982, 1004, 1008, 1180, 1182, 1216, 1219, 1220, 1226, 1254, 1259, 1591, 1706, 1802, 2019, 2204, 2225, 2297.

C. cf. wimmisensis (Gilliéron): Locs. WA.1005, 1284, 1287, 1342, 1346, 1348, 1810, 2013, 2219, 2230, 2258.

Ceromyopsis sp. [= "Isocardia striata" of Müller (1900): see note on this species on p.58]: Locs. WA.1005, 1180, 1282, 1284, 1345, 1346, 1634, 1810, 2215, 2230, 2258.

Grammatodon (Indogrammatodon) virgatus (Sowerby) [= Cucullaea lasti Müller, 1900: see Cox, 1940]: Locs. WA.835, 924, 1226, 1258, 1296, 1817, 2150, 2159, 2225, 2227, 2259, 2305, 2307.

G. (Indogrammatodon) cf. iddurghurensis Cox: Loc. WA. 1740

Lycettia indica Cox: Loc. WA.1818.

Modiolus glendayi Weir: Locs. WA.828, 835, 1182, 1191, 1220, 1226, 1287, 1346, 1810, 2019, 2225, 2227, 2259, 2297, 2303.

Myophorella (Orthotrigonia) cf. kutchensis (Kitchin))see
Trigonia prora Kitchin)Part II and
T. elongata Sowerby)Appendix II
T. aff. propinqua Kitchin)for localities

Trigonia sp. nov. aff. triangularis Goldfuss: Loc. WA.1740.

Species of Astarte, Eligmus, Eopecten, Exogyra, Gervillella, Goniomya, Lopha, Lima, Modiolus, Ostrea, Pecten, Pinna, Pholadomya, Protocardia, among others, are also present.

Brachiopods and simple corals are abundant locally, and belemnites are also present in the collections.

It is not clear whether a break in sedimentation exists within the group between the Upper Callovian and Upper Oxfordian horizons or if the absence of intermediate faunas is due to chance of preservation or to collection failure. The Upper Oxfordian faunas collected were from two localities only, and in several places (e.g. Nunga Stream - Loc. WA.2245 and Mamakambi Stream - Loc. WA.2309), Callovian strata lie very close to the Septarian Marl. This may indicate that the Septarian Marl oversteps the Oxfordian on to the Callovian, but this break is not fully established (see also pp. 157,159).

The strata in the Makangaga-Ruawa area that are correlated with the ?Bathonian-Upper Oxfordian division of the Mandawa-Mahokondo Series lie immediately to the north and south of the Matarawe Stream, north of the Ruawa Fault. It is not known if pre-Bathonian strata occur here as they are believed to do south of the fault, and on the map (Plate II), ?Bajocian-Oxfordian strata are grouped together.

Strata containing _Nerinella credneri_, identified by Hennig (1916a, p.187) with the "_Trigonia smeei_" Bed, reported to the south of the Matarawe Stream west of Ruawa, occur in a vicinity not visited during recent work. They are in an area perhaps more likely to be occupied by Callovian or pre-Callovian strata. It is suggested that Hennig may have been misled here as in his correlation (see Hennig, 1937a) of ?Bathonian-Callovian _Nerinella_-bearing beds in the Mandawa-Mahokondo area with the _Nerinea_ Bed of the Tendaguru Series.

North of the Matarawe Stream, poorly exposed strata including fine, soft, buff, marly sandstones; whitish, medium-grained, hard calcareous sandstone; grey, sandy limestones and occasional grey-green lumachelle limestones form an east-west scarp with dip-slope to the north. These are apparently the strata from which Hennig (1916a) obtained some of the fossils by which he dated the Pindiro Shales, which are not now believed to outcrop north of the Matarawe Stream. On lithological grounds (and since they lie below a grey marl tentatively correlated with the Septarian Marl of the Mandawa-Mahokondo area) they are provisionally correlated with the ?Bathonian-Oxfordian unit of the Mandawa-Mahokondo Series. There has been confirmation of a Callovian age of part of the sequence by the BP-Shell Petroleum Development

Company of Tanganyika Limited, on the basis of mollusc identifications by Dr. L.R. Cox. It is not clear if any Oxfordian strata do in fact occur in this area. The dip of the strata is about 8°. The lower boundary is mapped from air photographs and is rather indefinite, but a thickness of 350-400 feet is indicated.

From the strata now believed to be Callovian north of the Matarawe Stream, Hennig (1916a) recorded the following:- Rhynchonella sp. nov.; Gervillia aff. iraonensis, Cypricardia aff. nuculiformis, Neaera sp.; Alaria sp. (A. hamus group), ?Cryptaulax sp. (C. armata group).

?Bathonian-Oxfordian strata have not been definitely identified south of the NE-SW Ruawa Fault. Hennig (1937a, p.174) described Myophorella (Orthotrigonia) discordans (Hennig) from supposed Kimmeridgian strata (his "Unter Smeei-Schicht") near Tunduru, though he commented on the form being essentially of Middle Jurassic type. O. discordans is inadequately figured but of the same type as a specimen of M. (Orthotrigonia) sp. nov. aff. duplicata Sowerby from near Ruawa (Loc. WA.2274), though larger (if the figure is of natural size) and with coarser ornament (see Part II, p.130) Upper Jurassic strata, which as a rule are lithologically distinct, have not been identified in the immediate vicinity of Tunduru during recent work, and it is suggested that Hennig's specimens of M. (Orthotrigonia) discordans may have come from older strata than he supposed. Some support for this conception comes from Hennig's record of a new gastropod species, Nummocalcar (Platybasis) dietrichi both from the Tunduru area and from his "Nerinella Bed" in the core of the Mandawa-Mahokondo anticline, now known to be pre-Middle Callovian and not Kimmeridgian as Hennig supposed. This raises uncertainty as to the age of the specimen Hennig described as cf. Jurassiphorus sp. nov. supposedly from the local base of the "Trigonia smeei" Bed in the Tunduru area.

Lower Kimmeridgian - (?Upper Oxfordian - ?Middle Kimmeridgian).

In the Mandawa-Mahokondo anticline the unit succeeding the beds forming the "core" of the structure is the Septarian Marl. Its outcrop extends round the ridge formed by the pre-Kimmeridgian strata, with only one complete break at the south-west. The width of outcrop is decreased in places, in the south especially, due to faulting.

The Septarian Marl consists of grey and buff marls with thin intercalations of fine, yellowish, marly sandstones. Septaria are locally abundant and often fossiliferous. There are occasional ribs of silty concretionary limestone, also fossiliferous. The soft rocks, naturally, are ill-exposed and form relatively low ground. A total thickness of about 700 feet was previously estimated on the east flank of the anticline (Aitken, 1956a). It is seldom possible to determine the dip of the beds themselves, and in drawing sections (see Plates V, VI and VIII) the evidence can always be reconciled to a thickness in this order.

No break in sedimentation is immediately apparent below the marls but, as suggested above, the limited number of exposures of Upper Oxfordian strata recorded and the local adjacence of Callovian strata to the marls may indicate an overstep. The upper boundary of the Septarian Marl is not clearly defined, the criteria of mapping it being the presence or absence of septaria and the incoming above of intercalations of hard calcareous sandstone. The marls appear to extend only a short way above the change of slope at the base of the scarp of Middle Kimmeridgian - Tithonian beds ringing the structure. The difference in the sequence between the Mandawa-Mahokondo and the Makangaga-Ruawa areas (see below) has suggested that a break in the sequence might be sought at the top of the Septarian Marl. The scarp of Middle Kimmeridgian - Tithonian beds is virtually unbroken by faulting on the flanks of the structure, though this is not so at its northern and southern ends. Faulting which off-sets the the lower boundary of the Septarian Marl about the middle of the anticline does not affect the higher beds and might have preceded their deposition. Air photograph interpretation, however, suggests that it dies out within the marl outcrop. Palaeontologically there is no need for a break below the Middle Kimmeridgian - Tithonian beds, since fossils from the Septarian Marl dated as Lower Kimmeridgian are not from the uppermost strata in the marl sequence.

An ammonite (Perisphinctes sp.) from a nodule found loose in the Runjo Stream (Loc. WA.1264), apparently close to the base of the marls, has been dated by Dr. W.J. Arkell as plicatilis Zone (Upper Oxfordian). The plicatilis Zone would therefore seem to straddle the boundary between the Septarian Marl and the topmost beds in the core of the structure. All other ammonites examined by Dr. Arkell, and the collection monographed by Dietrich (1925a) suggest (Arkell, 1956, p.332) that the marls belong to the mutabilis - pseudomutabilis Zones of the Lower Kimmeridgian.

Dr. W.J. Arkell (in litt. to W.G. Aitken, 6 Oct. 1942) has identified the following in recent collections:-

Perisphinctes (Pachysphinctes) africogermanus Dietrich (Locs. WA.1009, 1011)

P. (?Progeronia) mahokondobeyrichi Dietrich (Loc. WA.1009)

Perisphinctes (?Progeronia) sp. (Loc. WA.796, 1009)

Aspidoceras richthofeni Müller (Loc. WA.1009)

Holcophylloceras mesoleum (Dietrich) (Loc. WA.1317)

The specifically identified forms were previously recorded by Dietrich (see below).

One new lamellibranch species, Trigonia sp. nov. aff. T. triangularis, has been recorded (from Loc. WA.2194 - see Part II, p.29) in boundary strata between the Septarian Marl and the overlying beds. The same species occurs in the Upper Oxfordian (Loc. WA.1740). Other fossils in the recent collections have not been examined in detail. The number of genera is not so great as is recorded by Dietrich (see below). _Gryphaea hennigi_ is prominent.

Arkell (1956, p.332) has revised the nomenclature of ammonite species previously recovered from the Septarian Marl by Müller (1900, p.520) and Dietrich (1935a). Arkell's list is as follows:-

Lytoceras aff. _frassi_ Dacqué

Phylloceras cf. _subplicatius_ Burckhardt

Ptychophylloceras ptychoicum (Quenstedt)

Holcophylloceras mesolcum (Dietrich)

Glochiceras aff. _fialar_ (Oppel)

Taramelliceras cf. _compsum_ (Oppel)

Taramelliceras cf. _harpoceroides_ Burckhardt

Streblites futtereri (Müller)

Streblites cf. _planopicta_ Dietrich (_non_ Uhlig ?)

Pachysphinctes africogermanus Dietrich

Pachysphinctes mahokondobeyrichi (Dietrich)

Pachysphinctes mülleri Burckhardt (= _P. elizabethae_ Müller _non_ de Riaz)

"Idoceras" mahokondobalderus (Dietrich) (gen. indet.)

Nebrodites aethiopicoherbichi Dietrich

Aspidoceras richthofeni Müller (= _A. kilindinianum_ Dacqué)

This list covers all the ammonite species recovered by Dietrich, except for _Perisphinctes recki_ Dietrich.

Hennig (1937a, pp.111,112) listed the following[1)]

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1) This list takes into account discrepancies between Hennig's fossil lists and his locality map where it seems certain that the fossils concerned are from the Septarian Marl and not as listed by him.

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in addition to a number that can be identified with species described previously by Dietrich:-

<u>Perisphinctes (Lithacoceras) jelski</u>

<u>P. (Lithacoceras) sparsiplicatus</u>

<u>P. (Pachysphinctes) latissimus</u>

<u>P. (Pachyspinctes) sparsiplicatus</u>

<u>Physodoceras liparus</u>

<u>P. silesiacum</u>

<u>Nebrodites</u> cf. <u>crassicostatus</u>

<u>Simoceras</u> cf. <u>doublieri</u>

It is probable that these determinations, which were not mentioned by Arkell (1956), would be subject to revision, as were Dietrich's.

Apart from ammonites, the following have been recorded from the Septarian Marl:-

[See Müller (1900)]

<u>Belemnites calloviensis</u>

<u>Gervillia</u> cf. <u>aviculoides</u>

<u>Gryphaea lobata</u> [= <u>G. hennigi</u>: see Dietrich, 1925a]

Ostrea marshi [= Lopha marshii; see Cox, 1940]

Pecten cf. subarmatus

Plicatula sp.

Pseudomonotis münsteri

Trigonia zonata[1].

1. Kitchin (1903, p.121) stated that he "was inclined to place little reliance on Dr. Müller's identification of the African form with T. zonata Agassiz."

[See Dietrich, 1925a]

Gryphaea hennigi [= G. lobata of Müller (1900)]

Cucullaea aff. irritans [C. irritans = Grammatodon (Indogrammatodon) irritans: see Cox, 1937.]

Pleuromya tellina

together with specimens of the genera: Rhynchonella; Ostrea, Pseudomonotis, Gervilleia, Ctenostreon, Plicatula, Pecten, Trigonia (Group of T. costata), Cyprina, Astarte (Group of A. pulla), Goniomya; Scurria, Pleurotomaria (Group of Reticulatae), Trochus, Pseudomelania, Cerithium; and Belemnites.

[See Beurlen, 1933.]

Eryma cf. bedelta

[See Hennig, 1937a.]

Alectryonia sp.

Exogyra sp.

Gryphaea sp.

Trochus sp.

In the Makangaga-Ruawa area, overlying the Callovian-Oxfordian strata north of the Matarawe Stream, is a series of marls. They give rise to soil, topography and vegetation very similar to those of the Septarian Marl of the Mandawa-Mahokondo area, with which they are correlated. Septarian nodules have not been noted in them, but calcareous concretions occur. No fossils have been obtained. The strike ofthe marl outcrop is E.-W. and the northerly dip may have decreased from that in the strata immediately below, since the overlying beds appear to have a slightly lower dip. A dip of 5° would suggest a thickness of about 120 feet. Hennig (1937a, pp.110, 186) believed that strata east of Lake Mbuo were to be correlated with the Septarian Marl of Mahokondo; this was based on the assumption that the Septarian Marl was to be correlated with the Middle Saurian Bed (Tendaguru Series) which in fact (Spath, 1927/1933; Aitken, 1956a, Arkell, 1956), is younger than the Septarian Marl. The strata to the east of Lake Mbuo belong to the Tendaguru Series and are younger than the Septarian Marl.

While in the Mandawa-Mahokondo area, there is no good evidence of a break in the sequence between the Septarian Marl and the lowermost part of the Tendaguru Series, the situation is more complicated in the Makangaga-Ruawa area. Not only is the sequence different, but earth movement has taken place before the deposition of later Kimmeridgian strata which are equivalent, in part at least, to the lowest member of the Tendaguru Series in the Mandawa-Mahokondo area.

Above the strata presumed to be equivalent to part of the Septarian Marl north of the Matarawe Stream, there lies an arenaceous sequence consisting of whitish or whitish-buff, fine, calcareous sandstones; coarse, friable, calcareous sandstones; and strong bands of medium-grained, hard, white, sparsely fossiliferous, calcareous sandstone. The strike is E.-W. as in the underlying marls and the dip northerly at about 5°. The thickness is estimated as about 220 feet.

The sandstone sequence is succeeded by purple marls with occasional pinkish, calcareous concretions. The junction between the sandstones and the purple marl runs E.-W. and is clearly marked on the air photographs by a vegetation line. The strike of the base of the overlying strata (Middle-Upper Kimmeridgian) is S.W.-N.E., the change presumably indicating an unconformity, and the width of exposure of the purple marl unit varies from one side of the Kihimbwi-Pindiro Valley to the other. The wide outcrop to the east would suggest a maximum exposed thickness as great as 650 feet if the dip is similar to that in the beds below.

The age of the sandstone sequence and of the purple marl is uncertain. The pre-"smeei" Oolite part of the Tendaguru Series of the Mandawa - Mahokondo area is also represented in the north of the Makangaga-Ruawa area (see below). If the sequence in the former area is in fact unbroken, the grey marl overlying the Callovian strata north of the Matarawe Stream, must be equivalent to only the lower part of Septarian Marl in its type area, and the overlying sandstone and purple marl units to the upper part of it. The ?Middle Kimmeridgian age is assigned on the assumption that the upper part of the Septarian Marl in its type area is of this age. Presumably the break indicated by the unconformity of the Tendaguru Series on the lower beds in the north of the Makangaga-Ruawa area was of short duration.

In the area just south of the Matarawe Stream and immediately west of the confluence with the Ruawa, a purple marl with calcareous concretions occurs in a narrow area just west of the prominent linear features of Middle Kimmeridgian-Tithonian strata. This appears to be 100-125 feet in thickness and may be equivalent to the purple marl unit to the north. However, if the unconformity in the Nambango-Ndondonga area is below the marine Middle Kimmeridgian-Tithonian strata there and not within the ?continental purple marl, it is perhaps easier to regard the purple marl south of the Matarawe as older, possibly equivalent to the purple marls of the ?Bathonian sequence there.

THE TENDAGURU SERIES

(a) General.

The vicinity of Tendaguru Hill, the type area of the Tendaguru Series[1], lies outside the area mapped, about

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1) Arkell (1956, p.334) believed that the term Tendaguru Beds is best restricted to the Jurassic portion of the sequence of Jurasic and Lower Cretaceous strata originally given this name. This suggestion presumably arises on account of the apparently widespread disconformity separating the Tithonian from the lowest dated Cretaceous strata in the Mbemkuru area, which are Hauterivian. While the placing of the top of a recognised stratigraphical unit below such a break is desirable, it is not thought that the signification of a long-established term should be altered for this reason alone, and this account deals with the Tendaguru Beds as originally defined.

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eight miles to the south-west of Mtapaia. It has been argued before (Parkinson, 1929, 1930a; Dietrich, 1933a) that the detail of the sequence there is only of local significance; strict correlation of sections of about the same range elsewhere in the area is not at present possible. Plate VIII shows tentative correlations of a number of sections in the Mbemkuru River depression and the Mandawa-Mahokondo area. The bases of these correlations is outlined below (p. 143 <u>et seq.</u>).

(b) The Mandawa-Mahokondo and Adjacent Areas.

The maximum development of the Jurassic part of the Tendaguru Series is in the Mandawa-Mahokondo area. Table IV includes a summary of the sequence there. As mentioned in reference to the Mandawa-Mahokondo Series, Hennig's (1937a) interpretation of the sequence has been amended. The "Haupt-Smeei-Zone" and much of the "smeei" Oolite are believed to be older than the "Trigonia smeei" Bed in the Tendaguru area.

Middle - Upper Kimmeridgian.

The strata between the Septarian Marl and the "smeei" Oolite were not subdivided during the recent survey as they were by Hennig (1937a). While Hennig's sketch map of the structure indicates the "Transition Sandstone" lying between the Septarian Marl and the "Haupt-Smeei-Zone", the text (Hennig, 1937a, p.111) suggests that it is between the "Haupt-Smeei-Zone" and the "smeei" Oolite. As already observed, therefore (Quennell, McKinlay and Aitken, 1956), the term is not valid.

The Middle - Upper Kimmeridgian is well exposed in the Mandawa Stream, upstream from the crossing of the Lindi-Kilwa road and other fairly complete sections occur in the Nandenga Stream and the Lihimaliao Stream at the south and south-west respectively of the anticline (Plates VI and VII). There is no indication of a break at the base of the sequence and the boundary to the Septarian Marl is frequently determined only by the presence or absence of septaria in the soil. There is also passage upwards to the Upper Kimmeridgian - Tithonian Beds; the junction is taken at the first incoming of strong bands of oolitic limestone. This appears to be at a fairly constant level throughout the area but does not constitute an exact datum. Aitken (1956a) gave the thickness as about 500 feet, measured in the Mandawa River section, but this is probably an under-estimate and Table VI suggests that considerable variation occurs.

The Middle - Upper Kimmeridgian sequence is made up of grey, silty marl; fine, grey, green or buff, soft sandstone; and hard bands of grey limestone, calcareous sandstone and grit. Fossils obtained from the beds include ammonites, belemnites, brachiopods, and gastropods, but the bulk of the collection consists of lamellibranchs. Reports on brachiopods and gastropods are not yet available.

Dr. W.J. Arkell (personal communication) has identified the following:-

Aspidoceras cf. mombasense Spath or A. cf. iphiceroides Waagen [a large specimen not in situ but derived from a hard sandstone low in the sequence (Loc. WA.2188)]

and (in litt. to W.G. Aitken, 6 Oct. 1952):-

Calliphylloceras sp. [comparable to the mainly Callovian C. disputabile Zittel but also to the forms such as C. canavarii (Meneghini) that range up into the Kimmeridgian. The specimen from the Mandawa River section (Loc. WA.793) was not in situ but could scarcely have travelled from a Callovian outcrop and was not in a septarian nodule, so probably was derived from the Middle Kimmeridgian]

Perisphinctes (? Pachysphinctes) cf. _staffi_ (Zweirzycki)

The few belemnites from the strata (Loc. WA.2187) belong to the genus _Belemnopsis_ (_fide_ Dr. W.J. Arkell).

Lamellibranchs in the present collection include:-

Astarte recki Dietrich (Locs. WA.812, 971)

Grammatodon (Indogrammatodon) irritans (Hennig) (Loc. WA.812)

Pinna (Stegoconcha) g-mülleri Krenkel (Locs. WA.812, 821, 944, 971, 1007, 1847)

Trigonia (Trigonia) tanganyicensis sp. nov. (Loc. WA.812)

T. (Indotrigonia) mandawae sp. nov. (Locs. WA.812, 971, 1852, 2002, 2189, 1876)

T. (Trigonia) sp. nov. aff. _T. triangularis_ Goldfuss (Loc. WA.2194)

together with specimens of the genera _Anomia_, _Brachydontes_, _Epihippopodium_, _Exogyra_, _Gervillella_, _Hinnites_, _Lima_, _Modiola_, _Ostrea_, ?_Oxytoma_, _Pecten_, _Pholadomya_, _Pinna_, ?_Prosogyrotrigonia_.

Of the named species, only _P. (Stegoconcha) g-mülleri_ has been observed above the Middle - Upper Kimmeridgian part of the sequence. Cox (1940, p.134) recorded several examples of the species from the _Nerinea_ Bed in the type area of the Tendaguru Series and Dietrich (1933a, p.61) (who placed it in the synonymy of his _Stegoconcha solida_ var. _tendagurensis_) recorded it both from the _Nerinea_ Bed and "_Trigonia smeei_" Bed there. _Astarte recki_ was recorded by Dietrich (1933a, p.40) from localities which on the German Tendaguru Expedition maps (see Hennig in Branca _et al._, 1914/16; Janensch and Hennig, 1914) are in the _Nerinea_ Bed or lower in the

Table VI. - Estimated thicknesses of the subdivisions of the Tendaguru Series in the Mandawa-Mahokondo anticline.

		Middle - Upper Kimmeridgian	Upper Kimmeridgian - Tithonian	
			"smeei" Oolite	Above Oolite
		(feet)	(feet)	(feet)
West Flank	Mahokondo-Nalwehe	-	100 (if base exposed)	c.1500 (to unconformity)
	Upper Mkomore	650	120 (to last exposure)	-
	Nandenga	620	250	-
	Lihimaliao	700	380	c.1350
East Flank	Kikundi	800	340	c.1000 (to unconformity)
	Mkomangoni	780	340	1200
	East of Nchia	620	380	340 (to unconformity)
	Ngirito	680	50	580 (to fault)

Tendaguru Series. At one of these localities it occurs with Trigonia (Indotrigonia) aff. mandawae sp. nov. Grammatodon (Indogrammatodon) irritans, apart from its occurrence noted above, is present in large numbers in bands in grey, silty marls slightly higher in the sequence. The specimens from the marls, however, disintegrate in transit. Dietrich (1933a, p.27) recorded that the species is common in the Nerinea Bed of the Tendaguru area, but is not found above the Middle Saurian Bed there. No form resembling T. tanganyicensis sp. nov. has been recorded before in East Africa. A similar shell figured by Lebkûchner (1933) as T. siliceum (though rather different from the holotype of this species), of the Upper Kimmeridgian of Southern Germany is the closest to T. tanganyicensis noted in the literature. Indotrigonia mandawae sp. nov. occurs gregariously and is presumably the form on which Hennig (1937a) based the correlation of the "Haupt-Smeei-Zone" with the "Trigonia smeei" Bed of Tendaguru. It is shown in Part II of this paper that this species is distinct from that occurring in the "Trigonia smeei" Bed in its type area.

Hennig (1937a, p.111) listed the following from the Transition Sandstone and the "Haupt-Smeei-Zone"[1)]

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1) See p.38 above on discrepancies between Hennig's lists and locality map. It is relevant here that the locality Z7 listed in the "Haupt-Smeei-Zone" is shown twice on the map, once in this bed and once in the "Vor-Smeei-Schicht".

Aspidoceras longispinum; Astarte krenkeli, A. subovata, Cucullaea texta, Pecten aff. episcopalis, Pleuromya tellina; Pleurotomaria aff. jurensis, Trochus sp.

The specimen of Aspidoceras cf. mombasense or A. cf. iphiceroides is a pointer to the age of the lower part of the subdivision. The Lower or Middle Kimmeridgian age suggested for this implies that this part of the sequence is older than the Nerinea Bed of the Tendaguru Series, which Spath (1927/1933, p.820) dated as Portlandian and Arkell (1956, p.335) as Upper Kimmeridgian. However, approximate equivalence of strata higher in the sequence with the lower part of the marine beds of the Tendaguru Series is suggested by the association in both of T. (Indotrigonia) mandawae (or aff. mandawae), Astarte recki and Perisphinctes (? Pachysphinctes) cf. staffi. The last named has also been identified by Dietrich (1925a, p.20) in a specimen figured by Müller (1900, Plate XIV, fig.5) from the lower part of the overlying "smeei" Oolite at Mandawa, on the basis of which Dietrich correlated the oolite with the Nerinea Bed.

The age of the strata may range from as low as Lower Kimmeridgian to Lower Tithonian, but an age from Middle to Upper Kimmeridgian is perhaps acceptable. It is not clear that the Tendaguru Series in its type area ranges as low as this, though there is no real means of dating the continental

Lower Saurian Bed. It may not involve important extension of the range of the series to include all the Middle - Upper Kimmeridgian strata of the Mandawa-Mahokondo area in it.

Upper Kimmeridgian - Tithonian.

Hennig (1937a, p.111) described the "smeei" Oolite as coarse, well-bedded oolitic limestone, which he regarded as a marine equivalent of the Upper Saurian Bed of the Tendaguru Series (as had Dietrich, 1933a). The type area was not defined but the Mandawa-Mahokondo anticline has been accepted as such (Quennell, McKinlay and Aitken, 1956) since Hennig had stated that the development of the oolite is greatest there. The outcrop of the "smeei" Oolite encircles the anticline with only a minor break due to faulting, at the south-east of the structure.

The sequence includes white and grey-white oolitic limestones with a variable sand and small pebble content, associated with grey or white, usually sandy, non-oolitic limestones and hard, calcareous sandstones. Interbedded are fine or medium-grained, silty, yellowish, buff or greenish, soft weathering calcareous sandstones. The development of oolite bands is not constant. In the area of Mitole Village several strong bands, almost without soil cover, form well-marked pavement features that can be clearly seen on the air-photographs (Plates IV, XI).

Further south on the east flank of the structure (e.g. in the Kimbarambara and Ngirito stream sections) a much smaller thickness of massive oolite is developed, though the base of the oolite appears to be fairly constant in position. In this southern area, however, thin ribs of oolite, usually greenish or buff, with a clay or silt matrix, persist to the end of the Jurassic exposures, in the Ngirito to over 500 feet above the massive oolite.

The thickness of the sequence within which the oolites occur was previously estimated (Aitken, 1956a) in the Mandawa Stream, as about 350 feet. Table VI shows the variation in thickness in a number of sections. Apart from the Ngirito section, that in the Kikundi is anomalous. By comparison with the nearby Mkomangani section, however, it would seem that a thin series of white limestones, not recorded as oolitic, should be included in the oolite sequence (see Plate V). The thickness of individual bands of oolite varies; an unbroken thickness of over 40 feet exposed in the Nandenga Stream on the western flank is the greatest observed.

Hennig (1937a, pp.110,111) believed that the oolite belongs to the upper part of the sequence yielding "Trigonia smeei" in the Tendaguru Series, and is largely equivalent to the Upper Saurian Bed of the western part of the outcrop of this series. However, in the Mandawa-Mahokondo area, Hennig's "Haupt-Smeei-Zone" below the oolite sequence, is believed to be older than strata yielding the typical East African "T. smeei" (= T. (Indotrigonia) africana sp. nov.). Indotrigonia africana s. str. occurs gregariously high in or above the oolite sequence. Dietrich's (1925a, p.19) correlation of the lower part of the sequence with the Nerinea Bed, though based on scanty evidence, is more nearly correct.

The sequence above the "smeei" Oolite consists of soft-weathering, fine, silty, yellowish and buff sandstones, with resistant grey or whitish calcareous grits and gritty sandstones, sometimes pebbly. The coarser beds form quite a large proportion of the upper part of the sequence. Table VI shows the thickness of Jurassic strata above the "smeei" Oolite in a number of sections. The succession exposed in the off-faulted area to the north-west of the anticline differs from that on the eastern flank, and from that exposed elsewhere on the west, notably in the presence of a red marl unit and of a white limestone horizon (see Plate V). Neither of these units has been seen to extend far along the strike.

At the south-east of the anticline along a strike of about 200 yards and terminated by faulting at both ends, is an outcrop of white limestone dipping at about 20°. The strike swings from N.E. at the road to N.N.E. downstream. The relationships of this limestone are obscure. It occupies much the same position in relation to the "smeei" Oolite as does the white coralliferous limestone (see Table IV) of the Neocomian at the northern end of the structure, but does not contain the characteristic coral growths of this horizon. Unfortunately the attitude of the immediately overlying bed, well dated as Lower Cretaceous (see p.96), is not clear. The impression has been gained that it is not steeply dipping, and this would accord with the apparent attitude of Lower Cretaceous strata a short distance to the west, where they lap against the steeply-dipping "smeei" Oolite near Namwenje Hill. Tentatively, the limestone is assigned to the Jurassic.

The succession is highly fossiliferous in part especially the coarse, calcareous, gritty sandstone bands. Lamellibranchs, particularly Trigoniids, are prominent; ammonites, nautiloids, brachiopods, corals, echinoids and gastropods occur.

Müller (1900, pp.515-518, p.546)[1] described from

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1) It is assumed that the locality "0.6 kms. south of the Mandawa Stream, 15 kms. north-west of Kiswere" (described by Müller as Cretaceous) is in strata corresponding to the "smeei" Oolite; it might belong to the preceding subdivision.

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strata now included in the Upper Kimmeridgian-Tithonian ("smeei" Oolite): Perisphinctes sp. (= P. staffi: see Dietrich, 1925a, p.20); Rhynchonella senticosta; Cercomya sp., Exogyra solea Müller, Gervillea sp., Ostrea marshi, Pecten sp.; Pleurotomaria sp. Hennig (1937a) described "Trigonia smeei" Vola and corals.

Reports are not yet available on specimens of brachiopods, corals, gastropods and echinoids in the recent collections. Of the lamellibranchs now housed for the most part in the Hunterian Museum, Glasgow, only the Trigoniids have been examined in some detail.

The ammonites (determined by Dr. W.J. Arkell) include Virgatosphinctes cf. communis Spath (Loc. WA.961) and Micracanthoceras sp. (Loc. WA.881) both from the northern part of the east flank of the structure. These are comparable with forms from the Lower Umia Beds of Cutch and date their horizon as Lower Tithonian. The few other ammonites from this part of the sequence have not been determined, but Dr. Arkell (in litt. to W.G. Aitken, 2 Dec. 1954) has remarked that none of the previously published "Trigonia smeei" Bed forms are represented.

The Trigoniids present, which are described in Part II, where localities are listed, include the following:

Trigonia (Trigonia) sp.

Trigonia (? Pleurotrigonia) sp. nov.

T. (Indotrigonia) africana sp. nov. (= "I.smeei" auctt.)

T. (Indotrigonia) robusta sp. nov.

T. (Indotrigonia) v-striata sp. nov.

T. (Indotrigonia) beyschlagi Müller

? Myophorella sp.

? Yaadia sp.

Megatrigonia (Megatrigonia) conocardiiformis (Krauss)
M. (Iotrigonia) cf. haughtoni (Rennie)
M. (Iotrigonia) cf. vau (Sharpe)
M. (Rutitrigonia) dietrichi (Lange)
Laevitrigonia curta sp. nov.
Opisthotrigonia curvata sp. nov.
A Trigoniid gen. et sp. indet.

Müller (1900, p.543) described "Trigonia" ventricosa Krauss (a Pterotrigonia according to recent classification) as accompanying the holotype of Indotrigonia beyschlagi at a locality near the Mkundi Stream to the north-west of the Mandawa-Mahokondo anticline, and dated the strata there as Lower Cretaceous on the basis of the former. Dietrich (1933a, p.54) believed that fossils from more than one locality in the Mkundi Stream area had been mixed in the collection Müller studied, and that T. beyschlagi and T. ventricosa (renamed T. mülleri by Dietrich) came respectively from Jurassic and from Cretaceous portions of the succession. Hennig (1937a, fig.2), however, evidently accepted that the two forms occurred together and placed what he termed the "Ventricosa-Smeei-Lager" at the junction between the Portlandian and the Valaginian. Spath (1935, p.189), however, showed that in Cutch there are several Trigoniids of Cretaceous aspect, including a form very like "T" ventricosa, which are in fact Jurassic. There are similar instances in Southern Tanganyika also, for example, the occurrence of Megatrigonia conocardiiformis in the Mkundi Stream (Loc. WA.2148), immediately above which is a bed rich in Indotrigonia aff. africana and I. aff. beyschlagi. It seems probable that the "T. ventricosa" from the Mkundi Stream is Jurassic too.

Other lamellibranchs from the Upper Kimmeridgian - Tithonian sequence include:

Arcomya robustissima Dietrich (Loc. WA.2261)

Astarte krenkeli Dietrich (Locs. WA.2172, 2176, 2179)

Corbis (Sphaera) subcorrugata Dietrich (Locs. WA.2261, 1656, 2550)

Cucullaea (Megacucullaea) eminens Cox (Locs. WA.2261, 2549)

cf. Cucullaea (Megacucullaea) kraussi (Loc. WA.2148)

Pinna (Stegoconcha) g-mülleri Krenkel (Loc. WA.868)

Seebachia janenschi Dietrich (Locs. WA.1628, 1779, 1782, 2267)

cf. Thracia incerta Agassiz (Loc. WA.1628)

together with species of Anomia, Astarte, Brachydontes, Exogyra, Gervillia (Gervillella), Hinnites, Lima, Modiolus, Ostrea, Pecten, Pholadomya, ?Velata.

<u>Neocomian - Lower Aptian</u>

Neocomian - Lower Aptian strata, for the most part probably equivalent to some part of the <u>Trigonia schwarzi</u> Bed of the Tendaguru Series, surround the northern end of the Mandawa-Mahokondo anticline and have been identified to the south in the Kloweka-Mirumba-Mbinga area. They stretch southwards, east of the rim of the Mbemkuru River depression to the south of Kiranjeranji Village and extend into the Mbemkuru drainage area south of there. They also occur in the Runyu Inlier to the east of the southern culmination of the anticline.

The Lower Cretaceous in the northern area of the anticline is taken to commence at a white coralliferous limestone overlying the highest sediments containing <u>Indotrigonia</u> of the <u>I. africana</u> group. Hennig (1937a, p.138) referred to a coral limestone east of the Mandawa-Mahokondo anticline presumably the same horizon as this, to the Lower Cretaceous. On the north-east flank this limestone extends from just south of Kiwawa (where it is cut off by faulting) to the Mkomangoni Stream. Over much of this distance, for about nine miles, exposure is almost continuous. What is believed to be the same horizon has been observed in the Nalwehe Stream, though the limestone sequence is here interrupted by sandy beds. The outcrop can be traced on the air-photographs round the "nose" of the structure in the northern off-faulted portion and its position has been confirmed where the limestone occurs with confused dips, immediately WNW. of the Mahokondo Fault.

The limestone is 40-50 feet thick in the Kikundi Stream section on the east flank of the anticline. It thins to the south and thickens northwards. The limestone sequence presumed to be its equivalent in the Nalwehe Stream, is about 200 feet thick including intercalated sandstones. The limestone is well-bedded where exposed in several stream sections on the east flank. Small boulders of calcareous grit have been observed at its base in a stream to the south of the Kikundi. In the Mpilepile Stream north of the Kikundi, small rounded quartz pebbles are scattered through its lowermost part, and a "conglomerate" of pebble-sized coral colonies in a slightly gritty matrix, occurs near the top. Near Kiwawa and close to the W.N.W. of the Mahokondo Fault, walls of limestone up to 20 feet in height stand up in a local karst development.

The main outcrop of the white limestone on the east flank is terminated at the Mkomangoni Stream by a late fault and overstep by Upper Cretaceous strata. Similar material occurs as a spread of boulders with some large masses, possibly outcrop, along a quarter-mile strike oblique to the main outcrop, a short way to the south (not shown on the map). The explanation of this occurrence, if it represents the same horizon, is obscure. The limestone is terminated to the north in the Kiwawa area by faulting associated with the Mahokondo Fault.

The only fossils obtained from the limestone have been colonial corals and algal masses, which tend to stand out on weathering, and very occasional large gastropod casts. Immediately below the limestone in the Mpilepile Stream, specimens of Opisthotrigonia curvata sp. nov. known elsewhere in the vicinity from the Tithonian have been found in a fine sandstone along with brachiopods and echinoids (Loc. WA.1691). In the Nalwehe Stream, Indotrigonia beyschlagi occurs immediately below it. Immediately above it, in the Namitambo Stream to the north-east of the structure, Eulytoceras cf. mikadiense (Krenkel) (identified by C.W. Wright) has been collected (Loc. WA.2044). This has previously been recorded from the Hauterivian-Lower Aptian Trigonia schwarzi Bed. On this basis it seems necessary to suppose an unconformity either below or above the limestone. That unconformity occurs below it is suggested by the following evidence[1]:

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[1] After completion of the preparation of this paper, Dr. E.D. Currie (Hunterian Museum, Glasgow University) has supplied the information that a community of echinoids from this locality consists of Toxaster sp., a genus thus far known from the Valanginian to the Cenomanian, with the greatest number of species in the Hauterivian. Although the collection comprises almost 200 specimens the preservation is too poor to allow

specific determination of the material. There is an obvious problem here, that either <u>Opisthotrigonia curvata</u> has a longer upward range than supposed, or <u>Toxaster</u> is not wholly a Cretaceous genus. It is possible that the supposed unconformity discussed below does not lie actually at the base of the limestone, but some way below it.

(a) The disparity in thicknesses of the post-"<u>smeei</u>" Oolite Jurassic strata between the Kikundi/Mkomangoni area (ca. 1,000 ft.) and the Nalwehe area (ca. 1400 ft.) (see Plate V and Plate VIII).

(b) The absence in the available collections from the east of the anticline, of communities of <u>Indotrigonia beyschlagi</u> Müller and <u>I.</u> aff. <u>africana</u> sp. nov. of the type prominent in the Nalwehe - Mkundi area to the north-west (see Part II, pp. 68-71).

(c) The abrupt change in lithology on the east flank of the anticline at least and the presence locally of boulders of calcareous grit in the base of the limestone. (The presence of a thin white limestone in the Jurassic sequence to the west of Mahokondo reduces the force of this evidence, showing that conditions existed in the area before the Cretaceous for the formation of such strata).

Overlying the limestone, and seen in the Kikundi and Namitambo stream sections, is a rather characteristic, dark grey, medium-grained, calcareous sandstone with intercalations of fine buff sandstone. Later gritty, calcareous, sometimes pebbly, medium-grained and coarse sandstones enter the sequence. The thickness exposed in the Kikundi Stream is about 280 feet, but is less in the Namitambo due to overstep by Aptian strata. As recorded above, the lower part of the sequence in the Namitambo has yielded Eulytoceras cf. mikadiense (Krenkel) suggesting an age equivalent to the Trigonia schwarzi Bed of the Mbemkuru area. The grey sandstones in the Kikundi Stream have yielded Cyprina (Venilicardia) sublineolata Dietrich (Loc. WA.2540) and a calcareous pebbly grit immediately below the unconformity of the overlying Albian marls has yielded Megatrigonia (Rutitrigonia) bornhardti, and Lima (Plagiostoma) euploca (Lange) (Loc. WA.2539). In a sandy, red-stained, oolite cobble in the same vicinity, cf. Cucullaea (Megacucullaea) kraussi Tate has been found (Loc. WA.2541). This too is a Trigonia schwarzi Bed fauna, and the strata are slightly younger than Lower Neocomian, the age previously supposed (Aitken, 1956a). Unconformably overlying strata at the north-east of the structure, which Aitken (1956a, pp.14,15) supposed to be Hauterivian/Barremian, are now known to be Upper Aptian (see p. 129).

Not far to the north of the point of disappearance of the Mahokondo Fault in the Kiwawa area (Loc. WA.2100) large numbers of Hibolites subfusiformis (Raspail) are derived from ill-exposed, buff, medium-grained calcareous sandstone, suggesting (fide Dr. W.H. Arkell in litt to W.G. Aitken, 6 May 1955) a Neocomian age.

In the Nalwehe Stream, west of the Mahokondo Fault, in the upper part of the sequence assigned to the "white coralliferous limestone", coral colonies are embedded as cobbles and boulders, sometimes as numerous as to form a conglomerate, in irregularly bedded, highly calcareous, sandstone. It is supposed that this is a facies of the limestone, but the alternative is possible that the strata are younger and the coral boulders are derived from erosion of the limestone. From the gritty matrix of a conglomeratic band of the type described at the top of the "limestone" sequence (Loc. WA.2185), two small specimens of Rutitrigonia sp., akin to R. bornhardti have been obtained, indicating a Lower Cretaceous age.

The strata overlying the white coralliferous limestone in the Nalwehe area are mainly fine, buff or grey, silty sandstones, with ribs of more calcareous material which stand out on weathering, and some grit bands. The fine sandstones are overlain by coarse, friable, whitish, unfossiliferous, calcareous grit, and this is succeeded by grey-green marls with limestone intercalations, assigned to the Upper Aptian.

To the south of the anticline in the Nloweka Stream, below the limestones forming the Nloweka Cliffs (Kiturika Beds of the Aptian), there are coarse calcareous grits, sometimes pebbly, and coarse to fine, grey or buff, calcareous sandstones. The calcareous grits have yielded specimens of Megatrigonia bornhardti (Müller), Astarte cf. stuhlmanni Müller and Gervillella sp.. There is no definite break below the limestones but higher dips occur in the sandstone-grit sequence which might reflect overstep of the Kiturika Beds on already disturbed Neocomian beds. The rather high dips (almost 20°) in the Neocomian strata, however, may be associated with the faulting that separates the Lower Cretaceous strata from the Jurassic oolite sequence immediately to the north. Further downstream in the Nloweka, immediately north of Mikaramu Village, strongly dipping Jurassic sediments appear to be faulted against soft-weathering, yellowish, fine and medium-grained calcareous sandstones with greenish clayey partings. These beds, presumably also Neocomian, have low, variable dips. It is possible that the junction of these beds with the Jurassic is unconformable and not faulted, and further east, certainly, their unconformity on the Jurassic can be traced round the southern end of the anticline to the Mbinga area. Near Mirumba Village fossils of Trigonia schwarzi Bed age have been found, and a similar assemblage in the Lihimaliao Stream downstream of the Lindi-Kilwa road crossing.

As has been discussed above (p.85), the relationships of a white limestone outcropping in the Lihimaliao Stream downstream of the road crossing are obscure. It has tentatively been assigned to the Jurassic, but could be equivalent to the "white coralliferous limestone" of the Cretaceous. The overlying Trigonia schwarzi Bed strata, however, appear to form a part of a low-dipping Lower Cretaceous sequence that to the west of the road, definitely oversteps steeply dipping Jurassic strata as low as Upper Kimmeridgian.

The fauna from the Lihimaliao (Loc. WA.1010/1152) includes:

Phylloceras kronkeli Zwierzycki, P. serum (Oppel), Lytoceras hennigi Zwierzycki, Lytoceras sp., Spitidiscus inflatus Zwierzycki and Barremites sp. (identified by Drs. W.J. Arkell and C.W. Wright) together with Corbis (Sphaera) corrugata Sowerby, Cucullaea (Megacucullaea) kraussi Tate and Exogyra sp., Gervillia (Gervillella) sp., Modiolus sp., Pecten sp.. From Mirumba (Loc. WA.2337), Lytoceras hennigi has been identified, along with Corbis (Sphaera) corrugata, Cucullaea (Megacucullaea) kraussi and Exogyra sp..

Corals and gastropods have also been found at one or other of these localities.

Very little is known of the Neocomian - Lower Aptian to the south of the Mandawa-Mahokondo area beyond the Lihimaliao and Mirumba occurrences. Below the Upper Aptian limestones capping the Nahumba Hills is a succession of fine to coarse, buff-weathering, usually soft, calcareous sandstones. Gervillia alaeformis var. percrassa has been noted from a coarse band near the base of the hills (Loc. WA.2369).

Outcrops in the area are poor, and except in the case of limestones and calcareous sandstones yielding _Orbitolina_, distinction between the Neocomian - Lower Aptian beds and Upper Aptian strata is not clear.

Most of the limestones do contain _Orbitolina_ and are regarded as Upper Aptian, but thin bands (probably 4 or 5 feet in thickness) at Mbinga to the east of the Njenga turn-off, near Mkudu Village, and a little to the west of Mtande Village do not, and probably belong to the Neocomian - Lower Aptian sequence.

The boundaries on the map (Plate II) in this area have been inserted in consultation with Mr. R. Stoneley of the BP-Shell Petroleum Development Company, Limited, who has also examined the area and has had the benefit of micro-fossil determinations of the ages of the strata.

The Runyu inlier of Lower Cretaceous strata, lying east of Ngirito, is surrounded by Upper Cretaceous marls, dated as Senonian by the BP-Shell Petroleum Development Co. Ltd.. The inlier is only about 300 yards from east to west. The main outcrop is of hard grey, medium-grained and rather coarse, sometimes pebbly, calcareous grits forming a pavement in the Runyu Stream about 60 yards long with a dip about 3° east. About 50 yards to the south, pebbly grits occur. The stream exposure (Loc. WA.1653) has yielded: _Megatrigonia (Rutitrigonia) bornhardti_ (Müller), _Gervillia alaeformis_ (Sowerby) var. _percrassa_ Müller, _Hinnites_

(Prohinnites) fraasi (Krenkel), and Astarte stuhlmanni Müller together with Lima sp. and Modiolus sp.. This is a typical Trigonia schwarzi Bed fauna.

At its eastern end, the inlier also contains strata that have yielded Orbitolina (Loc. WA.1654) and are probably Upper Aptian (see p. 133).

(c) The Makangaga - Ruawa Area

Middle - Upper Kimmeridgian

In the Makangaga - Ruawa area, there is discordance of strike between the base of marine strata containing Indotrigonia mandawae sp. nov. underlying an oolite sequence, and the base of the purple marl unit in the Ruawa area. The former are regarded as being equivalent to the Middle - Upper Kimmeridgian and the latter (see p.75) to the upper part of the Septarian Marl of the Mandawa - Mahokondo area. It is supposed that unconformity occurs at the base of the marine strata, but, alternatively, it could be within the purple marl.

At the base of the Nambango-Ndondonga Ridge, grey-buff, soft, marly sandstones with bands of fossiliferous concretionary limestone masses, occur just west of the northern end of Namateure Hill (Loc. WA.2533). These lie below the lowest oolite in the sequence and a concretionary limestone has yielded a specimen of Indotrigonia mandawae. In the southern part of the Nambango Village area ribs of grey limestone occur in a thin, ill-exposed, grey, marly sandstone succession.

South of Matarawe Stream, strata below the oolite sequence occur in the westernmost of the linear features that extend SSE. from about the confluence of the Matarawe and the Ruawa streams. For the most part they rest directly on the Pindiro Shales, but close to the south of the Matarawe Stream, post-Pindiro Shales strata of ? Bajocian and possibly younger age occur below them. These are separated from the Middle - Upper Kimmeridgian by a purple marl, possibly partly equivalent to that described to the north, but at present regarded as older (see p.75). The beds above the purple marl are hard, grey, sandy limestones, sometimes with scattered ooliths; medium-grained, grey-white, calcareous sandstone and fine grey-buff calcareous sandstones. These are about 100 feet in thickness.

West of Lake Mbuo exposures are poor, but there are whitish, medium-grained, calcareous sandstones in the sequence there. Hennig (1937a, Fig.1, p.145) recorded an outlier of the lower part of the pre-oolite sequence to the west of Lake Mbuo, but this was not observed during the recent survey. East of the lake, the strata exposed on the lower part of the first step of the strong linear feature there are grey, medium and coarse grained, usually gritty, calcareous sandstones, sometimes pebbly, with thin hard, grey limestone intercalations which sometimes contain scattered ooliths. Interbedded is soft-weathered, buff, fine-grained sandstone. Strong oolite bands outcrop higher in the slopes.

Similar strata are exposed below the oolite to the east of Tunduru. A notable feature in the Nangororo area is a brownish, ill-sorted, gritty, calcareous sandstone band over six feet thick, in which calcite rhombs up to 1½ inches, across are developed in patches. Hennig (1937a, fig.6) gave a section eastwards from Tunduru Village through the Kimmeridgian-Tithonian sequence there, showing sandstones, oolitic limestones and "saurian" marls. It is believed that a fault separates this sequence from the underlying Pindiro Shales (as is suggested in Hennig's fig.18) but otherwise the section is probably typical, though "saurian" marls have not been observed during the recent survey, and oolites enter the sequence lower than Hennig suggests. The section is not in fact east-west, but either runs SW.-NE. or is composite of profiles along different parallels.

In the Itukuri Village area the sequence is confused by faulting, but a small thickness of grey limestones and calcareous grits, intercalated in soft, buff weathering, fine and medium grained sandstones, apparently lies below the oolite.

The Middle - Upper Kimmeridgian strata (i.e. the pre-oolite Kimmeridgian-Tithonian sequence - Hennig's "Unter-Smeei-Schicht") is not as extensive as indicated on

Hennig's (1937a, fig.1) sketch map, which suggests that it is everywhere flat-lying. The exposures mentioned (Hennig, 1916a, p.155) east of Bwatabwata Village, directly overlying the Pindiro Shales, have not been observed. It has been suggested above (p.66) that strata to the south of the Matarawe Stream which Hennig placed in this part of the succession, may be much older.

Upper Kimmeridgian - Tithonian

The Upper Kimmeridgian - Tithonian strata, taken to commence at the entry of massive oolitic limestone into the sequence, forms the greater part of the strong linear features flanking the east of the Makangaga-Ruawa area, the Nambango-Ndondonga Ridge to the north and the less prominent feature in the Itukuri area to the south. The features formed by the oolites outline the main structure of the area.

The strata are similar to those exposed in the Mandawa-Mahokondo area. In the Nambango area, assuming a dip of 5° in the strata (dips observed are rather irregular), about the same thickness of strata with massive oolites is exposed as measured in the Mandawa-Mahokondo anticline, 350 - 400 feet. Massive oolite is exposed below the Nambango-Ndondonga Ridge in the Nambango Village area, and also in the Nambango Stream to the north. On the intervening feature, whitish, medium-grained, hard calcareous sandstones, and fine and medium-grained, buff, marly sandstones are exposed, and boulders of white coral limestone have been observed. On the lower slopes of Ndondonga Hill, white, medium-grained, calcareous sandstones are prominent and in the Kikurungu Stream, near the crossing of the old alignment of the Lindi-Kilwa road, grey-buff, gritty sandstones with ooliths, and fine and medium-grained, soft, buff sandstones are associated with grey, sandy oolite. Fine, grey, marly sandstone underlies this sequence, and boulders of coral limestone occur here also. The lower oolite is exposed to the south. The strata above the oolite have not been seen. The country to the north of the Nambango Stream is largely covered by unconsolidated sands, but purple marl apparently occurs in the sequence.

The strata forming the linear features on the eastern side of the Makangaga-Ruawa area expose a sequence of oolites; hard, calcareous, often gritty sandstones; fine, buff sandstones, etc. similar to those in the Mandawa-Mahokondo area. East of Lake Mbuo, Hennig (1937a, p.110) recorded a septarian marl which he believed to be the equivalent of the Septarian Marl of the Mandawa-Mahokondo sequence, but which is evidently younger. Except to the east of Tunduru, the upper part of the sequence is concealed by loose sands derived from the Ngarama Plateau to the east. East of Tunduru the dip is lower than further north, and decreases eastwards.

Hennig (1937a, p.109) in discussing the section east from Tunduru Village, laid some emphasis on the unusual presence of more than one band of oolite. This, in fact, is usual however, there being oolitic limestones at different levels in the sequences in the Nambango area, the Mandawa-Mahokondo area and the Minyoka-Ukulinga area.

In the Itukuri Village area, the oolite sequence delineates the southern pitch of the Makangaga-Ruawa structure. The massive, white, sandy oolite sometimes contains patches of calcite in rhombs up to 3 inches across. As well as the oolitic limestone, non-oolitic, reddish and pink, argillaceous limestones with scattered quartz grains occur in the sequence, in bands several feet in thickness. A hard rock consisting of rather coarse angular quartz grains in a plentiful matrix of fine, silty, buff, calcareous sandstone forms a bed several feet thick. The soft, fine-grained, buff sandstone that usually forms part of the oolite succession has not been observed here, within the oolite sequence, of which only a small thickness is exposed.

Not many fossils occur in the Upper Kimmeridgian - Tithonian beds. Indotrigonia africana sp. nov. is found throughout the sequence.

From a sandy oolite immediately east of Lake Mbuo (i.e. near the base of the oolite sequence) (Loc. WA.2547) and at about the same horizon 2 miles to the north (Loc. WA.1838/2544), Indotrigonia faunas include forms intermediate between _I. mandawae_ sp. nov. (typical of the Middle - Upper Kimmeridgian) and _I. africana_ sp. nov. (typical of the upper part of the oolite and the beds above them). These faunas may be compared to that described from near Mtapaia (see p.112 and Pt.II, p. 73). _Astarte_ sp., _Gervillella_ sp. and turreted gastropods have been noted along with _I. africana_ near Mangororo (Loc. WA.2305) in oolitic limestone. Hennig (1957a) has recorded, as well as "_I.smeei_", _Trigonia_ aff. _stremmei_ Lange and _Megatrigonia (Rutitrigonia) dietrichi_ (Lange), (as "_Lyriodon_" and "_Indotrigonia_" respectively), from the "_Trigonia smeei_" Bed in the area, presumably from this part of the sequence. A specimen of _Eryma_ aff. _fossata_ Krause from what he supposed to be the equivalent of the Septarian Marl east of Lake Mbuo, probably belongs here.

(d) The Mbemkuru Area.

Middle - Upper Kimmeridgian

The only Middle - Upper Kimmeridgian outcrops recognised in the Mbemkuru area are along the lower part of the scarp bounding the western side of the Minyoka and Ukulinga areas. Hennig (1914a, Pl.I) gave profiles showing detail of the southern escarpment of the Minyoka and the western side of Ukulinga, and (1914a, p.23) recorded the sequence in the Mbemkuru - Ukulinga - Minyoka area. However, he did not state thicknesses except that of massive oolite in the sides of the gorge between Ukulinga and Minyoka, given as

60 metres (Hennig, 1914a, p.21). The scale of the profiles is not given, and it is thought that scaling-off thicknesses on the evidence available would lead to inaccuracies. Moreover, Hennig (1937a, p.109) gives a thickness of only 20 metres for the oolite in the Minyoka - Ukulinga area.

South of the Mbemkuru, the Middle - Upper Kimmeridgian sequence measured on the road south-east of Mohinjiri Village comprises about 150 feet of sediments. About 100 feet at the base is made up of soft, fine-grained, grey, marly sandstones, buff-weathering towards the top, with thin intercalations of harder, fine-grained, grey calcareous sandstone. The upper 50 feet of the sequence contains various resistant bands of sandstone and limestone. In the Nanjema Stream section, eight feet of greenish silty sandstones underlie the lowest exposed oolite, but the underlying Middle - Upper Kimmeridgian is not exposed here or in the nearby Mbambala Stream.

Below the oolites at the south-west of the Minyoka area, thick, grey limestones, sandy at the base, occur, but no section has been measured in this area.

Fossils previously recorded from strata now assigned to the Middle - Upper Kimmeridgian are listed elsewhere (Quennell, McKinlay and Aitken, 1956 under Lower Saurian Bed and _Nerinea_ Bed).

Upper Kimmeridgian - Tithonian

The greater part of the Jurassic exposed in the Mbemkuru area is of Upper Kimmeridgian - Tithonian age. The base of the sequence is taken at the first incoming of massive oolitic limestone, which is assumed to be at about the same horizon as in the Mandawa-Mahokondo area. The strata can be dealt with in three distinct areas: a) east of the Kikundi-Mchinjiri Fault, b) between this fault and the east flank of the Makangaga-Ruawa anticline, c) the Mtapaia area. Fossils previously recorded from strata now assigned to the Upper Kimmeridgian - Tithonian are listed elsewhere (Quennell, McKinlay and Aitken, 1956 - under Nerinea Bed, Middle Saurian Bed, Trigonia smeei Bed and Upper Saurian Bed).

The high ground of the Minyoka and Ukulinga areas is made up of a succession lithologically similar to that of the "smeei" Oolite of the Mandawa-Mahokondo area, i.e. white, oolitic, sandy limestones, sometimes with a greenish clayey matrix; hard, white or buff, calcareous sandstones; and occasional sandy, non-oolitic limestones with interbedded fine, silty, buff or greenish sandstones. Indotrigonia africana sp. nov. occurs in and above this sequence and I. cf. africana and I. cf. mandawa are associated in the lowest oolite seen at the south-west of the Minyoka area (Loc. WA.2556). Hennig (1914a, p.21) estimated that the thickness of the oolite is about 60 metres (almost 200 feet) where the

Mbemkuru River cuts the escarpment but later (Hennig, 1937a, p.109) gave the thickness as 20 metres. Both figures are less than the estimated thickness of the oolite sequence in the Mandawa-Mahokondo area, but the latter is not unlike that measured on the road descent to Mchinjiri Village from the east where about 80 feet of strata include oolites. The section near the Turikira Stream north of the road east of Kikundi may be incomplete at the base, but about 180 feet of the oolite sequence is present here. The most complete measured section of the oolite sequence is that in the Nanjema Stream a tributary of the Mchinjiri. In this section there is an interval of about 70 feet in which only thin oolite bands occur in a sequence of green and buff sands and silts with thin hard calcareous sandstone and non-oolitic, sandy limestone intercalations. The lower band of oolite is about 40 feet in thickness and the upper about 15 feet. Above the oolite is a thin, coarse, gritty, brownish sandstone overlain by grey-buff or whitish, marly silts and fine laminated sandstones about 40 feet in thickness, and medium-grained, generally friable sandstones with some soft-weathering, coarse, gritty bands. Above these, near the steep rise up Mbambala Hill, are purple and grey-green marls, in which a 2 foot band of hard, grey, pebbly, sandy limestone has yielded Indotrigonia aff. africana (Loc. WA.2560). For about 150 feet above this fossil band the sequence is not well exposed. The marl continues for some distance, possibly occurring over a thickness in all of about 100 feet, and the sequence above appears to be mainly soft, fine-grained, buff sandstones. About fifty feet below the top of the northern end of Mbambala Hill hard, fine-grained, calcareous sandstones occur with Indotrigonia aff. africana (Loc. WA.2562) of a type similar to specimens from high in the Tithonian sequence in the Mkundi-Nalwehe area and I. aff. beyschlagi. These sandstones extend almost to the top of Mbambala, where a white medium-grained calcareous grit, with fragmentary specimens of I. aff. africana, also supposed to be Jurassic, occurs (Loc. WA.2563).

In the Turikira drainage, north of the Kiranjeranje-Makangaga road, the oolite sequence is again broken by a series of sandstones with only thin bands of oolite. However, this is thinner than the corresponding break in the oolite sequence in the Nanjema Stream (about 30 feet) and the almost unbroken oolites above are thicker than in the Nanjema (60-70 feet). The lower oolite band is slightly thinner (20-30 feet), but where measured may be incomplete due to faulting.

Near the Turikira Ridge, to the north of the Kikundi-Mtande path, and associated with thin, very sandy, fine, buff oolites, coarse grey and white grits, sometimes pebbly, occur in bands up to 15 feet in thickness; from one such band a community of Indotrigonia africana s. lato was obtained (Loc. WA.2404 - see Part II, p.75).

The sequence above the oolite is not well exposed and since the amount of the low easterly dip of the strata is not clear, estimation of thickness is doubtful. The highest certainly Jurassic outcrop on the west of the Turikira Ridge is about 150 feet topographically above the top of the oolite on the Kiranjeranje-Makangaga road. A 2° easterly dip would add about 250 feet to the thickness suggested by the difference in elevation.

The bulk of the exposed strata consists of rather thin-bedded, grey and whitish, medium-grained, calcareous sandstones, sometimes with pebble streaks, intercalated in soft, fine-grained, buff weathering, silty sandstones. On the Kiranjeranje-Makangaga road about a mile east of the oolite escarpment an ill-exposed section of about 60 feet shows strata in the following order:-

[Top]

20 ft.	(Soft, buff, fine-grained, silty, calcareous sandstone; (friable, medium-grained, grey-white, gritty sandstone.
10 ft.	(Hard, fine-grained, whitish calcareous sandstone; (hard, medium-grained, grey, calcareous sandstone (finely speckled with black.
30 ft.	(Fine and medium-grained, whitish friable sandstone; (purple marl; soft, buff, fine-grained silty, (calcareous sandstone.

To the north of the Mbemkuru River between the Kikundi-Mchinjiri Fault and the eastern flank of the Makangaga-Ruawa anticline is a large area of Upper Kimmeridgian-Tithonian strata, for the most part flat-lying. The total thickness of these is not known, but about a mile to the east of the plunging strata on the flank of the anticline, where the beds are apparently flat-lying throughout, about 250 feet of sediments occur between the Kiranjeranje-Makangaga road and the forest reserve boundary to the north. This sequence contains thin oolite bands, but the strong oolite horizons on the flank of the anticline lie below. The Jurassic outcrops some distance further up the southern slopes of the Ngarama Plateau.

No sequence has been determined. There are scattered outcrops of fine and medium-grained, buff or greenish calcareous sandstone, some soft weathering, some fairly hard and slabby; whitish, friable, fine and medium-grained sandstones; medium-grained and coarse, grey-buff or whitish, sometimes pebbly, calcareous sandstones; coarse, grey, calcareous pebbly grits; and sandy oolitic limestones. The calcareous grits are frequently fossiliferous and Indotrigonia africana has been observed at several localities (e.g. WA.2412 on the forest reserve boundary).

A short distance to the north of the Mbemkuru River, in the Kikundi area, southward-dipping Upper Kimmeridgian-Tithonian strata form a low scarp and dip-slope feature. The succession includes medium-grained to coarse, calcareous, sometimes pebbly grits; fine, grey, hard, calcareous sandstone; fine, buff, soft, silty sandstone; and grey and purplish marl (in the upper part of the feature). Fossils from a pebbly grit (Loc. WA.2534) include Trigonia

(Indotrigonia) africana sp. nov., Gervillia (Gervillella) sp., and Astarte sp., none well preserved. Whitish, calcareous grits with I. africana occur immediately west of the Kikundi-Mchinjiri Fault between the Kiranjeranje road and the Mbemkuru.

South of the Mbemkuru River, Jurassic strata have not yet been observed immediately to the west of the Kikundi-Mchinjiri Fault during the recent survey. A short distance to the south of the area, however, Upper Kimmeridgian-Tithonian strata occur in the neighbourhood of Matapwa and the outcrop probably extends northwards along the western side of the Mchinjiri Valley into the unmapped Lipogiro area. Janensch (1914a, p.50) and Parkinson (1930a, p.11) record bone-bearing sandstones close to Niongala Village, presumably one of the three Jurassic dinosaur-bearing beds of the Tendaguru Series (probably the Upper Saurian Bed). These are evidently close to the valley floor, and, according to Parkinson, pass below the alluvium of the Mbemkuru River. Their position is uncertain, and they are not indicated on the accompanying map.

Mtapaia Village stands on a low N.N.W.-S.S.E. ridge with a W.S.W. facing scarp and a corresponding E.N.E. dip-slope, which can be traced for some miles south of the village. Flat lying Lower Cretaceous strata lie immediately to the east, but the ridge itself is supposed to be made up of Upper Kimmeridgian-Tithonian strata. The poorly exposed strata include fine, grey, marly sandstone; fine, white, soft-weathering sandstone; and bands of grey, or buff, calcareous, medium-grained, sometimes pebbly, gritty sandstone. No fossils have been obtained. Near the Mtapaia-Ruangwa road about two miles from the village, white, sandy, oolitic limestones and white, calcareous sandstones have yielded communities of Indotrigonia. The shells occur gregariously and include both I. africana and I. mandawae together with intermediate forms (see Part II, p. 73). It is assumed therefore that these strata are low in the Upper Kimmeridgian-Tithonian sequence.

Neocomian - Lower Aptian

Marine Lower Cretaceous strata in the area of the Makangaga-Ruawa anticline are known only at the south of this structure, and can conveniently be dealt with along with those of the Mbemkuru area as a whole. In the type area of the Tendaguru Series, Janensch (1914c, p.228) gave the thickness of the Trigonia schwarzi Bed as five metres, but elsewhere in the Mbemkuru area, the thickness of strata assigned to the bed by other authors far exceeds this.

The Mbemkuru area has not been mapped in great detail, and the distribution of marine Neocomian - Lower Aptian beds shown on the map, is based to some extent on air-photograph interpretation. Confirmatory traverses have been made in the Turikira, Kongoningo, Kikundi, Itukuru (S.E. and S.W.), Mtapaia-Mchinjiri and Niongala areas.

Fossils previously recorded from the strata are listed elsewhere (Quennell, McKinlay and Aitken, 1956 - under "Trigonia schwarzi Bed").

For the most part the succession is arenaceous, made up of calcareous sandstones and grits, varying from fine to coarse, often pebbly, and frequently current-bedded. The determination of horizon within the sequence on the basis of lithology, is not practicable at present.

On the Turikira Ridge there is a succession of soft-weathering, medium-grained, buff, calcareous sandstones with numerous thin intercalations of more resistant, calcareous sandstones and occasionally of coarse grits. In one of these intercalations (Loc. WA.2492), a rather fine, buff, calcareous sandstone, with rounded quartz pebbles and enclosing small masses of coarse, calcareous grit, has yielded a large community of Megatrigonia (Rutitrigonia) turikirae sp. nov., together with Ptychomya sp., Astarte sp. and Gervillia (Gervillella) sp.. In the Turikira area, the boundary between the Lower Cretaceous and the Upper Jurassic is not clear from the lithology, though some purple marl occurs in the latter, and grits are more prominent.

Marine Neocomian - Lower Aptian beds outcrop along the south of the Ngarama Plateau, though their distinction from the Jurassic is again not clear. No fossiliferous strata were observed during the recent survey, but Hennig (1914a, p.116; 1937a, p.118) recorded the "Ntandi fauna" (though without Trigoniids) from near Runjo. The exact locality of this occurrence is unknown as Runjo Village no longer exists, but it apparently lies south-west of Kongoningo Hill. On the approach to this hill from the south, isolated exposures of coarse, sometimes pebbly, whitish sandstone have been observed presumably of the Lower Cretaceous. In the absence of satisfactory observations on the recent survey, Hennig's (1937a, p.118) record of the Lower Cretaceous sequence observed on a traverse from Tunduru to Kongoningo Hill is instructive:-

"220 m	Plateau rim of yellow sandstone, Makonde Sandstone.	
200 m	Coral limestone.	
185 m	Out-jutting limestone band, the material in which the Kongoningo ravine is cut.	Urgonian
155 m	Broad ribbed specimens of <u>Vola</u>, large specimens of <u>Alectryonia</u>, oysters.	<u>schwarzi-</u> <u>bornhardti</u> stage.
130 m	Kikomolerantwe Village; sandy soil.	
125 m	Runjo Village: level area. Friable sandstone, hard, fine-grained sandstone with silicified wood.	
110-115 m	Very coarse conglomerate, ferruginous crust, distinctly oolitic step."	

No good section on the eastern side of the Pindiro-Kihimbwi Valley has been observed. Dark red, medium-grained sandstones (Makonde Beds) occur near the top of the rise from

Ruawa to the Ngarama Plateau, but loose sand screens the remainder of the slope. The same applies to the slopes up to the plateau north of Namateure Hill. Red sandstones outcrop to low levels on the west side of Namateure Hill and marine Lower Cretaceous does not seem to occur below (cf. Hennig, 1937a, fig.1).

At the south of the Makangaga - Ruawa area, marine strata supposed to belong to the Lower Cretaceous occur about valley level to the east and south-east of Itukuri Village. The strata are poorly exposed in gullies running east from the ridge followed by the path to Itukuri Village from the road near the crossing of the Kihimbwi Stream near Makangaga. The sequence is made up of fine, whitish, sometimes friable, calcareous sandstones; grey, marly sandstones with occasional large, flattened, ovoid, calcareous concretions; medium-grained, ill-sorted, brownish and buff weathered, calcareous sandstone with fine calcite veining, the development of small masses of crystalline calcite and "ghost crystals" of calcite; medium-grained to coarse, calcareous sandstones with rounded quartz pebbles up to one inch in diameter. Just across the Kihimbwi Stream from these supposed Cretaceous exposures, on the western slope of the hillock on which Tunduru Village is situated (Loc. WA.2499), boulders of fine, whitish-buff, calcareous, shelly sandstone occur. The rock has not been seen in place but presumably makes up part of the sequence forming the southern end of the hillock. The fossils recognised, Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov., M. (Rutitrigonia) cf. krenkeli (Lange), Astarte stuhlmanni (Müller), are Trigonia schwarzi Bed forms, and the beds are supposed to be equivalent to strata to the west of the Kihimbwi. No fossils have been observed in the strata immediately west of the Kihimbwi Stream, however.

The beds appear to be nearly horizontal. If the strata at Itukuru and Tunduru are in fact equivalent, the movement of the fault passing between the two localities must have occurred, for the most part, before the deposition of the Cretaceous beds. Faulting present in the disturbed Jurassic strata in the Itukuri Village area has not been seen to extend into the area of the Cretaceous rocks. Angular unconformity appears to separate the two series.

On the steep south-eastern slope of the Itukuru Plateau in the Makumba Stream (not the stream of that name shown by Hennig, 1937a, fig.17) west of Makangaga, a section of over 70 feet of marine Lower Cretaceous strata is exposed below Makonde Beds. The base of the section is about 100 feet above the alluvial flats of the Kihimbwi Stream. The lower part of the section (ca. 30 ft.) consists of grey-white, fine, marly sandstones with hard ribs of fine, grey-brown, very calcareous, silty sandstone. In one such rib, a community of Megatrigonia (Rutitrigonia) schwarzi Müller has been found (Loc. WA.2415). Overlying this is a thickness of about 25 feet of fine, whitish, calcareous sandstones, usually hard, but occasionally slightly friable. A band in the lower part of this sandstone has yielded a community of Megatrigonia (Rutitrigonia) krenkeli Lange (Loc. WA.2416 about 20 feet above the R. schwarzi locality). The fossiliferous band contains occasional small pebbles of soft, brownish, fine, marly sandstone, and is tinged red in places.

The top of the fine sandstone sequence is marked by a band of gastropod limestone. The turreted gastropods make up about 75% of the rock, and the interstitial sediment is fine, brownish-stained sandstone. Again there are occasional pebbles of brownish, marly sandstone. About one foot of the band is exposed, which is probably the whole thickness. The gastropods weather out of the rock more or less complete and occur in large numbers in the stream bed near the outcrop (Loc. WA.2491).

Overlying this fossil band is a thickness of about 30 feet of coarse, white sandstone, of which the plentiful matrix is pure milky calcite. Occasional fossil fragments occur, and a specimen of Rutitrigonia krenkeli has been noted (Loc. WA.2466). The sandstone is massive and occurs in bands up to 10 feet in thickness, some of which are strongly cross-bedded. There are strong, open joints similar to joints in a limestone.

The top of the coarse sandstone forms a distinct step feature and there are no further exposures upstream in the Makumba Stream, but boulders of reddish-purple and brick-red, fine and medium-grained sandstone occur, belonging to the Makonde Beds. To the west of the Pindiro-Kihimbwi Valley, north of Itukuri Village, Lower Cretaceous strata below the Makonde Beds have not been observed.

In the Kikundi area immediately east of the confluence of the Kihimbwi with the Mbemkuru River, a small scarp and dip-slope feature occurs in Jurassic strata (see p.110) with flat-lying Lower Cretaceous beds resting on the dip-slope (see Plate XIII). The Lower Cretaceous beds include soft-weathering, fine, buff, sometimes cross-bedded sandstone; and hard, medium and coarse-grained, calcareous sandstones, sometimes gritty or pebbly. A locality in the upper part of the sequence has yielded: Lytoceras cf. hennigi Zwierzcki; Corbis (Sphaera) corrugata Sowerby and Megatrigonia (Rutitrigonia) cf. bornhardti Müller (Loc. WA.2535). From a point where the Mbemkuru River cuts into the south-west side of the hillocky Lower Cretaceous area, M. (Rutitrigonia) aff. nyangensis sp. nov. and Linotrigonia sp. have been found (Loc. WA.2498).

The occurrence recorded by Hennig (1937a, fig.1 and map in Branca et al., 1914/16) of the Trigonia schwarzi Bed both to the north and to the south-west of Mto Nyangi, is apparently not due to repetition by faulting as he suggests. In the Makumba Stream, the flat-lying marine strata extend to almost 200 feet above the Mbemkuru Valley floor. They probably also outcrop, therefore, in the valley cutting the centre of the

Itukuru area, but are separated by the Makonde Beds forming the rim of the Itukuru Plateau, from the Lower Cretaceous outcrops south-west of Mto Nyangi. The occurrence of the marine Lower Cretaceous in the valley in the centre of the Itukuru area, presumably accounts for Dietrich's record (see Hennig, 1937a, p.116) of Trigonia schwarzi Bed gastropods "between the Itukuru and Mbalawala plateaux".

South-west of the Itukuru Plateau, marine Lower Cretaceous strata extend down to the level of the Mbemkuru flats, but the upper part of the marine sequence is concealed by outwash sands from the plateau. West of the cultivated area around Mto Nyangi, near the road about a mile west of the lake, hard, reddish, calcareous, medium-grained sandstones occur with lenses of coarse grit. A little further west, in the sides of a flat-bottomed valley tributary to the Mbemkuru, hard, reddish-purple, current-bedded grits in bands and lenses up to four feet thick, associated with reddish medium-grained calcareous sandstones have yielded numerous fossils including (Locs. WA.2459-2465): Astarte brancai Dietrich, Astarte sp., Cardium (Tendagurium) rothpletzi (Krenkel), Corbis (Sphaera) corrugata Sowerby, Lima (Plagiostoma) euplcea (Lange), Megatrigonia (Rutitrigonia) nyangensis sp. nov., M. (Rutitrigonia) nossae sp. nov., M. (Rutitrigonia) kigombona sp. nov., M. (Rutitrigonia) sp. juv. indet., Modiolus sp., Monopleura sp., Ostrea s. lato sp., Ptychomya sp., gastropods and belemnites. The grits contain irregular, rounded cobbles and small boulders of hard, medium-grained, sandstone, irregularly disposed.

Further to the west, not far from the Nossa Stream, reddish-purple, marly sandstones with bands of concretionary argillaceous limestone occur at a roadside exposure (about 12 feet exposed).

Just to the west of the Nossa Stream, fine, buff, marly sandstone occurs, with thin intercalations of hard, fine, calcareous sandstone. In the stream itself a few hundred yards upstream of the road crossing, rather rubbly, whitish, medium-grained, gritty calcareous sandstone with thin harder ribs has yielded numerous fossils. These include (Loc. WA.2494): Astarte brancai Dietrich, Astarte sp., Corbis (Sphaera) corrugata Sowerby, Exogyra cf. couloni (Defrance), Gervillia alaeformis Sowerby var. percrassa Müller, Megatrigonia (Rutitrigonia) nyangensis sp. nov., M. (Rutitrigonia) nossae sp. nov., M. (Rutitrigonia) cf. bornhardti (Müller), M. (Rutitrigonia) kigombona sp. nov., Yaadia hennigi (Lange), Ostrea (s. lato) sp.

Apart from the absence of ammonites, this fauna compares very closely to that from the well known locality of Niongala (see below, p.123) at which strata as young as Aptian have been recorded.

Just to the east of the mapped area, at a locality named as Mikadi in the Marihi Valley, large fossil collections made by Fraas were examined by Krenkel (1910a) and various authors described the collections from there made by the German Tendaguru Expedition. The Lower Cretaceous does not appear to extend to the west of the Marihi Valley in the area mapped, though some doubt exists as to the age of fine, whitish, calcareous sandstones and buff, pebbly sandstones outcropping at the road crossing of the valley. Lithologically these could be Lower Cretaceous or Upper Jurassic strata.

East of the Mohinjiri River, there is an extensive outcrop of Lower Cretaceous strata stretching to the Mtapaia area, exposed below an often considerable cover of superficial sands and gravels. This is the Lipogiro area, which extends some way south of the area mapped. That the Jurassic closely underlies the exposed Cretaceous is suggested by records (Janensch, 1914c, p.50; Parkinson, 1930a, p.11) of bone-bearing strata close to Niongala Village, presumably one of the three Jurassic dinosaur-bearing beds of the Tendaguru Series. These are evidently close to the valley floor and, according to Parkinson, pass below the alluvium of the Mbemkuru River. Their position is uncertain, and they are not indicated on the accompanying map (Plate II).

Near the top of the first steep rise off the alluvium on the road to the west of Mohinjiri is a thin conglomerate band (12" - 15") of angular cobbles and small flat boulders of hard, rather fine, calcareous sandstone in a fine calcareous sandstone matrix. Small quartz and felspar pebbles are also present and small flattened silstone pebbles. The conglomerate contains corals and fragmentarylamellibranch fossils. The underlying strata, fine, buff, marly sandstones with intercalations of harder medium-grained sandstone is quite typical of the Lower Cretaceous, so that in spite of the supposed proximity of Jurassic beds, it is unlikely that this is to be regarded as a basal conglomerate of the Cretaceous.

About mid-way between Mchinjiri and Mtapaia (Loc. WA.2500) a sandy, partly red-stained, detrital limestone with ooliths, outcrops in a band about four feet thick. This is not a usual feature of the succession. Thin-bedded, calcareous sandstones, usually fine-grained but with thin, coarse bands also, occur in association. These total about 20 feet and the ill-exposed strata below are soft, fine-grained, reddish and grey-green weathering, calcareous, silty sandstones. Fossils from the limestone include Cardium (Tendagurium) rothpletzi (Krenkel), Corbis (Sphaera) corrugata Sowerby, Hinnites (Prohinnites) fraasi (Krenkel), and Pecten (Neithea) lindiensis (Krenkel).

To the north of the road in the Niongala area, close to the Mbemkuru flats and not far west of the Kikundi occurrence of Lower Cretaceous north of the river, richly fossiliferous horizons are exposed. Niongala was an area from which Fraas (1908a) (see also Krenkel, 1910a), and the German and British Tendaguru Expeditions made large fossil collections. The strata there are grey-buff, fine and medium-grained, soft-weathering, calcareous sandstones with frequent bands of hard, gritty, calcareous sandstones which are often highly fossiliferous. Fossils in the present collection include (Locs. WA.584, 585, 777-779): Astarte spp., Cardium (Tendagurium) rothpletzi (Krenkel), Corbis (Sphaera) corrugata Sowerby, Corbis (Sphaera) sp., Exogyra cf. couloni Defrance, Hinnites sp., Megatrigonia (Rutitrigonia) nossae sp. nov., Ostrea sp., Pecten (Neithea) lindiensis (Krenkel), Pholadomya gigantea (Sowerby), Pinna (Stegoconcha) sp., Ptychomya sp., together with Nautilus cf. mikado Krenkel, N. cf. pseudoelegans Krenkel; Ancyloceras sp. and other ammonites; corals; and echinoids[1].

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1) Dr. E.D. Currie (Hunterian Museum, Glasgow University) has associated the echinoid specimens collected (personal communication) with the group of Pygurus productus Agassiz to which Krenkel (1910, p.202) compared a specimen from the same area. She has observed, however, that Lambert and Thiéry (1909-25) placed this group in a separate genus Astrolampas, though on the evidence available on the apical system, this separation does not seem justifiable.

Fossils previously reported from the area are listed elsewhere (Quennell, McKinlay and Aitken, 1956 - under "Niongala Beds"). Spath (1930, p.135) dated certain fossils collected by the British Tendaguru Expedition as Aptian (notably Ancyloceras), but Neocomian horizons may also be present in the area.

The western boundary of the Lower Cretaceous area mapped to the south of the Mbemkuru River is near Mtapaia, where the Lower Cretaceous rests unconformably on Jurassic strata. In the neighbourhood of the road, the usual lithological types are exposed east of the village - fine, buff, calcareous sandstones with bands of medium-grained or coarse, sometimes pebbly, grits and sandstones. From a locality in the lower course of the Mtapaia River, presumably north of Mtapaia Village, Hennig (1937a, p.117) recorded "Trigonia bornhardti" and "T. transitoria" [Megatrigonia (Rutitrigonia) bornhardti and Yaadia hennigi respectively, according to recent nomenclature].

Immediately east of the village (Loc. WA.2565), in coarse, grey, calcareous grit, M. (Rutitrigonia) turikirae sp. nov. appears in large numbers, and Yaadia hennigi, Ptychomya robinaldina d'Orbigny var. hauchecornei (Müller), and Astarte stuhlmanni Müller occur.

The lithology of the Lower Cretaceous in the vicinity of Mtapaia is rather different from that immediately to the north of the Mbemkuru River, i.e. close to the river flats south-west of the Itukuru area (Locs. WA.2459-2463). The faunas in the two areas are also distinct, though the difference in elevation at which the two flat-bedded sequences occur is negligible. It is suggested that there is possibly such an unconformity here as Spath (1939, p.140) suggested must occur within the Trigonia schwarzi Bed.

THE UPPER APTIAN

(a) Marine Upper Aptian.

Marine Upper Aptian strata appear to be confined to the eastern part of the area mapped. Folding and faulting of the earlier strata up to and including the Neocomian - Lower Aptian occurred in places before the deposition of the Upper Aptian. There is a marked change in lithology in the northern part of the area (where unconformity is clear) at the commencement of the new cycle of sedimentation, but this is less noticeable in the south, where clear evidence of unconformity between the Upper Aptian and the Neocomian - Lower Aptian is lacking.

Pure, massive, white, reef limestone forms a prominent part of the sequence along the east and south-east of the Ngarama Plateau but to the east of the Mandawa-Mahokondo anticline the apparently equivalent sequence contains arenaceous and argillaceous strata with some calc-arenites. It is known that to the north the Aptian limestones extend much further west than in the area mapped, and although grouped with the underlying Neocomian - Lower Aptian beds, the massive white sandstone with calcite matrix exposed in the Makumba Stream (see p.117) might belong to the Upper Aptian. The Upper Aptian limestones form part of the Kiturika Beds named by Hennig (1914a, p.237), of which the type area lies some miles to the north of the area mapped.

Their massive development along the eastern edge of the coastal plateaux probably indicates the proximity of the continental margin at the time of their development. There is, in fact, no evidence of post-Aptian marine transgression west of the line of the eastern margin of the plateaux and pre-Upper Aptian sediments west of this line are all of inshore or continental origin.

A series of marls outcrops near Nalwehe and further north below the limestones. These, which form much of the cultivated land in this vicinity, are grey-green, with scattered whitish septaria. Some slabby intercalations of fine white, calcareous sandstone and sandy limestone occur in the lower part of the sequence which probably is about 150 feet thick. No fossils have been observed. Although the marls do not seem to extend south of Nalwehe Hill, to the north they appear to be associated with the limestone sequence rather than the underlying Neocomian - Lower Aptian beds. They are possibly to be correlated with septarian marls which Hennig (1937a, p.121) recorded to the east of the Kiturika area. Probably the marls pass eastwards into the lower part of the argillaceous/arenaceous sequence with some calc-arenites, of supposed Upper Aptian age east of the Mandawa-Mahokondo anticline. In the Namitambo Stream section for example, the lower part of this eastern sequence is more argillaceous than the upper part.

The development of the Upper Aptian limestones and the exposed thickness, possibly about 200 feet, is less than in the type area of the Kiturika Beds near the Mavudyi River to the north, and on the Likonde Plateau to the south of the Mbemkuru, where thicknesses of over 500 feet have been recorded (Hennig, 1937a). There are a number of isolated occurrences of limestone to the east of the Ngarama Plateau around the southern end of the Mandawa-Mahokondo anticline, more similar to the limestones of the plateau than to the calc-arenites in the eastern facies of the Upper Aptian. These are discussed separately (p. 135).

White reef limestones with some calcarenites occur to the north and south of Nalwehe, and both types, the reefal limestones occasionally pinkish, occur along the eastern side of the Ngarama plateau, especially prominent in a series of small hills projecting from the plateau. These hills apparently stand as isolated masses due to erosion, but local reefal development may have contributed to their isolation. Weathering has sometimes left pinnacles and wall-like masses of limestone, but outwash sands from the plateau often blanket the outcrop area. South of the Njenga area, the outcrops cease for some distance, but south of the Nloweka Fault, strong limestone cliffs develop, and limestones have been observed as far round the plateau edge as Kongoningo Hill. Both calc-arenites and reefal limestones occur here also; the former, which are more common, are sometimes slightly oolitic. Orbitolina occurs frequently especially in the reefal type (e.g. Loc. WA.1720). Coral growths are comparatively rare but algal material is abundant. The limestones elsewhere have yielded a considerable fauna (see Quennell, McKinlay and Aitken, 1956 - under Kiturika Beds).

Orbitolina has not been encountered in pre-Upper Aptian strata in southern Tanganyika nor, so far, in strata proved to be younger than Aptian there (fide Dr. W.D.V. Jones of BP-Shell Petroleum Development Co., Ltd.) and this form is regarded tentatively as an indication of the Upper Aptian in the area. It is partly on this assumption that strata in the Namitambo Stream section, and further south along the eastern flank of the Mandawa-Mahokondo anticline have been assigned to the Upper Aptian. In the case of the Namitambo section, confirmation of the age has been obtained from microfaunas (fide R. Stoneley of the BP-Shell Petroleum Co., Ltd.).

In the Namitambo Stream the unconformity of the Upper Aptian on the equivalents of the Trigonia schwarzi Bed is at about the crossing of the Lindi-Kilwa road. There is no pronounced angular unconformity, but a slight reduction in the general angle of dip is apparent. The dips measured in the stream section are low and variable in direction. The lowest estimate of thicknesses of the Upper Aptian in the section is over 250 feet.

A coarse-grained, grey-brown, hard, calcareous, gritty sandstone about 12 feet thick, with "carious" weathering due to small, greenish, sandy marl inclusions, probably marks the base of the sequence. The lower part of the section, however, is made up mainly of soft grey-green marls, calcareous silts and fine or medium grained sandstones, with hard intercalations of up to about 12 inches, of fine, grey and whitish sandstones and argillaceous limestones. In a thin band of grey, medium grained calcareous sandstone, Orbitolina has been observed (Loc. WA.2051). Higher in the succession there is a greater proportion of whitish, calcareous sandstones, and calc-arenites, more or less contaminated by quartz grains, occur. More especially in the calc-arenites, but also in the sandstones, "carious" weathering sometimes occurs, due to the weathering out of small, generally ovoid inclusions as in the sandstone at the base of the sequence. Intra-formational erosion is indicated in several places by the presence of angular cobbles of sandstone or sandy limestone embedded in calcareous sandstone bands. Macro-fossils are rare [an ammonite (Loc. WA.2053) and fragmentary lamellibranch remains have been noted], but Orbitolina is common both in the calcareous sandstones and in the calc-arenites.

To the north of the Namitambo Stream section, the line of unconformity below the Upper Aptian crosses the Lindi-Kilwa road and runs along the base of the feature formed by the ? Neocomian, white, coralliferous limestone. The faulting that terminates the outcrop of the limestone does not appear to affect the Upper Aptian strata.

South of the Namitambo, between the Mpilipili and Kikundi streams, the outcrop of the ? Neocomian limestone is interrupted by overstep of Upper Aptian strata including highly calcareous sandstone and sandy, detrital limestone, both containing Orbitolina. One interval of limestone exceeds 25 feet in thickness. Ill-exposed, grey, sandy marls are also present.

There appears to be faulting in the area of this overstep as there is abrupt termination and swing of strike of the ? Neocomian limestone outcrop both to north and south of the Upper Aptian area. Moreover, easterly dips of 15° - 20° occur in the Upper Aptian, confined to this immediate area, possibly suggesting that a wedge of strata bounded by faults converging westwards has hinged downwards in post-Aptian times (as indicated in Plate II). If it exists, this faulting does not extend westwards as far as the road, however, and no off-set outcrop of the ? Neocomian limestone has been observed.

The outcrop of the Upper Aptian indicated on the map to the north of the Kimbarambara Stream is delineated on air-photograph interpretation, but specimens of Orbitolina in calcareous sandstones from the area south of the

Mkomangani Stream have confirmed the presence of these strata there (fide. R. Stoneley of the BP-Shell Petroleum Development Co., Ltd.).

The southward extension of the Upper Aptian east of the Ngirito fault is again mapped on the basis of air-photograph interpretation, there being few exposures. It is confirmed below the Upper Cretaceous marl sequence in a gully entering a tributary of the Lihimaliao Stream to the east of the Lindi-Kilwa road crossing of this stream. Here, Orbitolina occurs (Loc. WA.2326) in a conglomerate of small pebbles of weathered, sometimes ferruginised silts and fine sandstones in a fine, grey, calcareous sandstone matrix. A white limestone, largely reefal with numerous coral heads, overlies this conglomerate. The underlying strata are grey marls and fine, buff-weathering sandstones, for the most part. There are two bands of detrital limestone with coral heads in the sequence one about six feet in thickness, the other represented only by boulders, but Orbitolina has not been seen in either of these. Not far from the junction of the tributary with the Lihimaliao Stream, and apparently underlying the Orbitolina - bearing conglomerate, is an extensive outcrop of flat-lying, fine and medium-grained, calcareous sandstones with occasional unweathered sandstone pebbles in the sandstone matrix. There are worm-tubes in the fine sandstones in places. These rocks are also assigned to the Upper Aptian.

North of this tributary, close to the Ngirito Fault and almost on the watershed between the Kimbarambara and Lihimaliao drainage (Loc. WA.2330), is an isolated wall-like mass of whitish detrital limestone with numerous Orbitolina and containing broken remains of turreted gastropods. The exposure is about 25 feet long, 15 feet high and 12 feet wide at its widest point. The outcrop is of similar material to that forming a small outlier presumed to rest directly on Jurassic strata between the Mbaru Stream and the Lindi-Kilwa road north of the Lihimaliao crossing (Loc. WA.2329). This outlier takes the form of a small knoll of massive limestone blocks associated with a few boulders of calcareous sandstone. The relations of the two limestone occurrences are obscure.

In the Runyu inlier to the east of the southern culmination of the Mandawa-Mahokondo anticline, a hundred yards or so downstream of the pavement exposure (see p.97) of Neocomian - Lower Aptian strata, there are Orbitolina-bearing beds. A bedding plane of gently dipping, fine, grey, calcareous sandstone with scattered clay pellets is overlain by a three-foot thick band of slightly sandy, grey-buff, detrital limestone with small irregular green clay intrusions which give it a cavitied appearance on weathering. This limestone contains Orbitolina (Loc. WA.1654). The relation of the Upper Aptian to the older beds is not clear, but the low dips present suggest disconformity and not faulting.

Around the southern end of the Mandawa-Mahokondo anticline, and extending southwards to the Mtande area, there are a number of known outcrops of Upper Aptian strata, but their relations are not very clear. The interpretation given in Plate II of the geology of this area is tentative, and takes into account datings of samples on microfaunal evidence supplied by the BP-Shell Petroleum Development Co., Ltd. through Mr. R. Stoneley, in collaboration with whom the interpretation of the geology was prepared.

Exposures in the area are poor and the argillaceous and fine arenaceous facies of parts of both the Neocomian - Lower Aptian sequence and the Upper Aptian makes differentiation difficult. There are, however, a number of limestones containing Orbitolina which can be satisfactorily dated. The most notable of these is at Namarombe Hill (Loc. WA.1799) where massive, white, detrital and reefal limestones with some associated fine, calcareous sandstone occur. This apparently local development of massive reefal limestone may be a reef knoll. In the Lihange area, a thin band of grey-white detrital limestone with Orbitolina (Loc. WA.2361) associated with a coarse calc-arenite containing small, rounded, quartz pebbles, occurs in an essentially argillaceous sequence. There are other limestones in the area, of similar appearance, however, in which Orbitolina has not been observed (see p.97 above), which may belong to the Neocomian-

Lower Aptian succession.

The relation between the Upper Aptian limestones of the southern end of the Ngarama Plateau, on Nahumba Hill, etc. and the outcrops at lower levels between Kindole and Mtande is not clear. Probably a monoclinal fold or faulting accounts for the difference in elevation. The eastward change from limestones on the high ground to the west to a more argillaceous facies with thin limestones in the east would mask the effect of this supposed structure to some extent. However, the apparent absence of Jurassic strata east of the Turikira Ridge, while they occur quite high on its western slopes is an indication of downwarping, and eastward dips can be detected on air photographs on and near Nahumba Hill.

(b) Makonde Beds

The Makonde Beds, originally described as Upper Cretaceous by Bornhardt (1900) were regarded as a continental equivalent of the Aptian Kiturika Beds by Hennig (1914a, 1916b, 1937a). Evidence for intercalation of the two facies supposed by Hennig, or of passage from one to the other has not been observed in the area mapped, where the beds have not been dated other than as Aptian or post-Aptian.

The beds have been seen in situ only in the western flank of the Ngarama Plateau, on Namateure Hill and in the Mbalawala and Itukuru areas. They have not been recognised in the areas adjacent to the Mbemkuru River (in the "Niongala Scholle") where Hennig (1937a, fig.1) mapped them. Hennig (1937a, p.118) assigned yellow sandstones overlying Aptian limestones at the southern end of the Ngarama Plateau to the Makonde Beds. Red sandstone again overlies Aptian limestones on the west of the plateau a few miles to the north of Namateure outside the area mapped. All the Makonde Beds strata observed in the mapped area have been in colours of red or red-brown, but elsewhere, for example in the Namgaru Valley to the south, grey-white strata occur. No extensive silicified horizon such as is present in the Makonde Plateau (the Newala Sandstone) occurs in the area.

Reddish-purple and brick red, fine and medium-grained sandstone, sometimes finely colour banded, and purple, ochreous mudstones occur near the top of the flat-topped ridge at the south-east of the Itukuru area. Sandstone boulders of the same type appear in the Makumba Stream section above the marine Lower Cretaceous strata there. North of Itukuri Village, the marine Lower Cretaceous has not been observed on the western side of the Pindiro-Kihimbwi Valley, due to the transgression of the Makonde Beds. A blanket of loose sands conceals the actual boundary of the plateau-forming strata, but there is usually an abrupt change of slope to indicate its position. Brick-red and reddish-purple, fine-grained sandstones outcrop about half a mile upstream of Bwatabwata Village to the west of the Pindiro Valley. There are cliff exposures of massive horizontal beds about 50 feet above the valley bottom and there is no other rock type occurring on the scree slopes below. Pindiro Shales occur on the other side of the narrow valley and the Makonde Beds apparently rest directly on these. The Makonde Beds here are at a much lower elevation than the marine Lower Cretaceous in the Makumba Stream.

Dark-red, medium-grained, massive sandstones occur near the top of the rise from Ruawa Village to the Ngarama Plateau, but loose sand screens the remainder of the slope. The same applies to the slopes up to the plateau immediately north of Namateure Hill. Makonde Beds outcrop to low levels on the western side of Namateure Hill, with no marine Lower Cretaceous apparent below them, though there are no exposures on the lowermost slopes. Hennig (1937a, fig.1) showed the occurrence of Neocomian strata on Namateure, but he did not indicate any traverse to the hill. Air photographs suggest that a thin cover of Makonde Beds or of the sand cover that blankets the plateau to the east, extends on to the eastern end of the Nambango-Ndondonga Ridge. Around the south and south-west of the Itukuru area, the Makonde Beds, which apparently form the southern rim of this "plateau", have not been seen in place, but boulders (including silicified mudstones near Mto Nyangi) indicate that the lithology is typical.

Hennig (1937a) has recorded passage upwards from the Trigonia schwarzi Bed into both the Kiturika Beds (Upper Aptian) and the Makonde Beds at different localities in the Lindi-Kilwa Hinterland.

In the Makangaga-Ruawa area, however, the Makonde Beds rest on horizontal marine Lower Cretaceous at the south-east of the Itukuru Plateau and at an elevation about 130 feet lower, rest on Pindiro Shales near Bwatabwata Village two miles to the north. There is no suggestion that the Makonde Beds are faulted or change from their horizontal attitude, and it is supposed that they were laid down on an uneven surface of Jurassic and Lower Cretaceous strata. Overstep of Aptian limestones, not younger than the Makonde Beds, on to folded, faulted and eroded Jurassic and Neocomian-Lower Aptian strata in the Mandawa-Mahokondo area has been established. Locally, therefore, there is not an upward passage from the Trigonia schwarzi Bed, either to the Kiturika Beds or to the Makonde Beds. The lateral passage of the Makonde Beds into the Kiturika Beds cannot be established in the area. From their elevation, part of the Makonde Beds is clearly younger than the highest Kiturika Beds there. There is no suggestion of differences in elevation on the pre-Kiturika Beds surface along the eastern side of the Ngarama Plateau as large or abrupt as on the pre-Makonde Beds surface in the Makangaga-Ruawa area. The unconformity below the Makonde Beds is possibly greater than could be expected to occur between the Lower and Upper Aptian. If Hennig's belief that the Kiturika Beds and the Makonde are intercalated in places is at all open to question, it could be supposed that the Makonde Beds are wholly younger than the others. It would be acceptable on air photograph interpretation of the area of the Coastal Plateaux as a whole, to suppose that the considerable features formed by the Upper Aptian limestones have been "swamped" by a later continental sands series. This suggestion cannot be pressed too far however, since the capping of loose sands on the plateaux could induce this appearance. Parkinson (1930a, p.16) on the basis of a comparison between the heavy mineral suites from the Tendaguru Beds and the Makonde Beds just south of the area recently examined, was able to say: "the evidence so far as it goes, supports the suggestion that the Makonde Series of this district is in reality much younger than hitherto supposed" and, (p.8) that "the Makonde Beds .... may be, in part, the much younger Mikindani Sands." Parkinson's evidence possibly relates only to the unconsolidated material that caps the plateaux, but the argument he advances may still have some force, since the capping of the plateaux is probably derived from the Makonde Beds.

THE ALBIAN AND UPPER CRETACEOUS

The Albian occurs as an overstepping series, itself largely overstepped by Upper Cretaceous strata. In the area of the Kikundi Stream (Mandawa-Mahokondo area) it rests unconformably on Neocomian - Lower Aptian Beds. The bulk of the strata are green marls, but there are intercalations, up to about eight inches in thickness, of fine, hard, buff weathering, grey-cored, calcareous, ripple marked sandstone with worm tracks and fucoid markings. Close to the unconformity, high dips occur, but these are evidently very local, and just downstream the dip is only in the order of 2° to the east. The strata form the base of a green marl sequence with some sandstone intercalations throughout, extending through the whole Upper Cretaceous. This sequence, which appears to "feather-out" against a positive area of Jurassic and Lower Cretaceous to the west, has been dated, and the boundaries within it have been determined on microfaunal evidence by the BP-Shell Petroleum Development Company of Tanganyika, Limited.

THE CAINOZOIC

(a) Paleogene

To the east of the belt of Upper Cretaceous marl country, which is between two and three miles wide in the area mapped, there is an almost continuous scarp capped by white foraminiferal Paleocene limestones. This enters the area at several places. At Mtumbuka Hill, the western scarp face is largely of green marl, probably of the Upper Cretaceous sequence, but further to the north, east of Mitole, the foraminiferal limestones, with intercalated marls, descend to low levels in the scarp.

(b) Neogene

Presumed Neogene deposits (not depicted on Plate II) cap the Ngarama and Mbalawala plateaux and the high ground of the Itukuru area. These are whitish and orange sands of unknown thickness which blanket the slopes leading to the plateaux and often conceal the boundaries of underlying formations. In suggesting that the Makonde Beds as mapped by Hennig (1914a) may be, in part, the much younger Mikindani Beds, Parkinson (1930a, p.8) may have been considering Neogene sands overlying the true Makonde Beds.

Surface sands and gravels occur widely south of the Mbemkuru River in the Lipogiro area, and mask the underlying rocks to some extent. Hennig (1914a, p.11) named these the Lipogiro Gravels. They were described as being confined to a distinct land surface, sometimes forming gravel beds, but usually present only as a thin gravel spread as the result of erosion. Bedded gravels may have been deposited on a fairly level surface but the thin gravel spread which occurs widely throughout the area mapped, does not appear to conform to any particular level. The gravel spread is often of small quartz pebbles in a sandy matrix, but sometimes a spread of rounded quartz pebbles of up to two inches in diameter occurs and more angular pebbles of felspar and metamorphic rocks are common.

Reddish sands and fine gravels occur on the watersheds in the area of the Turikira Ridge and at the highest point on the road crossing the Minyoka area, dark red-purple boulders of a highly laterized, sometimes pebbly sand occur. Similar material has been observed in the Itukuru area and to the east of the Ngarama Plateau near Njenga, but not in large masses.

In the Kikundi area near the Mbemkuru River, in a gravel spread capping the hillocky country of Lower Cretaceous sediments, a stone implement made of a purple quartzitic sandstone has been found (Loc. WA.2536). Another has been found near the Lindi-Kilwa road half a mile south of the Mandawa River crossing (Loc. WA.2580), and on the path to Mbambala Hill from the Matapua/Mtapaia road fork in the Ukulinga area (Loc. WA.2559), numerous implements and flakes of purple and brown quartzitic sandstone and occasionally of chalcedonic silica, mark a factory site.

LOCAL CORRELATIONS

(a) Mandawa-Mahokondo Series.

Correlation (see Plate VIII) between the Mandawa-Mahokondo and Makangaga-Ruawa outcrops is largely on the basis of lithology. This is sufficiently distinctive in the case of the Pindiro Shales. The Callovian has been confirmed in the Makangaga-Ruawa area (fide R. Stoneley) by determinations of fossil molluscs by Dr. L.R. Cox obtained by the BP-Shell Petroleum Development Co.Ltd., and the correlation of the overlying marl unit with part of the Septarian Marl is therefore fairly acceptable. The completely different sequence in the two areas in the strata lying immediately below the Middle Kimmeridgian - Tithonian sequence makes correlation obscure, but it is supposed that uplift in the Ruawa area gave rise to a change in facies there in the later part of the period occupied by deposition of the Septarian Marl in the Mandawa-Mahokondo area. It has been assumed above (p.98) that an unconformity present in the north of the Makangaga-Ruawa area lies above the purple marl unit. It could also lie within it, and the purple marl exposed to the south of the Matarawe Stream (see p.75) could then be conveniently correlated with that to the north; but the unconformity is more likely to coincide with an abrupt change of facies.

(b) Tendaguru Series and Upper Aptian

The type section of the Tendaguru Beds is partly a littoral sequence, partly estuarine or continental. The succession is thin as compared with equivalent, more wholly marine sections to the east. Hennig (1914a, 1937a) attempted correlations throughout and beyond the area presently described, and aspects of correlation have been discussed by several authors as outlined previously (p.19 <u>et seq.</u>). In view of the nature of the type section, it is not easy to prove equivalence of strata elsewhere to members of the sequence there.

Hennig's mis-correlation of the succession in the Mandawa-Mahokondo area with that at Tendaguru has been commented on above. This was based on several misconceptions: that the Septarian Marl was equivalent to the Middle Saurian Bed (in this following Dietrich, 1925a); that the strata with Nerineids in the two areas, now known to be of widely different ages, were equivalent; that a community of <u>Indotrigonia</u> below a strong oolite in the Mandawa Stream section was equivalent to the community in the "<u>Trigonia smeei</u>" Bed at Tendaguru, and hence that this oolite was younger than the "<u>Trigonia smeei</u>" Bed and equivalent to the Upper Saurian Bed at Tendaguru.

It can be demonstrated (see Pt.II) that communities of <u>Indotrigonia</u> below the oolite sequence at Mandawa

(I. mandawae sp. nov.) are specifically distinct from those in the upper part of and above the oolite (I. africana sp. nov.). I. africana is substantially the same as the specimens hitherto described as Trigonia (Indotrigonia) smeei in the "Trigonia smeei" Bed of the type area of the Tendaguru Series.

Oolite does not actually enter into the sequence in the immediate vicinity of Tendaguru, though it occurs nearby to the north-east in the Mtapaia area, and has been recorded by Janensch and Hennig (1914, p.5) from the Maimbwi Stream to the south-west.

Only a single specimen of Indotrigonia has been obtained from the lower part of the oolite in the Mandawa-Mahokondo area (Loc. WA.2542), and this is intermediate between I. mandawae and I. africana. A community from low in the oolite sequence east of Lake Mbuo in the Makangaga-Ruawa area (Loc. WA.2547) also contains "intermediate" forms, though many of the specimens can be assigned to I. africana. The same applies to a community from about the same level south of the Matarawe-Ruawa confluence (Loc. WA.2544). I. mandawae has been obtained from below the oolite in the Ndondonga area (Loc. WA.2535) and in the lowermost part of the oolite sequence at the entrance to the Mbemkuru gorge at the south-west of the Minyoka area (Loc. WA.2556) both I. aff. mandawae and I. aff. africana occur. From the oolite near Mtapaia (Locs. WA.582 and WA.781) communities have been obtained (see Pt.II, p.73) containing forms intermediate between _I. mandawae_ and _I. africana_, though generally more closely related to one or other of these.

No specimen has been figured from the Tendaguru area strictly comparable to _I. mandawae_, though a specimen apparently from low in the sequence there is similar to this (Lange, 1914, Pl.XXI, fig.1a). From the Tingutinguti, a stream descending from Tendaguru Hill, some way below the outcrop of the "_Trigonia smeei_" Bed (which is represented by the "_smeei-pflaster_" indicated by Hennig (1937a, fig.3b), and apparently from the outcrop area of the _Nerinea_ Bed, specimens of _Indotrigonia_ intermediate between _I. africana_ and _I. mandawae_ have been collected (Loc. WA.767) that can be matched in the community from the oolite near Mtapaia. The "_smeei-pflaster_" in the Tingutinguti (Loc. WA.766 - see Pt.II, p.72) contains only _I. africana_ or specimens close to this.

The distribution of _I. mandawae_, _I. africana_ and intermediate forms with relation to the local base of the oolite sequence suggests that oolite sedimentation commenced at about the same horizon over a widespread area in pre-"_Trigonia smeei_" Bed times, probably at an horizon in the _Nerinea_ Bed.

The correlations within the Jurassic portion of the Tendaguru Series as shown in Plate VIII, are made on these assumptions.

A palaeontological break exists below the Neocomian - Lower Aptian subdivision. It is convenient to regard this as dividing the Jurassic from the Cretaceous, but it is not improbable in view of the presence of several normally Cretaceous lamellibranchs (see p.188) - though admittedly, some of these cannot be other than Jurassic - that the Jurassic cycle of deposition extended into the lowermost Cretaceous.

The thickness of the Lower Cretaceous Trigonia schwarzi Bed at Tendaguru was given by Janensch (1914c) as 5 metres (about 16½ feet), and the age of its base within the Neocomian or Lower Aptian is not known. A much greater thickness is present elsewhere, but the age limits of any particular section of the Lower Cretaceous in the area mapped is uncertain, though Niongala is the only locality from which Aptian ammonites have been recorded. No Cretaceous ammonites older than Hauterivian have been described (Spath, 1930, 1927-33, 1939). Angular unconformity occurs at several places below the marine Lower Cretaceous, and the view is accepted that the palaeontological break reflects a widespread physical break in the Mesozoic sequence. Uneveness of the post-Jurassic surface on which the Lower Cretaceous was deposited may have affected the age of the local base of the Cretaceous. The angular unconformity that exists between Jurassic and Cretaceous in parts of the Mbemkuru River depression is not apparent in the north of the Mandawa-

Mahokondo area where direct evidence of a stratigraphical break is obscure. A break is apparent in the south of this area however.

Insufficient data are available to indicate what use the abundant Trigoniids might be in correlation in the Lower Cretaceous. A few pointers are available, however. Megatrigonia (Rutitrigonia) bornhardti (Müller) and R. schwarzi (Müller) have been said to be mutually exclusive and Hennig (1937a, p.116) considered that the former is older, though this was not Dietrich's (1933a, p.78) view. The conception of R. schwarzi has been modified (see Part II, p.180) and specimens that are now assigned to the three species R. schwarzi Müller, R. nyangensis sp. nov. and R. nossae sp. nov. were formerly grouped as R. schwarzi. R. schwarzi s. str. has been observed at only one locality (Loc. WA.2415 in the Makumba Stream) apparently at a higher horizon than the other species, and almost certainly in the Aptian. R. bornhardti has not been seen in association with R. schwarzi but a poor specimen comparable to it is associated with R. nyangensis and R. nossae from the Nossa Stream (Loc. WA. 2494). It may be quite true to say, however, that R. bornhardti occurs gregariously only at lower horizons than the group of R. schwarzi. The possibility is to be considered that the single specimen from the Nossa Stream and one from the Kikundi area (Loc. WA.2535) which might also come from above the usual horizon of R. bornhardti are derived fossils, but there is no direct evidence of this. Both in the Turikira area and at Mtapaia, R. turikirae occurs near the local base of the Neocomian - Lower Aptian and may be a variant of the R. bornhardti stock confined to a particular level in the sequence.

As far as it goes, the greater part of the evidence points to R. krenkeli (Lange) being younger than the similar but more elongate R. kigombona sp. nov., but the single specimen of the former recorded from near Tunduru Village (Loc. WA.2499) leaves this in doubt. The locality of the only known considerable community of R. krenkeli (Loc. WA. 2416) is slightly above that of R. schwarzi in the Makumba Stream. Yaadia hennigi occurs in association with R. turikirae near Mtapaia and with R. nossae, R. nyangensis and R. kigombona a short distance to the north.

It seems probable that a further study of the distribution of Rutitrigonia would enable a definite subdivision of the Trigonia schwarzi Bed (of the whole of which, R. schwarzi s. str. is not typical), and possibly the terms Niongala Beds and Ntandi Beds of Fraas (1908b), now abandoned, might conveniently be revived.

Spath (1930, p.135) remarked of the strata assigned to the Trigonia schwarzi Bed that "There is apparently a conformable succession from the Hauterivian to the Aptian" but (1939, p.140) altered this view and said "The succession, moreover, is unlikely to be continuous from the lowest

Hauterivian through the Barremian into the Aptian, and probably includes only very fragmentary deposits of each of these formations."

Information is not at present available to show which of these opinions is correct. The presence of Lower Aptian at Niongala (Spath, 1930, p.135) which must lie close above the Jurassic in view of its low elevation and of Parkinson's (1930a, p.12) record of one of the Saurian Beds nearby, might support the second suggestion, assuming disconformities in the sequence. Also, most of the strata are of littoral origin, and gaps in the succession would be expected.

The lamellibranch assemblage in the Kigombo area is almost identical with that reported from Niongala, but no ammonites which at Niongala show that Aptian strata are present, have been encounteredthere. The assemblage is probably of the same age as the Niongala fauna, however, but the relation between it and the Rutitrigonia turikirae/ Yaadia hennigi fauna at Mtapaia (see p.124) is not clear. This might be an area in which there occurs such a disconformity as Spath (1939, p.140) suggested.

The facies of the Trigonia schwarzi Bed throughout the Mbemkuru area remains much the same, except in the Makumba Stream section which possibly includes higher horizons than have been observed elsewhere. East of the Turikira Ridge, a greater proportion of argillaceous material seems to enter the succession, but coarse grits occur to the most easterly outcrop in the Runyu Inlier, and also at the north-east of the Mandawa-Mahokondo anticline.

The question whether the Makonde Beds and the Upper Aptian Kiturika Beds are approximately equivalent is unresolved. Hennig's evidence suggesting the equivalence did not come from the area under discussion, in which the Makonde Beds would appear to be the younger formation.

It remains to be emphasised that the assignment of all the Orbitolina-bearing strata long the east of the Mandawa-Mahokondo area to the Upper Aptian (see p.129 above) still requires confirmation. Also the assumption that the arenaceous/argillaceous facies there is exactly equivalent to the limestone of the Kiturika Beds, and the underlying marls, requires complete demonstration.

STRUCTURE

(a) General

The interpretation of the structure of the area has been facilitated by the use of air photographs. There is pronounced structural control of the topography and marked "textural" differences can be distinguished on the air photographs between areas occupied by the main components of the sequence.

The outstanding structural features are the Mandawa-Mahokondo and the Makangaga-Ruawa anticlines. The structures lie en echelon, the axes running approximately NNW.-SSE., though in the former, the axis swings to nearly N.-S. in its southern part. Both structures are elongated domes and the Mandawa-Mahokondo anticline has two distinct culminations. In the cores of both structures, massive gypsum is exposed, and boreholes drilled by the BP-Shell Petroleum Development Company of Tanganyika, Limited, in the two culminations of the Mandawa-Mahokondo structure and in the Makangaga-Ruawa anticline, have penetrated an evaporite series (halite and anhydrite with some interbedded shale). Diapiric movement has contributed to an unknown extent in the formation of the anticlines, but the elongation of the structures, the regularity of outward dips and parallelism of the axes seem to indicate that lateral pressures have also been involved. Diapiric movements have led to a complicated fault pattern in the vicinity of the dome structures, probably even more complicated than is suggested by the map, especially in the Pindiro Shales.

Folding is largely restricted to the two anticlinal areas, and elsewhere, dips are low, though angular unconformity between Jurassic and Cretaceous strata can be detected in the Kikundi (Mbemkuru) and the Mtapaia areas. The Mbemkuru Depression between Mtapaia and the Kikundi-Mchinjiri Fault appears to represent an area of sag. The Runyu inlier to the east of the southern culmination of the Mandawa-Mahokondo structure probably indicates a separate uplift.

The relation between Jurassic and Cretaceous is more complicated than suggested by Aitken (1956c). An unconformity below the Upper Aptian is more clearly distinguishable than that below the local base of the Neocomian. Plate IX shows a hypothetical cross-section of the area, incorporating known surface data, with suggested relationships of concealed formations. Uprise of the metamorphic basement is indicated below each of the three main areas of uplift, but the rôle of the evaporites underlying the Makangaga-Ruawa and Mandawa-Mahokondo structures, and presumed to underlie the Runyu inlier, in the updoming, is recognised by the indication of local increase in the thickness of the Pindiro Shales containing the evaporites. Whether movement of salt into the region immediately above the axis of the tectonic uplift is likely, however, is a matter for speculation.

The presence of Karroo sediments below the exposed Jurassic is suggested since they outcrop in this position in the Matumbi area north of the Matandu River and in north Tanganyika and southern Kenya. Their presence in Madagascar, which presumably occupied a position on the other side of the basin of deposition (see pp.181-183), would also support the suggestion. If they are present, the position and nature of their junction with the metamorphic basement, whether they overlap as shown or are downfaulted against it, is unknown.

Hennig (1937a) supposed that a major flexure line runs down the eastern side of the Coastal Plateaux of Tanganyika, and related the Mandawa-Mahokondo anticline directly to this. There is no reason to doubt the existence of such a structural line - of flexuring or faulting - to north and south of the anticline, but the interconnection is not clear. No evidence has been adduced to suggest that there is faulting or strong flexuring along the east of the Ngarama Plateau, though south of the anticline, east of the Turikira ridge, some such structural feature exists (see p.135). The Upper Aptian east of the anticline is at a considerably lower level than the limestones on the plateau, though assymmetry of the anticline itself is not apparent in the dips recorded on the two flanks. The strong development of reef limestones along the eastern side of the Coastal Plateaux suggests proximity to the continental margin in

Upper Aptian times. There is no record of later Mesozoic or of Cainozoic marine sediments occurring to the west of this line, which probably was one of the main structures adjacent to the continental edge for a long period. Even in Jurassic times there is some difference in facies east and west of the line in that no continental beds occur to the east. The difference in the facies of the Lower-Middle Kimmeridgian, as between the Ruawa area and the Mandawa-Mahokondo area, however, is probably related not to the major structural line, but to differential uplift in the dome structures in the two areas.

(b) The Mandawa-Mahokondo Anticline

The Mandawa-Mahokondo anticline is essentially a simple structure, though there is a complicated fault pattern in its inner part. Strata from Bajocian (or older) to Neocomian (or Lower Aptian) are involved in the folding, while Upper Aptian strata are generally not more than slightly affected. There are distinct culminations at the northern and southern ends of the structure. The northward pitch in the Mahokondo area is much less steep than at the south in the Nondwa area. In the south the outcrops of successive beds of the Jurassic form a semi-circular pattern, and there is a tendency to the development of radial and ring faulting, giving the southern culmination the appearance of a piercement structure (see Plate X). The anticline is more or less symmetrical, with dips on either flank up to 20° - 25°, decreasing outwards.

The Pindiro Shales in both culminations exhibit high and confused dips and puckering of the strata is sometimes visible. Drag folding probably occurs. There is reversal of dip also in the ?Bathonian subdivision exposed in the Mkomore Stream, which suggests minor folding there in addition to faulting. The outlier of Septarian Marl on the western side of the saddle between the culminations, south of the Lonji Stream is mainly due to faulting, but there has apparently also been minor folding on a north-south axis.

The faulting in the anticline is most apparent in the core, and the strong escarpment formed by the Middle Kimmeridgian - Tithonian strata is virtually unbroken on the flanks, though faults cut it at the northern and southern ends of the structure.

A strong fault-zone, with down-throws to the west, follows roughly the axis of the fold. The amount of throw on the faults along this zone apparently varies rapidly. For example, on the western flank of the northern culmination, the Mkomore Fault has cut out some hundreds of feet of strata (Pindiro Shales and the overlying ?Bathonian sequence), while only two miles to the north, the junction of the Septarian Marl with the beds of the core, is only slightly off-set by the faulting. There is the alternative explanation here, that the greater part of the movement on this fault preceded the deposition of the Septarian Marl (see also p.64). However, a N.-S. fault bounds the eastern side of the Septarian Marl outlier south of the Lonji Stream. The movement on this fault apparently followed that on the NW.-SE. fault at the north of the outlier. SE. of the point where the fault lines meet, the NW.-SE. fault downthrows NE. while to the NW. it downthrows SW. The movement here is taken to have been reversed at the time of the N.-S. faulting.

NW.-SE. faults cross the "saddle" between the two culminations, their direction possibly being reflected in the difference of the directions of elongation of the two areas of updoming. These intersect the N.-S. axial faulting in the southern part of the structure.

The southern culmination is very highly disturbed. Radial and tangential faults are present and the N.-S. axial trend and the NW.-SE. fault trend all contribute to the pattern. The radial faulting at the south-west terminates at the Nloweka Fault which is associated with the tangential series, and on which the latest movement was post-Aptian.

At the south-east of the culmination a strong zig-zag fault-line with NW.-SE. and N.-S. directions, off-sets the Kimmeridgian - Tithonian oolite ridge. The NW.-SE. direction of this line where it cuts the ridge, is coincident with the radial direction from the southern culmination. The detail of the structure in this area is obscure. The present interpretation suggests that there was post-Tithonian movement on the fault, older than the earliest Cretaceous beds, followed by later movement affecting Lower Cretaceous strata. The latest movement on the fault, in post-Aptian times, may have affected only the southern part of its length where it is in continuation of the N.-S. Ngirito Fault.

A major fault running SW.-NE. (the Mahokondo Fault) cuts the structure at its north-west end (see Plate XI). This is probably a line of movement of importance beyond the immediate vicinity of the Mandawa-Mahokondo anticline. It may be continued in the Ruawa Fault in the Makangaga-Ruawa structure though the latest throw of this fault is in the opposite sense. The Mahokondo Fault downthrows to the north-west; it passes beneath Aptian strata in the Kiwawa area to the north-east, and west of Mkomore to the south-west. The relation of the outcrop of the Kimmeridgian-Tithonian oolite to that of the Neocomian "white coralliferous limestone" near this fault is not clear, since the former is much less arcuate than the latter. The faulting present, may be more complicated than the map indicates.

The effects of diapirism possibly continued over a considerable period and several of the known or postulated unconformities in the Jurassic - Cretaceous sequence may be related to it and have only local significance. Since the diapiric movement is likely to have been initiated by earth movements, compressional folding also may have begun at an early stage.

The high dips in the Pindiro Shales may be due to drag folding in these incompetent beds, not necessarily preceding the deposition of the overlying ?Bathonian sequence, but uplift and erosion before the deposition of the ?Bathonian beds is indicated by the conglomerate at their base in the Mkomore Stream section which contains occasional shale fragments. In the southern culmination of the structure the ?Bathonian sequence has not certainly been observed, and the Upper Bathonian/Callovian rocks apparently rest directly on the Pindiro Shales in the west of the Hondwa area, and also to the east of the Mbaru Stream.

There is no evidence of angular unconformity within the Upper Jurassic. However, fairly detailed fossil collection has not brought to light any Lower Oxfordian faunas, although good Upper Callovian and Upper Oxfordian ammonite faunas occur. A break in the sedimentation is therefore possible. The dated Upper Oxfordian localities are very few and in many places, the base of the Lower Kimmeridgian Septarian Marl (for example in the Nunga and Namakambi Streams - Locs. WA.2245 and 2309), is very close to dated Upper Callovian strata. It is therefore suggested that the Septarian Marl may be an over-stepping horizon, the underlying Oxfordian being in part removed by erosion. As mentioned above (p.157) movement on the Mkomore Fault might have largely preceded the deposition of the Septarian Marl. One or two faults, notably one in the vicinity of the Namakongoro Stream, off-set the base of the Septarian Marl, but not apparently the top of this subdivision. It is quite reasonable to suppose, however, that these die out within the marl sequence, as there appears to be normal passage into the overlying Middle Kimmeridgian. It is thought that the discrepancy between the sequences of about this age in the Mandawa-Mahokondo and the Makangaga-Ruawa structures (see p.73) is due to differential uplift.

The widespread development of oolites at about the Kimmeridgian-Tithonian junction, not only in the Mandawa-Mahokondo structure but throughout the area mapped, probably indicates a period when updoming was not in progress, but the succeeding alternation of coarse, pebbly beds and fine sandstones probably reflects minor movements, diapiric or otherwise, in the Tithonian. The white coralliferous limestone taken as the local base of the Neocomian and the overlying <u>Trigonia schwarzi</u> Bed strata, dip with the Tithonian strata, though there is probably a disconformity below the limestone (see p.91). At the south of the anticline, however, there is angular unconformity between the Kimmeridgian-Tithonian oolite sequence and Neocomian strata. The northern and southern culminations appear to have been uplifted independently, therefore.

There is marked unconformity below the Aptian which rests directly on the Jurassic in places. In the north of the structure, the Mahokondo Fault, which post-dated the folding there, apparently passes beneath Aptian strata near Kiwawa and west of Mkomore. At the south, however, movement on the Mloweka, Mbaru and Ngirito faults, presumably associated with uplift of the southern culmination, affects Aptian strata. This again suggests independent movement of the northern and southern culminations, though, apparently, there is minor faulting affecting Upper Aptian strata north of the Kikundi Stream (see p. 131).

(c) The Makangaga-Ruawa Anticline

The structure of the Makangaga-Ruawa area (see Plate XII) is interpreted as an anticlinal fold in Jurassic strata, closed to the north and south to form an elongated dome, broken by faulting, and only partly exposed under a cover of younger plateau-forming sediments.

As in the case of the neighbouring Mandawa-Mahokondo anticline, the core is occupied by the Pindiro Shales. The type area of these beds is in the Makangaga-Ruawa structure, and they outcrop over a wider area than in the other anticline. The shale sequence is highly disturbed. As in the Mandawa-Mahokondo area, the higher dips of the shales as compared to the overlying beds may not be due entirely to disturbance before the deposition of the younger strata, but may have resulted from drag folding in the incompetent rocks. The structure is regarded as having developed in the same way as the Mandawa-Mahokondo anticline. A less complete or less developed sequence is exposed above the shales, however, than in the Mandawa-Mahokondo area. This may be in part due to non-deposition, or to erosion and overstep within Bathonian - Lower Kimmeridgian strata, since the area is closer to the coastline of the Jurassic period than the Mandawa-Mahokondo area. However, overstep by Middle Kimmeridgian-Tithonian strata and some strike faulting has contributed to the absence of the older beds over much of the area. Undetected strike faulting may occur along the eastern boundary of the Pindiro Shale outcrop. The overstep of the Pindiro Shales by the Tendaguru Beds was noted by Hennig (1914a, 1937a). Hennig (1914a, p.50) originally believed that the higher strata were quite undisturbed but later (1937a, p.138 and figs.6 and 18) indicated that the Ngarama Plateau is the position of a synclinal axis. Recent work has shown that flat-lying Jurassic Tendaguru Beds are not present on the Pindiro-Kihimbwi Valley floor to the extent Hennig (1937a, fig.1) suggests. At all their outcrops, which generally form marked linear topographic features, these beds are outwardly dipping round the broken rim of the dome structure. The western flank of the dome is concealed below flat-lying Makonde Beds of the Mbalawala Plateau, but the southern "nose" is preserved in the oolites exposed in the Itukuri area.

At the northern end of the structure the sequence below the Middle-Upper Kimmeridgian sequence is more complete than further south, and divergence between the strikes of the Tendaguru Beds and the underlying strata suggests overstep following movement in about Middle Kimmeridgian times. The large NE.-SW. Ruawa Fault which is possibly a continuation of the Mahokondo Fault, though its latest throw is not in the same direction, has moved in different senses at different times. The exposure of the structure in Jurassic strata is too incomplete below the blanket of Makonde Beds for a full interpretation to be suggested, but downthrow to the north-west in about Middle Kimmeridgian times and the reverse movement in the Upper Tithonian or later (pre-Makonde Beds) seems to have occurred. The Middle Kimmeridgian-Tithonian strata had been laid down disconformably on the faulted and possibly updomed lower beds, and subsequently further updomed before this second phase of movement. The exact dating of the earlier fault movement with respect to the Kimmeridgian sequence is not certain, and it cannot be supposed that later updoming would be regular in a structure cut by such a fault line.

The Middle Kimmeridgian overstep probably accounts for the much smaller exposed thickness of strata between the Pindiro Shales and the Tendaguru Beds immediately south of the Ruawa Fault, than occurs to the north. Differential movement due to the fault, however, could have affected the deposition on its two sides.

As indicated by Hennig (1937a, fig.18), though not shown on his sketch map (his fig.1), there is faulting on the eastern side of the Pindiro-Kihimbwi Valley, in the Kikumiru area, separating the Pindiro Shales from the Tendaguru Beds. This faulting accounts for the termination of the NW.-SE. oolite ridge east of Lake Mbuo against the N.-S. ridge east of Tunduru Village, where the throw is to the west; to the south, the throw is reversed. Near Lake Mbuo, however, the Tendaguru Beds appear to rest unconformably on the Pindiro Shales, which in this area are very highly disturbed, though a strike-faulted contact is also possible. Hennig (1937a, fig.1, p.144) records an outlier of the "Trigonia smeei" Bed resting on the Pindiro Shales in this vicinity.

Marine Lower Cretaceous beds immediately to the south-west of the structure are apparently flat-lying and are certainly horizontal in the Makumba Stream (cf. Hennig, 1937a, fig.16, where a southerly dip of the Lower Cretaceous in the Itukuru area is indicated). South of Itukuri Village, therefore, where the southern "nose" of the structure in Jurassic rocks is visible, there is angular unconformity below the Cretaceous strata. It has not been established whether the marine Lower Cretaceous is involved in major faulting that is apparent in the Jurassic strata here. Minor faulting in the Jurassic immediately south of Itukuri Village does not appear to affect the supposed Lower Cretaceous there. It has been suggested, however (p.116), that at least the bulk of the movement on the Pindiro-Kikundi fault between Itukuri and Tunduru preceded the deposition of the Neocomian strata in this vicinity.

Except at Itukuri, Makonde Beds apparently rest directly on the Jurassic. The actual boundary is usually masked by a loose sand deposit, but there is usually a marked change in slope where the junction can be taken to lie. Off-setting of this line of junction by faulting is nowhere observed. As discussed, elsewhere, however, the Makonde Beds are undated and are possibly younger than the Aptian to which they have hitherto been assigned. The surface on which the Makonde Beds were laid down was of considerable relief, and they over-step on to strata of all the subdivisions of the Jurassic and dated Lower Cretaceous exposed in the area.

(d) The Mbemkuru and Adjacent Areas

Over the greater part of the Mbemkuru area, both Jurassic and Cretaceous strata are essentially flat-lying. In two localities, however, apart from that mentioned above near Itukuri, dip can be observed in Jurassic strata where immediately overlying Lower Cretaceous beds are horizontal. The first of these is in the Kikundi area immediately east of the confluence of the Kihimbwi with the Mbemkuru River (see p.110 and Plate XIII). A scarp and dip-slope feature in Jurassic strata occurs there, the dip being southwards.

The other is immediately south of Mtapaia Village, where Jurassic strata dip at a low angle beneath Lower Cretaceous beds (see p.111 and Plate XIV). The Jurassic strata flatten-off southwards. Another easterly dip-slope is seen on the air-photographs on the western side of the Mtapaia Valley. It can be confirmed on the ground in both cases that the overlying Lower Cretaceous strata are approximately horizontal, but the assumption that there is unconformity between the Jurassic and Cretaceous rests finally on air-photograph interpretation. The dip of the overlying strata has not been seen immediately adjacent to the contact with the Jurassic in either case. However, in the Kikundi area, there is no southward dip in Cretaceous strata about 100 yards south of the contact. Along the strike from the Mtapaia dip-slope feature, to the north of the Mbemkuru River, flat-lying Cretaceous strata can be seen at the south-west of the Itukuri area. Since dip-slopes presumably of Jurassic beds, are visible to the west, it is assumed that the overstepped Mtapaia dip-slope feature continues into this area, submerged by the Lower Cretaceous.

The most prominent faulting in the area is on the Kikundi-Nchinjiri line, which is marked by a strong fault-line scarp. Middle - Upper Kimmeridgian strata on the eastern upthrow side are faulted against Upper Kimmeridgian - Tithonian beds to the west. The throw is several hundred feet, but lessens to the north. The fault is slightly sinusoidal near the Mbemkuru River and unless even more marked curvature occurs further south the throw on the main fault must decrease southwards and be taken up by a parallel fault at the west of the Mchinjiri Valley. It is possible that instead of being sinusoidal, the fault is off-set by the Pindiro - Kikundi Fault. However, there seems to be no difference in level of apparently corresponding horizons immediately to the north and south of the Mbemkuru River east of the Kikundi - Mchinjiri Fault to suggest that the other fault continues along the line of the Mbemkuru. The Pindiro - Kikundi Fault apparently decreases in importance towards the east, but the line can be detected on the air photographs (see Plate XIII).

The strata east of the Kikundi - Mchinjiri Fault are low dipping. The level of the top of the oolite succession drops about 100 feet from the vicinity of the Matapua - Mchinjiri road fork to the Matarawe Stream to the east, indicating a dip of little more than $\frac{1}{2}^{\circ}$. North of the Mbemkuru along the Kiranjeranje-Makangaga road, the easterly dip is probably little more than this. However, where the Mbemkuru River breaks through the scarp a more pronounced dip is apparent (see Plate XIII), and the river breaks through between the Minyoka and Ukulinga areas along the axis of a slight undulation.

The dips recorded in the Turikira Stream close to the fault branching eastwards from the Kikundi - Mchinjiri line are anomalous, and suggest that the latest movement here may have been in a reverse direction to the greater part of the movement. The dips of the Jurassic strata appear to remain low as far as the Turikira Ridge. Since no Jurassic appears to the east of this ridge though it outcrops quite high on the western side, a downwarp or fault along the east of the ridge must be supposed, unless the Lower Cretaceous is banked against a Jurassic feature. Eastward dips detected on and near Mahumba Hill support the concept of a down-warp, which would be in continuation of the tectonic feature bounding the eastern side of the Coastal Plateaux (Hennig, 1937a) which is interrupted by the Mandawa - Mahokondo anticline.

The part of the Mbemkuru River depression immediately adjacent to the river has been discussed in reference to the "Niongala-Scholle" (Hennig, 1914a, 1937a; Parkinson, 1930a). This sunk land was postulated by Hennig (1914a, p.19) to account for the presence of Lower Cretaceous strata at the low elevation there. The sunk-land was supposed to be bounded to the north by an east-west fault passing through Mto Nyangi (at which a strong spring issues at the base of the Itukuru Plateau). The southern boundary fault was placed a little south of Niongala Village and the sunken block was shown to be terminated on the east by a north-south fault a mile or so west of the confluence of the Mchinjiri and the Mbemkuru. The westward extent of the down-faulted block was not defined but it was supposed to have reached to the Kigombo area.

Parkinson (1930a, p.11) found no evidence for the existence of the southern bounding fault, noting Lower Cretaceous strata in the Lipogiro area 3½ miles south of the position of the fault indicated by Hennig, where Hennig mapped Jurassic. Parkinson did not examine the northern boundary of the supposed fault trough, but suggested that erosion without previous folding of Jurassic strata had taken place, before the deposition of Lower Cretaceous strata.

Hennig (1937a) could not accept Parkinson's objections. His Text Figure 1, however, indicates the northern bounding fault in a different position to that shown previously, passing well to the north of Mto Nyangi, with areas of Makonde Beds within the trough. Stepping of the eastern bounding fault was shown.

The present interpretation does not fully agree with either of these previously made, but favours Parkinson's. Faulting has occurred in the area, the Kikundi - Mchinjiri Fault corresponding approximately to that bounding the supposed trough on the east. Parkinson's view is supported that there is no E.-W. faulting immediately south of the Mbemkuru. The faulting present to the north, the Pindiro - Kikundi Fault, is not on either line that Hennig indicates, and does not cut the Itukuru Plateau nor skirt the southern edge. In that Jurassic strata occur both to north and south of this Pindiro -

Kikundi Fault, it does not have the same function as Hennig's supposed fault. The break in sedimentation preceding the deposition of the Trigonia schwarzi Bed that Parkinson suggested, is confirmed by the angular unconformity existing in the Kikundi and Mtapaia areas.

While the fault trough postulated by Hennig cannot now be accepted to account for the distribution of Lower Cretaceous strata in the Mbemkuru area, some tectonic control must be envisaged. Possibly a sag developed after the deposition of the Jurassic, its axis parallel to the line of the Mbemkuru River, and probably some distance to the south. The easterly dipping Jurassic strata near Mtapaia might mark the position of the western end of this sag, and the Kikundi - Mchinjiri Fault its eastern extremity. The movement on this fault line would be greatest at the axis of the sag and would decrease to north and south with dying out of the fault. The Lower Cretaceous would be deposited in this depression, but there has evidently been further movement along the north-south fault line in post-Lower Cretaceous times.

GEOLOGICAL HISTORY

The earliest record in the geological history of the area is of the formation of a thick evaporite series under lagoonal conditions ending in Bajocian times. The extent of the evaporites beyond the present outcrops of the Pindiro Shales is not known. It is not known if any pre-Bajocian sediments underlie the evaporites. Graphite flakes in sandstones in the shale sequence in the Makangaga-Ruawa area suggest proximity to a shoreline of metamorphic rocks. Plate IX suggests that Karroo strata underlie the evaporites to the east of the area, but this is surmise only. An equivalent of the marine Karroo of Madagascar might be antipated. It is postulated that the evaporites extend eastwards at least as far as the Runyu area and that the uplift giving rise to this inlier is partly due to diapiric movement as in the case of the two main anticlinal structures further west. There is evidence that more normal marine conditions succeeded the lagoonal deposition before the end of Bajocian times, in thin limestones occurring in the uppermost part of the Pindiro Shales near Mkomore and succeeding the shales in the Ruawa area south of the Matarawe Stream. Other indications of this are the local occurrence of coarse grits (Luere and Nondwa) and of silicified oolite boulders (Luere and Itukuri) associated with the shale sequence.

A period of erosion followed, and the succeeding ?Bathonian sediments, which are certainly recognised only in the northern part of the Mandawa-Mahokondo area, probably represent a largely estuarine phase, with some continental deposition indicated by the presence of reddish and red/green mottled marls in the sequence. In a conglomerate at the base of the sequence and in grits higher up, limestone boulders and pebbles of uncertain origin occur. These could be derived from the limestone bands at the top of the Pindiro Shales, or possibly are evidence of a marine episode of which no continuous sediments are exposed in the area, except possibly to the south of the Matarawe Stream near Ruawa. The origin of small boulders of metamorphic rocks in the grits of the ?Bathonian sequence is also uncertain. These, and the presence of quite large, fresh, felspar crystals in the basal conglomerate again suggest a not distant shoreline of metamorphic rocks. More wholly marine conditions succeeded the estuarine rocks before the next break in the succession which apparently occurred in the later Bathonian and is marked by overstep noted in the air-photographs of the northern end of the Mandawa-Mahokondo anticline though not detected on the ground.

From the late Bathonian to the Upper Oxfordian a littoral and shallow water neritic environment appears to have persisted, and sediments of this environment occur both in the Mandawa-Mahokondo and Makangaga-Ruawa areas. The conditions were very favourable to marine invertebrate life. No physical break in the sequence has been detected, but ammonite collections from the Mandawa-Mahokondo area which contain an abundant Middle-Upper Callovian and, locally, a good Upper Oxfordian fauna, but no species of intermediate age, suggest that disconformity exists.

The succeeding Lower Kimmeridgian (? Upper Oxfordian-?Middle Kimmeridgian) strata, are also of fairly shallow water origin. There is some evidence in the Mandawa-Mahokondo area of slight overstep by these beds over the Upper Oxfordian, and that fault movement may have occurred before the deposition of the Kimmeridgian. Early in the period the marl facies of deposition was similar in the Mandawa-Mahokondo and the Makangaga-Ruawa areas. This persisted in the former, presumably into the Middle Kimmeridgian. Current-bedded, often coarse sandstones, followed by probably continental, purple marls, were deposited, during the later part of the time interval in the Makangaga-Ruawa area, presumably indicating uplift there.

Before the deposition of the Middle Kimmeridgian-Tithonian sediments, which were transgressive and which occur throughout the area mapped in much the same facies, there was strong faulting in the Makangaga-Ruawa area on the Ruawa Fault, following uplift there. It is possible that pre-Bathonian movement on this line influenced the nature and extent of Bathonian-Oxfordian deposition to the north and south of the line, but there are no exposures to prove this. The present interpretation allows the overstep of the Middle Kimmeridgian-Tithonian strata to account for the absence of

Upper Bathonian to Middle Kimmeridgian exposures south of the fault. There is no evidence of corresponding uplift or faulting in the Mandawa-Mahokondo area.

The Middle Kimmeridgian-Tithonian strata are largely of littoral or deltaic facies. ?Continental deposits (purple marls) occur at several levels; these may prove equivalent to the saurian beds of the type area of the Tendaguru Series to the south-west of the area mapped. The furthest east that the ?continental marls have been observed is about one mile west of Mahokondo in the north of the area and in the neighbourhood of Mbambala Hill in the south. East of this and to the eastern limit of Jurassic exposures, frequent minor uplift and erosion is indicated by thin intra-formational conglomerates. An interval of oolite deposition apparently commenced at about the same time throughout the area.

There is little evidence of angular unconformity in the north of the Mandawa-Mahokondo area between the Tithonian and the Neocomian, but disconformity apparently occurred, there being a fuller Jurassic succession to the west of the anticline than to the east. The lowermost Neocomian horizon exposed in this area, a white coralliferous limestone, which dips with the underlying Jurassic, may be older than any Cretaceous rocks further west. The immediately succeeding strata may be as young as Hauterivian, so that a considerable break in deposition between Jurassic and Cretaceous probably occurs even in the east of the area. There is angular unconformity in the south of the Mandawa-Mahokondo area and further west, this is especially marked where horizontal lower Cretaceous strata rest on strongly disturbed Upper Kimmeridgian or Lower Tithonian beds, to the south of the Makangaga-Ruawa anticline.

It appears therefore that uplift proceeded independently, not only between the Mandawa-Mahokondo and Makangaga-Ruawa anticlines in Kimmeridgian times, but even between the two culminations of the former immediately before Cretaceous deposition began. The Kikundi-Mchinjiri Fault was probably also active at this time, when a sag seems to have developed in the Mbemkuru area to the west of it, in which Lower Cretaceous deposition took place. There was also post-Neocomian movement on this line. The pre-Cretaceous surface was one of some relief. There is local evidence of unconformity elsewhere in the Mbemkuru River depression than at the south of the Makangaga-Ruawa structure, though as a rule the Jurassic and Cretaceous are both nearly horizontal. The instances of proven unconformity between the Jurassic and Cretaceous are sufficiently widespread to confirm the previous supposition on palaeontological evidence that a break exists. This break is probably of more significance than earlier ones, of which there is usually only local evidence, and which may well be related only to local positive movements in the two main anticlinal areas.

The environment of the Neocomian - Lower Aptian deposition was also mainly near-shore, as in the Jurassic, and slight oscillation is again indicated by rapid alternation of coarse and fine sediments and the occurrence of intra-formational conglomerates. There is the suggestion of disconformity within the Neocomian - Lower Aptian time interval in the Mbemkuru area. Evidence of continental deposition supervening in western areas as occurs in the Jurassic, is not clear. There appears to be an increase in the proportion of fine sediments towards the east, though coarse grits persist to the easternmost exposures, indicating that the shallow shelf conditions of deposition persisted there.

In the neighbourhood of the Mandawa-Mahokondo anticline there was uplift, faulting and erosion before the deposition of the Upper Aptian sediments, the lowermost of which, in the north of this area, are marls. Along the edge of the Ngarama Plateau, and in extension of large outcrops to the north and south, are massive reefal limestones which indicate proximity to the continental margin. These overstep the underlying Aptian marls and the eroded Neocomian - Lower Aptian beds, and rest directly on Jurassic strata. Contemporaneously with the limestone deposition, a mixed argillaceous-arenaceous facies with relatively thin calc-arenites was laid down to the east. In the south of the area, though again there was overstep of Upper Aptian limestone on to Jurassic strata, there is no marked unconformity between the Neocomian - Lower Aptian beds and the Upper Aptian. In the south of the area, however, Aptian strata are involved in faulting, including the ring-faulting associated with the up-doming of the southern culmination of the Mandawa-Mahokondo anticline. To the north the Upper Aptian is not involved in faulting, except apparently in a local area north of the Kikundi Stream.

Upper Aptian marine beds are not known in the area to the west of the Ngarama Plateau, though north of the area mapped, they have a greater westerly extent. The higher areas are blanketed by continental sandstones of Upper Aptian or post-Aptian age, resting on an uneven surface.

The post-Aptian Cretaceous, essentially a marl facies, is confined to the east of the area in a series of locally overstepping subdivisions. The Aptian and Upper Cretaceous lap against the positive areas of the Mandawa-Mahokondo anticline and the block formed by the Turikira-Minyoka-Ukulinga areas. The eastern side of this block is apparently formed by a continuation of the tectonic line bounding the coastal plateaux of Southern Tanganyika, which is interrupted by the development of the Mandawa-Mahokondo anticline. There appears to have been no post-Aptian marine transgression anywhere to the west of this tectonic line. No shore-line facies has been detected in these uppermost Mesozoic beds, but some of the sandstone intercalations in the dominantly marly facies are of shallow water origin.

In the Paleocene, limestone deposition recommenced alternating with marls. These are the youngest marine sediments in the area, but continental Neogene sands and gravels occasionally laterized, are widespread, being preserved mainly on watershed areas and on the plateau tops.

REGIONAL SETTING AND PALAEONTOLOGICAL RELATIONS OF THE MESOZOIC ROCKS

The Jurassic outcrops in Southern Tanganyika are the most southerly recorded on the mainland of East Africa, and extend for only a few miles to the south of the area mapped. There are, however, extensive outcrops along the western side of Madagascar, the arrangement of which forms a mirror image of those on the Kenya-Tanganyika coast (Millar, 1952, p.21; Caswell, 1953, p.16; Arkell, 1956, p.336). Upper Kimmeridgian and Tithonian strata have not been recorded in Tanganyika north of the Matandu River, or elsewhere in East Africa south of Harrar (Abyssinia) and Somaliland, though represented in Southern Madagascar and Cutch. Callovian-Middle Kimmeridgian strata are more widespread in the East African area however.

Northwards from the Mandawa-Mahokondo area, the nearest pre-Upper Kimmeridgian outcrops are in the Matumbi Highlands south of the Rufiji River, but correlation of the strata in this little known area is not certain. The Matumbi Series, as originally defined (Stockley, 1943, p.8), commences with oolitic and porcellaneous limestones and calcareous sandstones (the Mtumbei Beds) believed to be of Bajocian age. These are to be generally correlated with the limestones which mark the earliest major marine transgression of the Jurassic throughout much of the coastal area of Tanganyika. At the south of the Matumbi area, however, the limestones are underlain by several hundred feet of felspathic pebbly sandstones (Quennell, McKinlay and Aitken, 1956) which it would be tempting to correlate with the ?Bathonian sequence of the Mandawa-Mahokondo Series. If the Bajocian dating of the Mtumbei Beds and of the Pindiro Shales and the immediately overlying strata is correct, however, this correlation is not tenable. There are no limestones in the Mandawa-Mahokondo Series that match those of the Matumbi Series, except possibly the thin limestone overlying the Pindiro Shales south of the Matarawe Stream in the Makangaga-Ruawa area. The limestone cobbles and boulders that occur in the ?Bathonian grit sequence in the Mkomore section are also of a similar type. The inference might be that the lagoonal Pindiro Shales are the equivalent of much of the limestone sequence further north and that the limestone facies was developed only briefly in the exposed areas of Middle Jurassic in the southern Kilwa District and was largely eroded in Bathonian times. The upper part of the Matumbi Series (the Kipatimu Beds) is made up largely of massive sandstones and purple mudstones, but these have not been adequately dated. They cannot be correlated with any particular part of the Mandawa-Mahokondo Series, though the development of purple mudstones bears some resemblance to that in the ?Bathonian of the Mkomore section.

The facies of the Middle and Upper Ruvu Beds in the hinterland of Dar es Salaam, however, is not dissimilar to that of the ?Upper Bathonian-Oxfordian of the southern Kilwa District and Upper Callovian strata near Tanga show a continuation northwards of this facies.

Dietrich (1933a, p.79) summarised the palaeontological relations of the faunas of the Tendaguru Series as follows: "In the Upper Jurassic and Lower Cretaceous, the East African area formed an independent marine sub-province; in the Upper Jurassic it contained indigenous, Indian, European and cosmopolitan elements; in the Neocomian, indigenous, South Andean, European and cosmopolitan elements."

According to Arkell (1956, p.614) the Jurassic was deposited in "the great southern bay off the central Tethys, which extended across the Arabian sea and down the east side of Africa to Madagascar". He added that this area "developed several peculiar faunas which warrant the recognition of an Ethiopian province, though in a wider sense than used by Uhlig and including Cutch, Baluchistan and Arabia". Du Toit's (1937, pp.97-98) conception of this southward extension of the Jurassic sea was as a synclinal gulf associated with the fragmentation of Gondwanaland, branching from the Himalayan geosyncline. He observed that "the progressive overlapping by younger beds in a southerly direction along the east side of Africa, beginning with the Triassic, would indicate the steady propagation of this furrow south-westwards between Africa and Indo-Madagascar." Du Toit, followed, for example, by Millar (1952, p.21), Caswell (1953, p.16) and Spence (1957, p.32) accounted for the Mesozoic outcrops of East Africa and Madagascar forming "mirror images" by supposing that Madagascar had "drifted" from a position adjacent to the Kenya-Tanganyika coast.

Spence supported the hypothesis in view of detailed similarities in the Karroo succession in the Eastern Province of Tanganyika and the Morondava Basin of Southern Madagascar. Aitken (1956d, p.23) suggested that support might also derive from the evidence of a Toarcian transgression in Northern Kenya and Northern Madagascar which was not recorded in Tanganyika or Southern Madagascar, and the gap in the Mesozoic sequence in the early Neocomian in the two southern areas. Dixey (1956, p.26), however, believed that the bulk of vertebrate fossil evidence pointed to Madagascar having been isolated since Permian times and suggested that the resemblance in the Mesozoic successions were merely due to Madagascar and the East Africa mainland being on the opposite sides of a geosyncline. He pointed out that basement "highs" could be matched across the Mozambique Channel and suggested that this had merely "acted as a lag area in relation to the rising areas of the main East African ridge and Madagascar, as part of the basin and rim structure of Africa."

Arkell (1956, pp.310-311) has given a general correlation table of the Jurassic deposits in East Africa and

Madagascar, and called attention to the identity of numerous ammonite species from different stages in the Jurassic sequence in this area with species found in Cutch. In particular, the ammonites listed from the Middle Callovian strata of the Mandawa-Mahokondo Series are mainly species figured from the anceps and rehmanni Zones of Cutch (Arkell, 1956, p.333). Of this fauna Dr. Arkell (<u>in litt</u> to W.G. Aitken, 6 October 1952) has said further that it is of pure Cutch development and is new for the mainland of Africa, though reported from the Mangoky region in the south of Madagascar. Arkell (1956, p.331) also compared specimens from high in the Jurassic sequence above the "<u>smeei</u>" Oolite in the Mandawa-Mahokondo area (Loc. WA.961) to <u>Virgatosphinctes communis</u> Spath of the Lower Tithonian of Cutch.

For the most part, other faunas than the ammonites collected during the recent survey have not been examined in detail. Table VII gives a tentative summary of the distribution in the Ethiopian Province of a few of the lamellibranch species noted in these collections or recorded elsewhere from Southern Tanganyika. This demonstrates a similar relationship of the less-free-moving lamellibranch fauna as exists between the ammonite faunas of the province. Most striking is the number of species common to Cutch and Southern Tanganyika. A further point of likeness is the existence in Tanganyika of a species of <u>Laevitrigonia</u>, <u>L. curta</u> sp. nov. of the same group as <u>L. spissicostata</u> (Kitchin) only known so

TABLE VII

The distribution in the Ethiopian Province of some Jurassic lamellibranch species found in Southern Tanganyika. Species of which records are not known outside this province are asterisked.

	North Tanganyika	Kenya Somalil.
Callovian - Oxfordian		
Astarte major Sowerby		
* *Astarte mülleri* Dacqué	x	
Ceratomya cf. *wimmisensis* (Gilliéron)		x
C. telluris (Lamarck)		x
C. concentrica (Sowerby)	x	
Exogyra nana (Sowerby)	x	x
Grammatodon (Indogrammatodon) virgatus (Sowerby)		
* *G. (Indogrammatodon)* cf. *iddurghurensis* Cox		
* *Lycettia indica* Cox		
* *Modiolus glendayi* (Weir)		x
* *Myophorella (Orthotrigonia)* cf. *kutchensis* (Kitchin)		
Trigonia elongata Sowerby	x	
* *Trigonia prora* Kitchin		
* *Trigonia* aff. *propinqua* Kitchin		
Lower Kimmeridgian		
* *Gryphaea hennigi* Dietrich		
Middle Kimmeridigian - Tithonian		
* *Cucullaea (Megacucullaea) eminens* Cox		
Gervillella anceps Leymerie		
Modiolus (Pharomytilus) perplicatus Étallon		x
Megatrigonia conocordiiformis (Krauss)		
Pecten (Chlamys) curivarians Dietrich		x
* *Pinna (Stegoconcha) g-mülleri* Krenkel		
Lopha marshii (Sowerby)	x	
Thracia incerta (Roemer)		x
* *Trigonia beyschlagi* Müller		

far from Cutch. Similarly Opisthotrigonia, represented in Tanganyika by O. curvata sp. nov., has only been recorded previously from Cutch.

The association of beds containing dinosaur remains at Tendaguru with strata datable by marine invertebrates, caused some interest (Schuchert, 1918; Mathew, 1924; Simpson, 1926) as a possible means of dating the Morrison Formation of North America. Simpson showed that a similar stage in development had been reached in a number of comparable reptilian genera and supposed approximate equivalence of the East African and North American faunas. This is also mentioned by Romer (1945, p.538).

Dixey (1928, p.55) described continental beds of Cretaceous age with dinosaur remains from the northern end of the Nyasa Trough in Nyasaland, which have been correlated with bone-bearing strata in the Nyasa and Rukwa Troughs in Tanganyika (Harkin, 1955; Quennell, McKinlay and Aitken, 1956). Dixey inferred a correlation of the Dinosaur Beds of Nyasaland with those of Tendaguru, the Cretaceous age of at least some of the reptile beds of Tendaguru being at that time accepted in some quarters. If the beds in Nyasaland are correctly dated, however, the correlation cannot now be accepted.

The continental ? Lower Cretaceous Makonde Beds contain no fossil material except fossil wood, and exact correlation with similar sediments elsewhere is in doubt. As regards the equation of the Makonde Beds with similar strata (the Tunduru Beds) forming much of the "Inland Plateaux (see Plate I), there has been some controversy. McKinlay (in Quennell, McKinlay and Aitken, 1956) has outlined previous work, and has concluded that the conflicting palaeontological and lithological evidence does not allow of any certainty in the correlation. It would seem possible that both Cretaceous beds, as supposed by most of the earlier German workers (Bornhardt, 1900; Dantz, 1903; Scholz, 1914), that can be correlated with the Makonde Beds, and Karroo strata of similar facies as suggested by Stockley (1947, 1948) and Boonstra (1953a,b) are present.

Marine Neocomian strata, contrary to the case of the Jurassic, are widespread on the eastern seaboard of Africa as far south as the Cape Province of South Africa. The oldest satisfactorily dated Neocomian strata are Hauterivian in age in southern Tanganyika and the oldest Cretaceous beds known further north in Tanganyika and in southern Kenya are Aptian. An unbroken sequence from Jurassic to Cretaceous is not claimed until as far north as Somaliland (Macfadyen, 1933, p.29). South of Tanganyika, the Valanginian is recorded in Mozambique and South Africa, and according to Haughton (1956, p.18) there is a complete succession in the Cretaceous upwards from the Lower Aptian in Zululand, except possibly for the Turonian. In Tanganyika, all the stages of the Cretaceous are represented (Quennell, McKinlay and Aitken, 1956), as also is the case in Madagascar, though in the south of the island, the lowest Neocomian strata are Hauterivian. In the north of the island, the succession is complete from Infra-Valanginian. In Cutch and elsewhere in the north Indian area the Cretaceous sequence is fragmentary.

The Cretaceous bounding the Indian Ocean was deposited in an extension of the sea in which the Jurassic strata of the Ethiopian Province were laid down. There was still an important connection to the Tethys, but other faunal elements also entered the area. In Southern Tanganyika only the Lower Cretaceous faunas are well known.

Zwierzycki (1914, p.83) thought that the Trigonia schwarzi Bed ammonites formed a typical Lower and Middle Neocomian Mediterranean assemblage and instanced several species as comparable with Indian Neocomian forms. Spath (1930, p.134) showed that there were no pre-Hauterivian forms in the Trigonia schwarzi bed and that Krenkel (1910a) had been mistaken in believing some forms he described from Tanganyika were comparable to Valanginian forms from the Uitenhage Beds. Spath (1939, p.140) indicated that Zwierzycki's comparisons to Indian (Salt Range) species were at fault. Although Hauterivian - Lower Aptian strata are recognised in Madagascar particularly in the south, the lists of ammonites of this age given by Besairie (1952, 1953) and Houre (1950) show nothing exactly comparable to the records of ammonites from Southern Tanganyika.

Lange (1914, pp.269-279) distinguished six distinct elements in the Lower Cretaceous lamellibranch faunas:-

1. The Cosmopolitan Element.
2. The East African Element.
3. The Mediterranean Element.
4. The South African Element.
5. The South American Element.
6. The Indian Element.

Although he recognised the distinct East African Element, Lange observed that many of the species belonging to it differed only in minor degree from Mediterranean forms, and considered that up to 50% of the fauna had a distinctly Central European aspect. This presents a parallel with the case of the Jurassic Ethiopian Province.

More than half of Lange's "East African Element" consists of Trigoniids some of which still remain unique to Southern Tanganyika, though Megatrigonia (Rutitrigonia) krenkeli, M. (Rutitrigonia) schwarzi and Yaadia hennigi have later been recorded in Mozambique or Zululand (Hennig, 1937a; Rennie, 1936).

With the South African "Uitenhage" and the Indian Neocomian lamellibranch faunas, Lange did not recognise very strong links. This is understandable in view of the recognition that the Uitenhage Beds are not younger than

Valanginian while Hauterivian strata are the oldest Neocomian beds in Tanganyika. The uppermost Umia Beds of Cutch, the fauna of which Lange compared to the Tanganyika material, are also older than the Trigonia schwarzi Bed. Lange pointed out that there was as close relationship of the Uitenhage and Cutch faunas to that of the Jurassic "Trigonia smeei" Bed as to the Neocomian of Tanganyika. It has since been pointed out (Spath, 1927-33, p.798) that the lamellibranch faunas on which arguments for the age of the strata in the Indo-African area were based, for example by Kitchin (1926, 1929), contain forms occurring both in the Upper Jurassic and the Lower Cretaceous. A number of such species from Tanganyika or species to which both Jurassic and Cretaceous specimens have been compared, are listed below:

Cucullaea (Megacucullaea) kraussi (Tate)
Gervillia (Gervillella) anceps (Deshayes M.S., Leymerie)
Megatrigonia concardiiformis (Krauss)
M. (Iotrigonia) haughtoni (Rennie)
M. (Iotrigonia) vau (Kitchin)
Pterotrigonia ventricosa (Krauss)

A number of other essentially Cretaceous genera and subgenera of Trigoniids occur also in the Upper Jurassic. As well as the two forms mentioned above, the Jurassic Megatrigonia (Rutitrigonia) dietrichi, ?Pleurotrigonia sp. nov., Yaadia sp. recorded in Part II, are cases in point from Tanganyika.

Many of the lamellibranchs that Lange described as common to East Africa and South America are in fact cosmopolitan species. Of the Trigoniids he quoted, Yaadia transitoria is not now believed to occur in East Africa, though the similar Y. hennigi is fairly common. "T. cf. delafossei" is merely compared to the South American species and though South American forms have been compared to "T. conocardiiformis" none has been certainly identified with it. It is demonstrated in Part II that "T. schwarzi" is not synonymous with "T. longa var. undulato-striata" of South America; and "T. kühni" Müller of Tanganyika is merely a form similar to "T. heterosculpta". There is, nevertheless, a strong similarity in aspect between the lamellibranch faunas of the Neocomian of South America and the eastern seaboard of Africa.

Du Toit (1937), recording the Neocomian faunas of Cutch, Madagascar, Eastern Africa and the Argentine as all largely "Indian", said (p.118) "The presence of strong Indian Jurassic and Cretaceous elements in Argentina argues for a continuous continental shore or shelf between those lands by way of the Cape" and (p.117) "At the close of the Jurassic, the south-westerly prolongation of the Mozambique trough to Mossel Bay (Cape) and thence westwards outside the Gondwanides, enabled the Lower Cretaceous Uitenhage fauna - itself derived from India via Madagascar - to reach Neuquen (western Argentina)."

Though not supporting the theory of "Continental Drift" as did Du Toit, Kitchin (1908) discussed the dispersal of sub-littoral lamellibranch faunas of southern facies northwards from Patagonia to Texas and from South Africa to the north-west Himalayas and possibly to New Caledonia. Such a dispersal occupying a considerable period of time may have allowed minor differentiation from common stocks in the lamellibranch faunas of the several areas mentioned; or the age of the known similar faunas may not be identical.

There appears to have been no general discussion on the palaeontological relations of other groups of fossils.

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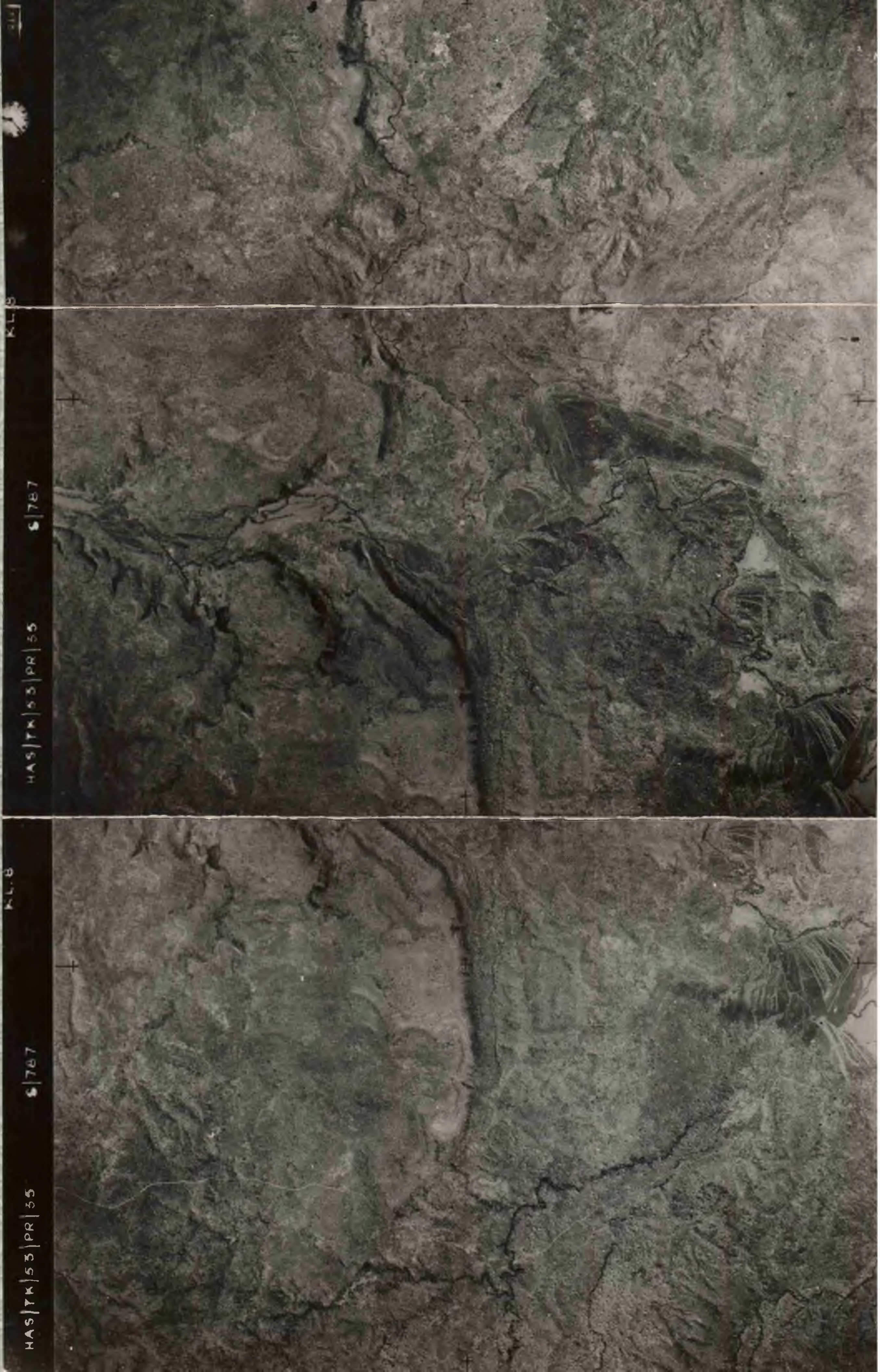
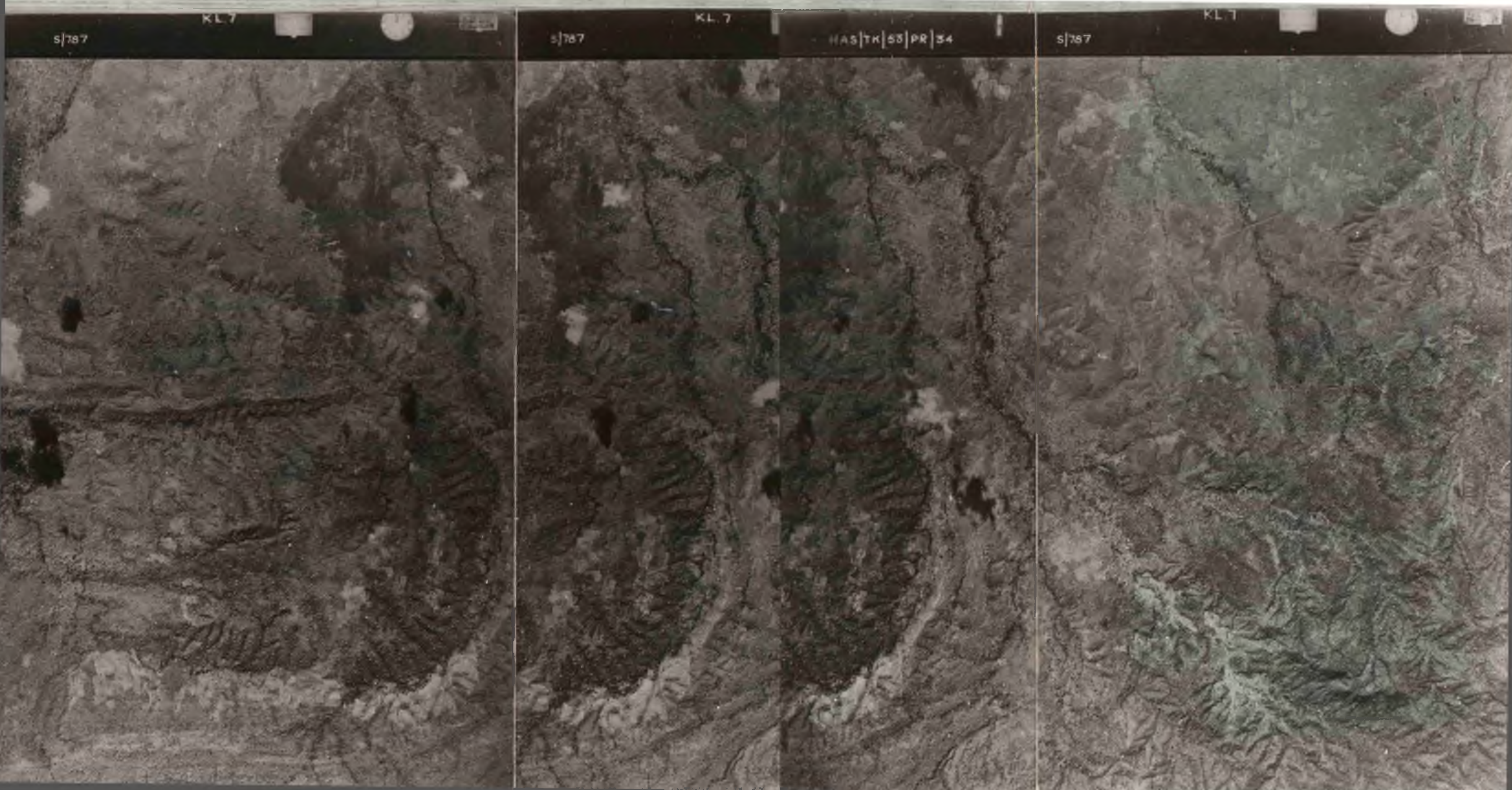

KL.8
HAS|TK|53|PR|35
S|787
KL.8
HAS|TK|53|PR|35
S|787

PLATE XIII. Air photograph stereo-pair of the Kikundi (Mbemkuru) area (with extension, out of stereo-vision, north to the Turikira Stream and south to the Mchinjiri area.



s|787
KL 7
s|787
KL 7
HAS|TK|53|PR|34
s|787
KL 7

PLATE X. Air-photograph stereo-pairs of the southern end of the Mandawa - Mahokondo Anticline (with extension, out of stereo-vision, north to the Mandawa River and south to Mtande).


HAS|TK|53|PR|34
S|787
KL.10a
S|787
KL.10a

PLATE XIV. Air-photograph stereo-pair of the Mtapaia area (with extension, out of stereo-vision, north to the Itukuru area).

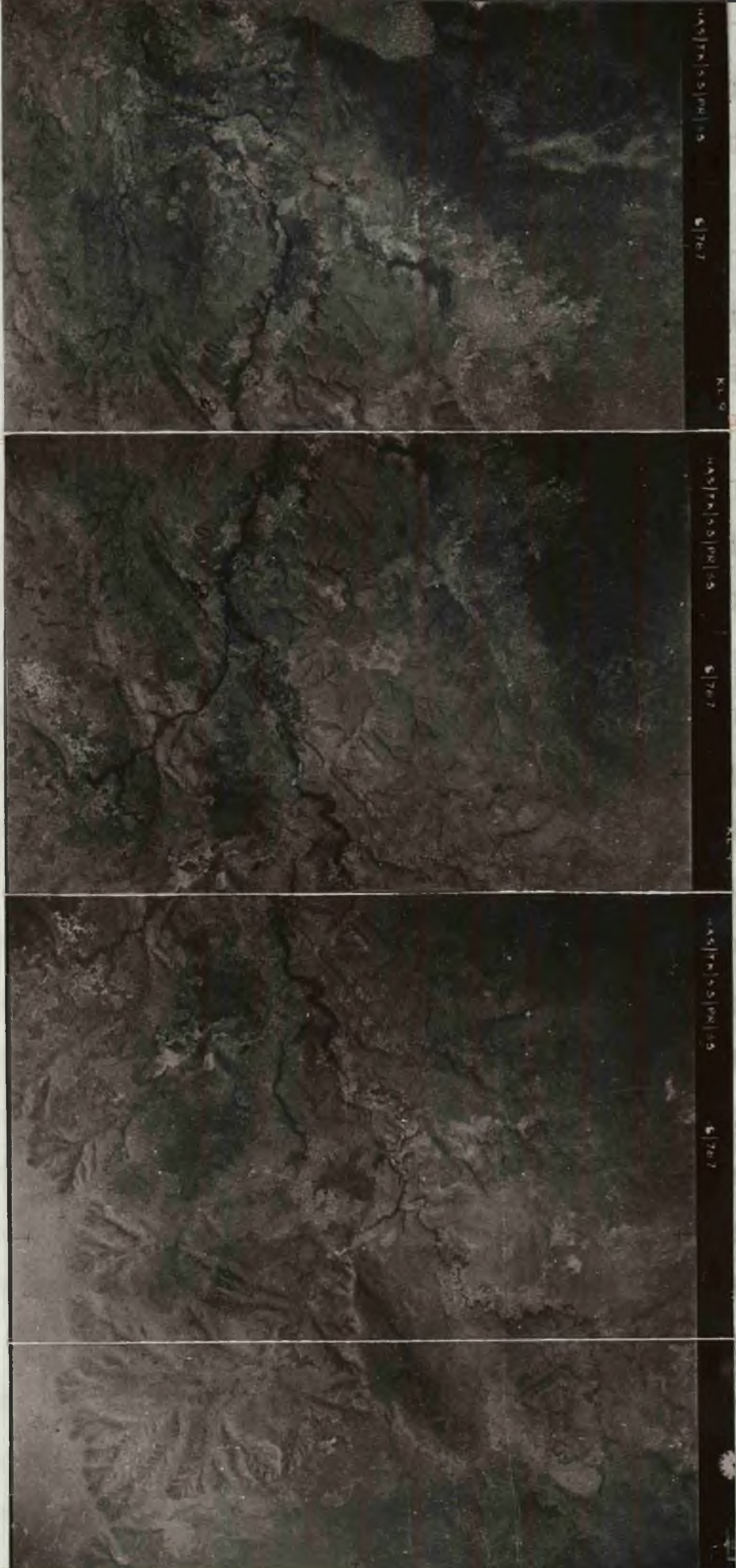
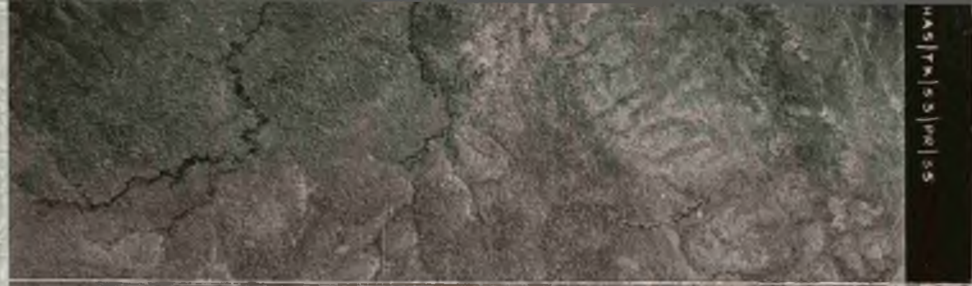


PLATE XII. Air-photograph stereo-pairs of the Makangaga - Ruawa Anticline. The whole structure from the Nambango-Ndondonga Ridge in the north to the Itukuri area in the south is covered, but only the Ruawa and the Lake Mbuo areas can be seen in stereovision.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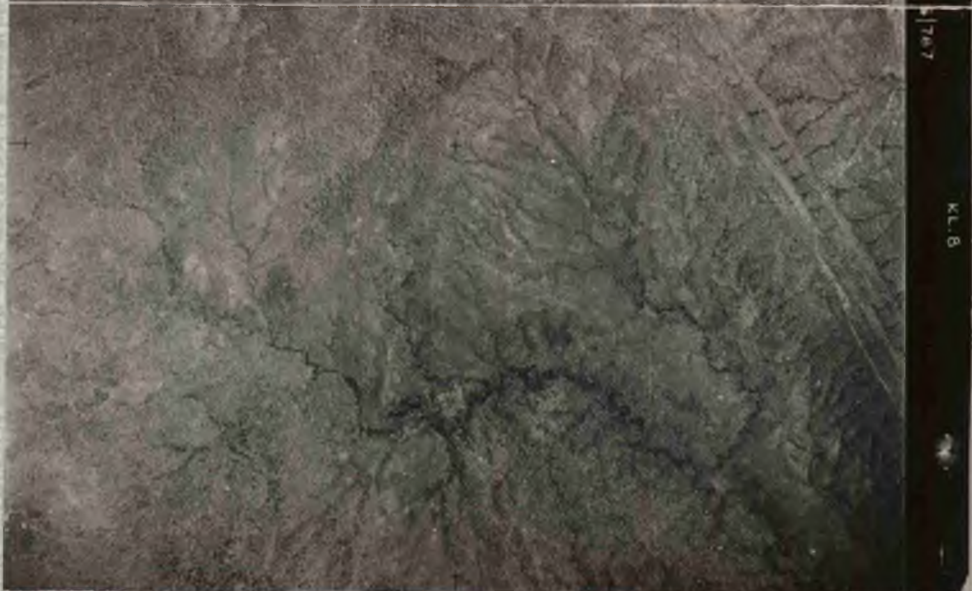
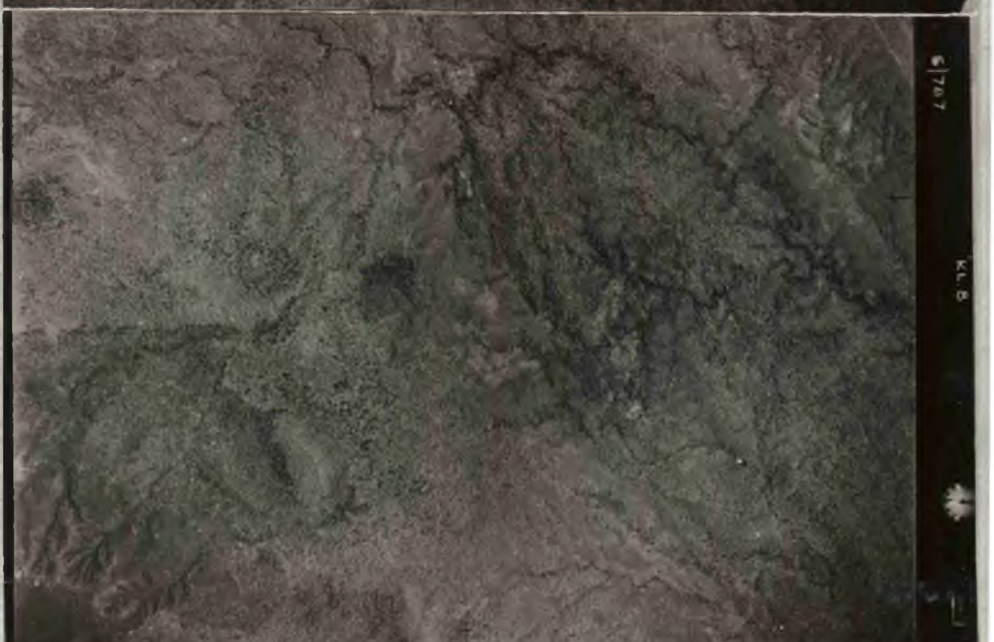
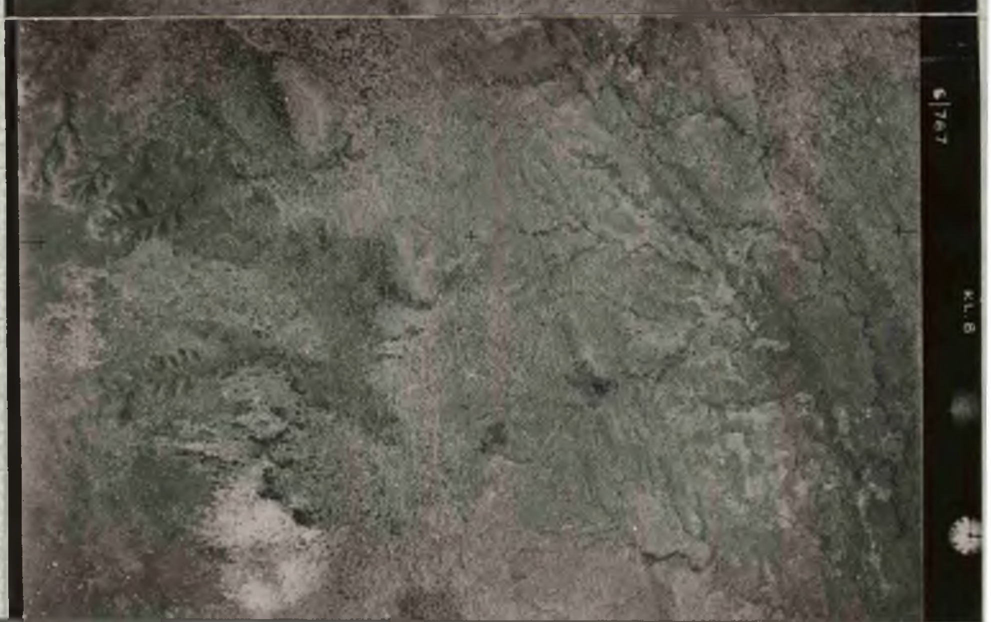
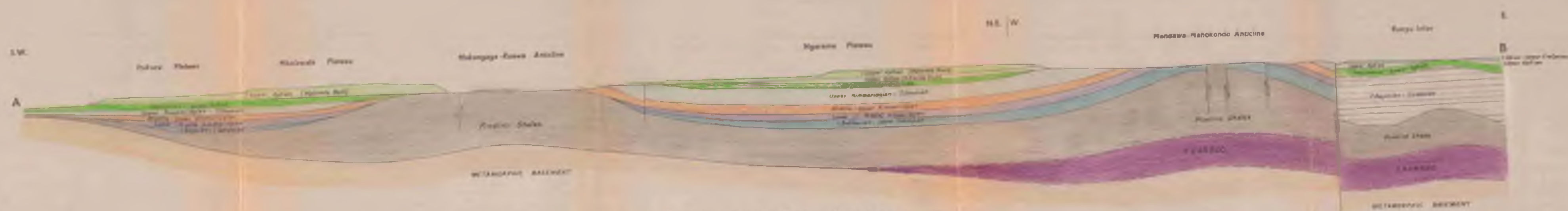

767
KL.8

6|767
KL.8

6|767
KL.8

PLATE XI. Air-photograph stereo-pairs of the northern end of the Mandawa - Mahokondo Anticline.

Plate IX



Hypothetical Cross-Section
of the
MAKANGAGA-RUAWA and MANDAWA-MAHOKONDO ANTICLINES

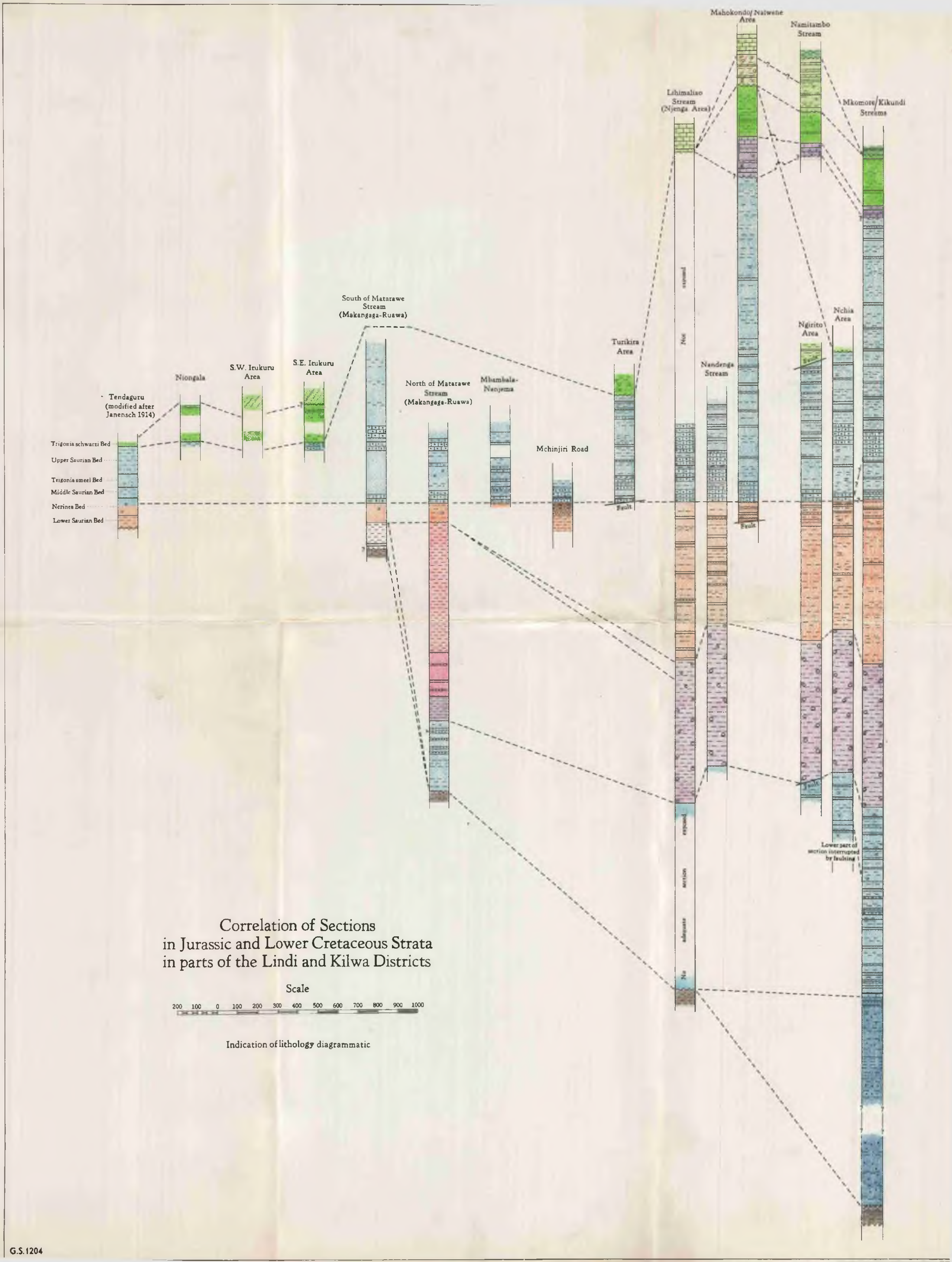
Horizontal & Vertical Scales 1 : 50,000 (approx.)

MILE 1 0 1 2 3 4 5 MILES

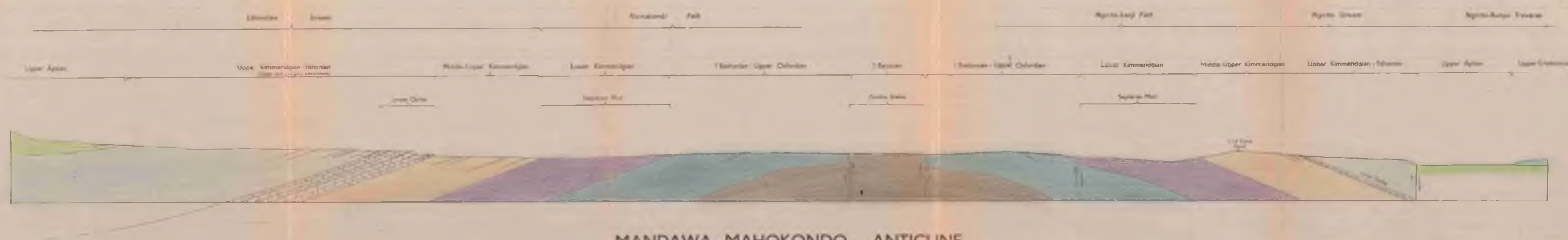
by W. O. Aitken 1957

Geological Survey Department, Dodoma, 1957

G.S. 1132



Correlation of Sections
in Jurassic and Lower Cretaceous Strata
in parts of the Lindi and Kilwa Districts



MANDAWA - MAHOKONDO ANTICLINE

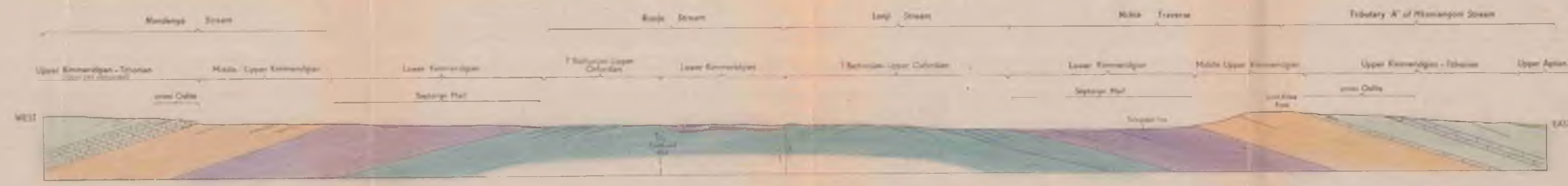
Composite Generalized Section across Southern Area

Elevations from aneroid readings

Plate VI


MANDAWA - MAHOKONDO ANTICLINE
Composite Generalized Sections across Northern Area

Plate V



MANDAWA - MAHOKONDO ANTICLINE

Composite Generalized Section across Central Area

Data from compass and stadia traverse plan. Measured dips indicated.
Elevations from aneroid readings.

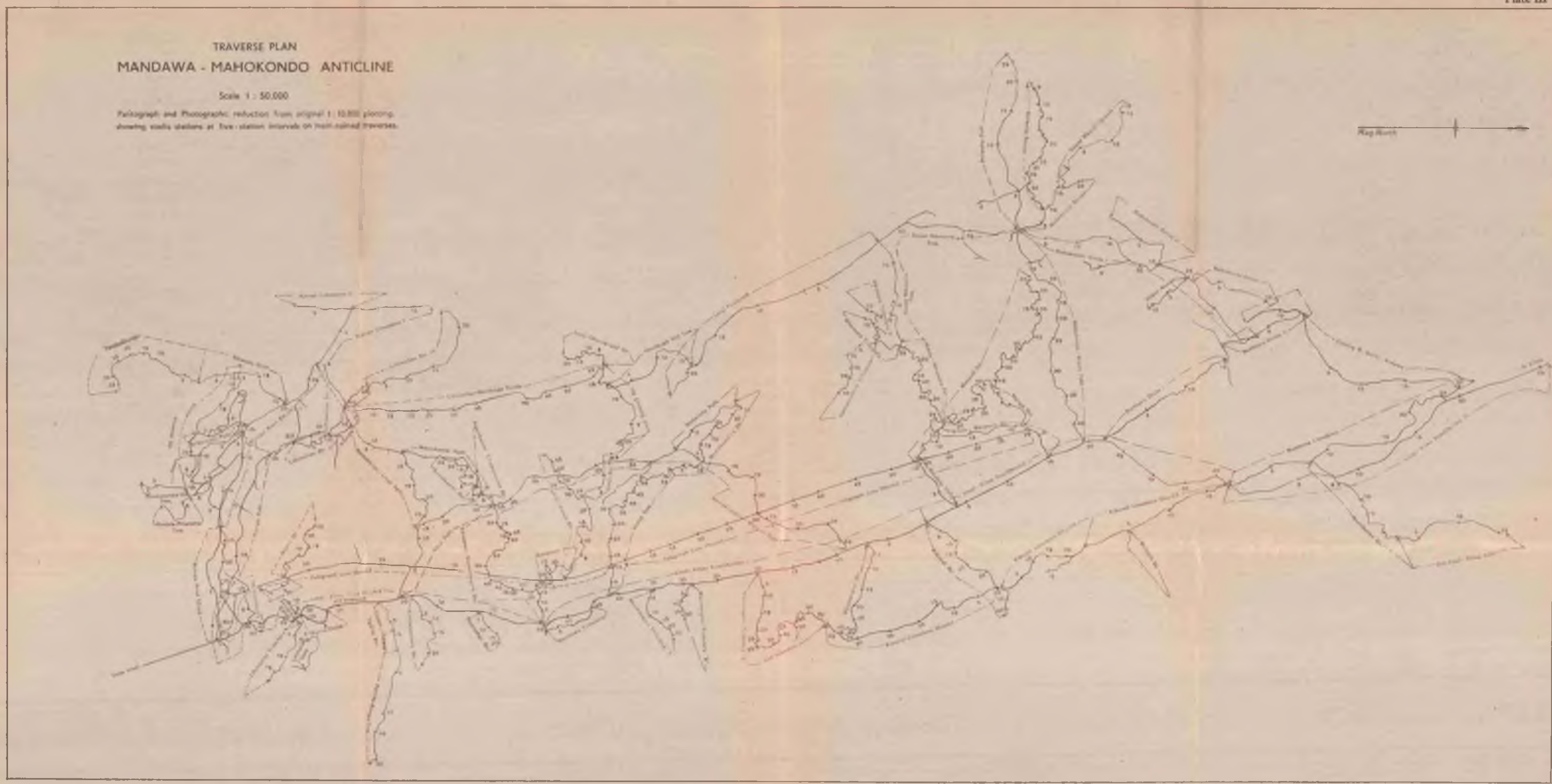
Horizontal and Vertical Scale 1 : 18,000

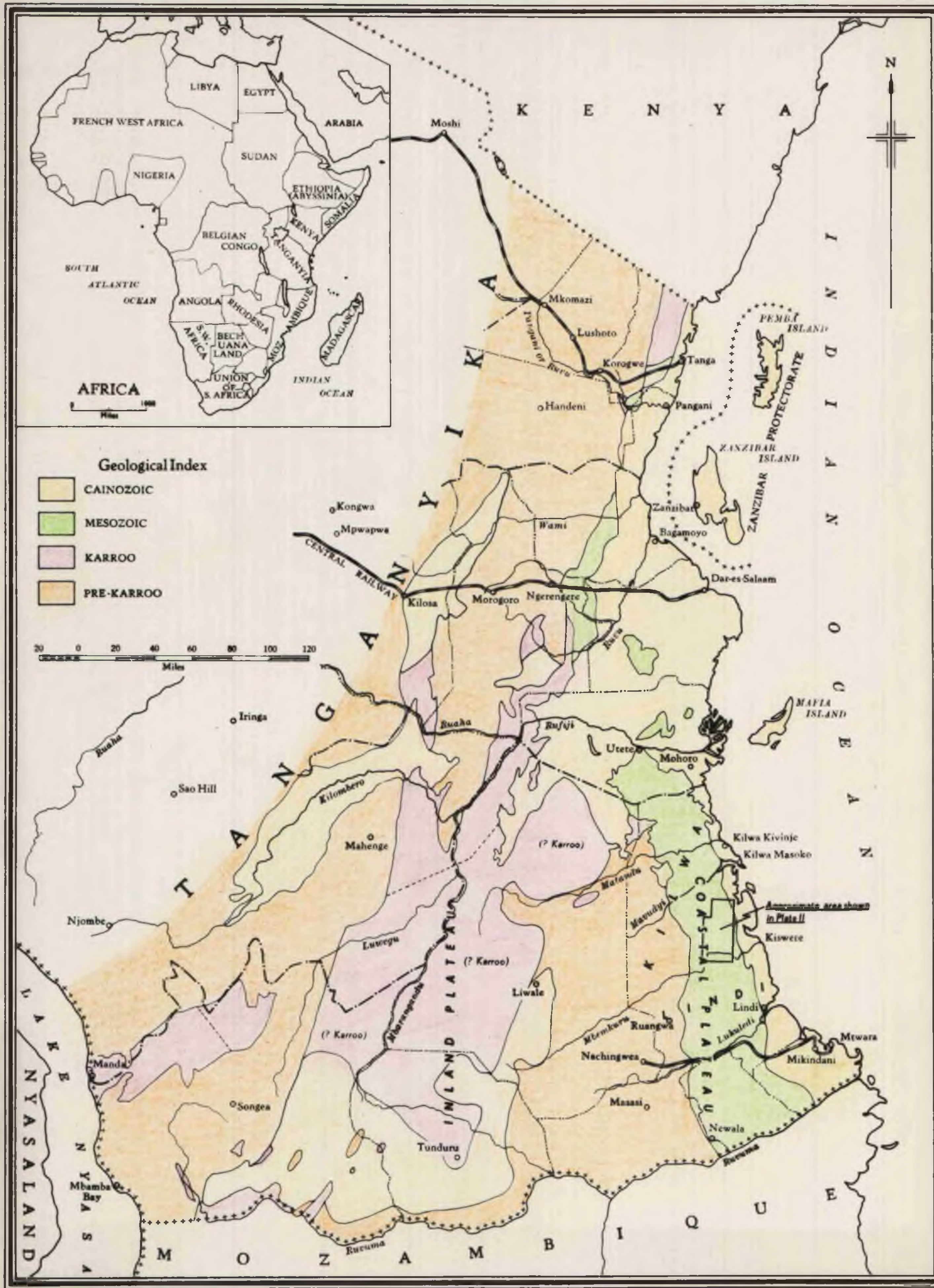
By W. G. Aitken, 1957.

G.S.1129

Geological Survey Department, Dodoma, 1957.

PLATE IV. Air-photograph print lay-down of parts of the Lindi and Kilwa Districts.

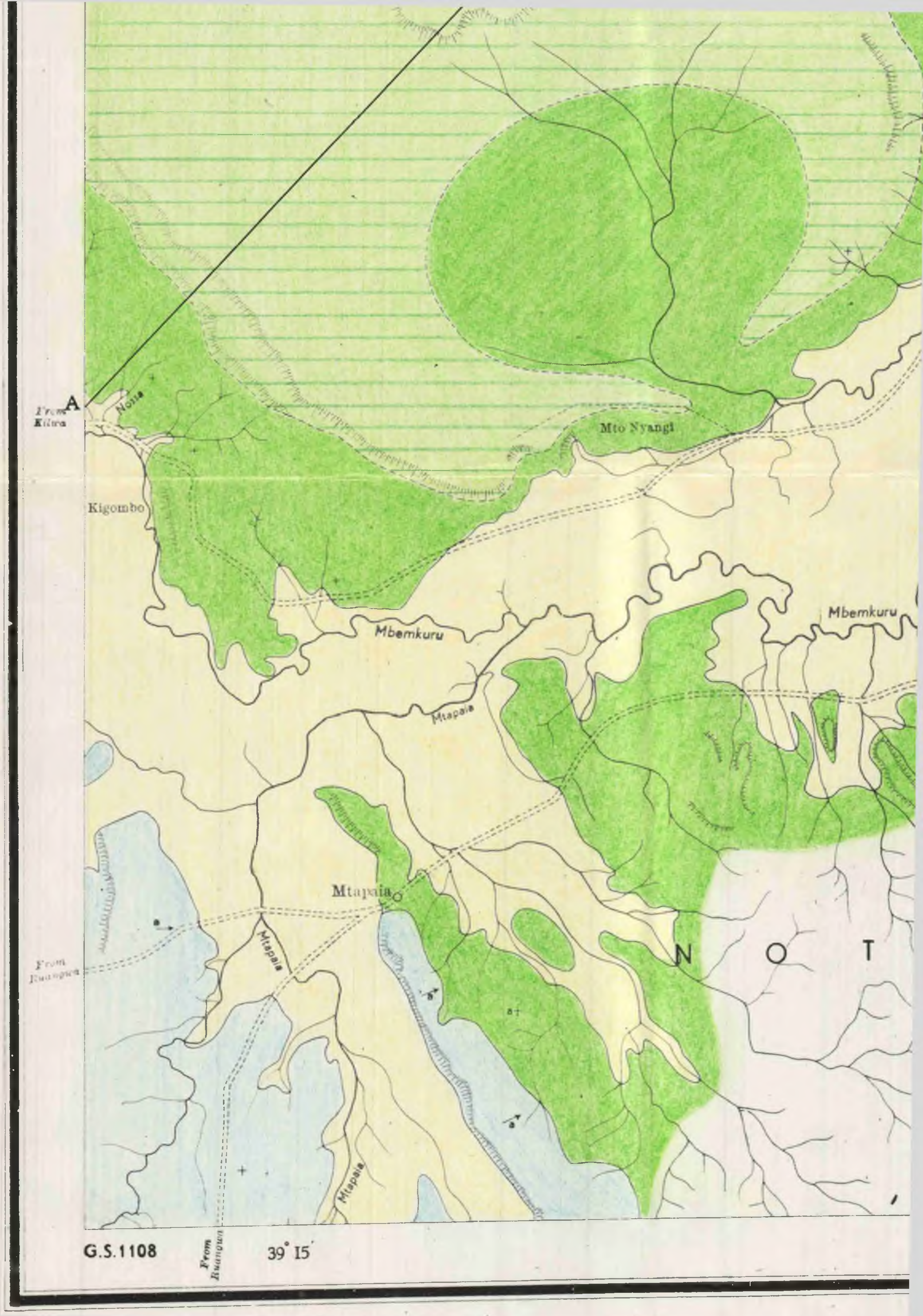

TRAVERSE PLAN
MANDAWA - MAHOKONDO ANTICLINE
Scale 1 : 50,000
Pantograph and Photographic reduction from original 1 : 10,000 plotting,
showing stadia stations at five-station intervals on main-named traverses.



Location map with outline of geology of part of Eastern and Southern Tanganyika

Plate XV


Fossil Locality Map
of parts of
KILWA & LINDI DISTRICTS
(SOUTHERN PROVINCE OF TANGANYIKA)
NGARAMA
PLATEAU
PLATEAU
NOT SURVEYED


A
From
Kilwa
Nossa
Mto Nyangi
Kigombo
Mbemkuru
Mbemkuru
Mtapaia
Mtapaia
Mtapaia
Mtapaia
From
Ruangwa
N O T
G.S.1108
From
Ruangwa
39° 15'

GEOLOGY AND PALAEONTOLOGY

OF THE

JURASSIC AND CRETACEOUS BEDS OF SOUTHERN TANGANYIKA

PART II

TRIGONIIDAE OF SOUTHERN TANGANYIKA

(Plates I - XLI).

PART II.

TRIGONIIDAE OF SOUTHERN TANGANYIKA

CONTENTS

TABLES.

PART II

TRIGONIIDAE OF SOUTHERN TANGANYIKA

I. INTRODUCTION

From the Tendaguru Series in Southern Tanganyika, numerous species of "*Trigonia*" s. lato have been described or discussed in the past (Müller, 1900; Krenkel, 1910; Lange, 1914, 1917; Hennig, 1914a, 1914b, 1937; Kitchin, 1929; Dietrich, 1933; Cox, 1952a, 1952b). In Part I it has been shown that in the Mandawa-Mahokondo area, from which much of the present collection came, strata associated with the Tendaguru Series by Hennig (1937) are older than this series, which straddles the Jurassic-Cretaceous junction. The older rocks, now termed the Mandawa-Mahokondo Series (Quennell, McKinlay & Aitken, 1956), also contain Trigoniidae, which are described along with those from strata equivalent to the Tendaguru Series.

Most of the material studied, all of which was collected by the author, is housed in the Hunterian Museum, Glasgow University (specimen numbers with prefix "S" quoted below), and other specimens remain in the collections of the Geological Survey of Tanganyika (specimen and locality numbers with prefix "WA"). The majority of Jurassic specimens came from the Mandawa-Mahokondo area while many of the Cretaceous Trigoniids described came from the Mbemkuru River depression. Specimen and locality lists are given in Appendices I-II which should be read in conjunction with Plates III and XV of Part I.

Cox (1952b) discussed previous attempts to classify the Trigoniidae and reviewed known representatives of the family. He defined divisions deserving to rank as genera and sub-genera, presenting brief diagnoses of each and applying to these, names previously available or new. In so doing he proposed the elimination of many names as redundant. More lately, Kobayashi (1954), Kobayashi and Mori (1954, 1955), Kobayashi and Tamura (1955, 1957) and Kobayashi and Amano (1955), in a study of Jurassic Trigoniidae from Japan, have made further comprehensive proposals on classification. These include the establishment of a number of new sub-families, elevation to generic rank of many of the former sub-genera and the establishment of new sub-genera and "sections". They observed that a limited number of developmental trends operate in the various sub-families; in some cases these were suggested as accounting for the development of one sub-family from another. As publication of the results of the studies on Japanese Trigoniidae and the proposed new classification is still incomplete, Cox's classification and his order of treatment of taxonomic groups are followed meantime. Mention is made where appropriate, of the later proposals.

Table I outlines the stratigraphical distribution of known Trigoniidae in Southern Tanganyika[1], a considerable

---

[1] A reference to "Tr. brancai" by Hennig (1914a, p.130) which from the context would appear to be a Trigonia, refers, in fact, to Trochus brancai.

	?Bajocian	?Bathonian	Callovian	Oxfordian	Kimmeridgian Lower Middle & Upper	Tithonian	Neocomian Lower Upper	Aptian	Original Record in S. Tanganyika	Occurrences reported outside Tanganyika
? Prosogyrotrigonia sp.					+				New	-
*Trigonia (Trigonia) zonata Agassiz					+				Müller (1900)	Europe
T. (Trigonia) prora Kitchin			+	?					New	Cutch
T. (Trigonia) elongata Sowerby			+	?					New	Europe, Cutch, Madagascar, Mangychlak Peninsula
T. (Trigonia) aff. propinqua Kitchin			+						New	Cutch
*T. (Trigonia) suprajurensis Agassiz			?	?					Hennig (1937)	
*T. (Trigonia) aff. denticulata (=silicea)			?	?					Hennig (1937)	Europe
*T. (Trigonia) stremmei Lange						?	[?	?]	Lange	-
*T. (Trigonia) aff. stremmei Lange						?			Hennig (1937)	-
T. (Trigonia) sp. nov. aff. T. triangularis Goldfuss				?	+				New	-
T. (Trigonia) tanganyicensis sp. nov.					+				New	-
T. (Trigonia) sp. (1)					[(?)	?]			New	-
T. (Trigonia) sp. (2)						+			New	-
*T. (Trigonia) sp. (3) Hennig 1914					[(?)	?]			Hennig (1914)	-
T. (? Pleurotrigonia) sp. nov.						+			New	-
T. (Indotrigonia) mandawae sp. nov.					+				New	-
T. (Indotrigonia) africana sp. nov.					?	+			New	-
T. (Indotrigonia) beyschlagi Müller						+	?		Müller (1900)	Cutch
T. (Indotrigonia) robusta sp. nov.						+			New	-
T. (Indotrigonia) v-striata sp. nov.						+			New	-
*T. (Indotrigonia) matapuana Krenkel					?	?			Krenkel (1910)	-
T. (Indotrigonia) sp. nov.							[?	(?)]	New	-
Myophorella (Myophorella) sp.						[(?)	?]		New	-
M. (Orthotrigonia) cf. kutchensis (Kitchin)			+	?					New	Cutch, (?) Madagascar
*M. (Orthotrigonia) discordans (Hennig)					+				Hennig (1937) whose dating is questioned	-
M. (Orthotrigonia) sp. nov. aff. O. duplicata (Sowerby)	[(?)	?] [?	?]						New	-
Yaadia hennigi (Lange)							[?	?]	Lange (1914)	Zululand
? Yaadia sp.						+			New	-
Megatrigonia (Megatrigonia) conocardiiformis (Krauss)						[(?)	?] [?	?]	Lange (1914)	S. Africa, Zululand, Mozambique, Cutch
M. (Megatrigonia) rogersi (Kitchin)							[?	?]	Hennig (1937)	Mozambique, Madagascar
*M. (Megatrigonia) staffi (Lange)							[?	?]	Lange (1914)	-
M. (Iotrigonia) cf. haughtoni (Rennie)						+			New	Zululand
M. (Iotrigonia) cf. vau (Sharpe)						?			New	S. Africa
*M. (Iotrigonia) kühni (Müller)							[?	?]	Müller (1900)	-
*M. (Iotrigonia) sp.							[?	?]	Dietrich (1933)	-
M. (Rutitrigonia) dietrichi (Lange)					?	+			Lange (1914)	-
M. (Rutitrigonia) bornhardti (Müller)							+	?	Müller (1900)	-
M. (Rutitrigonia) turikirae sp. nov.							[(?)	?]	New	-
*M. (Rutitrigonia) janenschi (Lange)							(?)	?	Lange (1914)	-
*M. (Rutitrigonia) cf. janenschi (Lange)							(?)	?	Lange (1914)	
M. (Rutitrigonia) schwarzi (Müller)							?	(?)	Müller (1900)	Mozambique
M. (Rutitrigonia) nyangensis sp. nov.							?	(?)	New	-
M. (Rutitrigonia) aff. nyangensis sp. nov.							[?	?]	New	-
M. (Rutitrigonia) nossae sp. nov.							?	(?)	New	-
M. (Rutitrigonia) spp. juv. indet. ("niongalensis" Lange)							?	?	Lange (1914)	
M. (Rutitrigonia) sp.							[? (?)]		New	-
M. (Rutitrigonia) krenkeli (Lange)							[?	(?)]	Lange (1914)	Zululand
M. (Rutitrigonia) kigombona sp. nov.							[?	(?)]	New	-
*Pterotrigonia ventricosa (Krauss)							[?	?]	Hennig (1937)	S. Africa, Mozambique, Zululand, Cutch, Attack Dist. (Pakistan)
*P. mülleri (Dietrich)						[(?)	?] [?	?]	Dietrich (1914) [Müller (1900)]	-
Linotrigonia (Linotrigonia) sp.							[?	?]	New	-
Laevitrigonia curta sp. nov.						+			New	-
Opisthotrigonia curvata sp. nov.						+			New	-
Trigoniid gen. et sp. indet.						+			New	-
Trigonia s. lato = "Indotrigonia dietrichi" of Dietrich (1933, Pl. II, figs. 40, 41)					+	?			Dietrich (1933)	-

KEY

\+ = definite dating
? = indefinite dating
? ? = one or other dating, or possibly both
[? ?] = one or other dating, but not both
(?) = more probable dating

* Not represented in the present collection

proportion of which are represented in the material under study. The table indicates other areas where particular species occur, but many have not been reported from outside Southern Tanganyika.

Apart from the obvious relations of the later representatives of the fauna with species from the South African and Mozambique areas, the most noticeable similarity is to the Trigoniid fauna of Cutch, from the Callovian to the Lower Cretaceous. This similarity has been observed previously in the case of species of Indotrigonia and Megatrigonia s. str. (Dietrich, 1933; Cox, 1952a). To these may now be added Trigonia s. str. and Orthotrigonia. Also, though the species are not identical in the two areas, Opisthotrigonia is only known in Cutch and Tanganyika.

If the specimen assigned tentatively to Prosogyrotrigonia is indeed a Trigoniid and belongs to this genus, it is much younger than any hitherto reported. Prosogyrotrigonia has been recorded from Upper Triassic and Lower Liassic strata in the Far East.

The distribution of Trigonia s. str. is as usual; an abundance of typical costate forms occurs in pre-Kimmeridgian strata, but very few in later beds, and these less typical.

The form from the Tithonian tentatively assigned to Pleurotrigonia is older than the previously recorded species of the sub-genus T. (Pleurotrigonia) blankenhorni Newton from the Lower Cretaceous of Zululand.

Indotrigonia is most common in the Upper Kimmeridgian and Tithonian, in the group of *I. africana* sp. nov. The oldest member of this group, *I. mandawae* sp. nov., may be as old as Middle Kimmeridgian but no Oxfordian species, such as *I. smeei* (Sowerby) of Cutch, has been noted. A new species believed to be Aptian in age is an unusual occurrence, but it is possible that the latest members of the *I. africana* species group extend into the Lower Neocomian.

"*Trigonia smeei*" (= *Indotrigonia africana* s. lato) was reported by Lange (1914, p.228) in the Neocomian/Lower Aptian marine strata of the Mbemkuru area (the *Trigonia schwarzi* Bed). Hennig (1914a, p.15; 1937, p.173) and Kitchin (1929, p.218) accepted its occurrence there, but Dietrich (1933, p.30) questioned it and Cox (1952a, p.115) and Arkell (1956, p.335) believed Dietrich's view to be correct. It has not been noted in Neocomian/Lower Aptian strata during recent collecting.

Myophorella s. str. is represented only by a single small shell from the Tithonian but the sub-genus *Orthotrigonia* is not uncommon in Callovian strata (as in Cutch) and occurs also in ?Bajocian and ?Bathonian beds. It has been suggested elsewhere (Pt.I, p.66) that *O. discordians* (Hennig) may have been wrongly assigned to the Kimmeridgian by its author (Hennig, 1937, p.174).

The presence of *Yaadia* in the Lower Cretaceous is normal. If the Jurassic specimen assigned tentatively to the genus in fact belongs here, the occurrence is unusual, though the genus is known from the Jurassic Malone Formation of Texas (see Stoyanow, 1949, p.67 et seq.) and in the ?Tithonian ?Neocomian Umia strata of Cutch.

Megatrigonia, normally a Cretaceous genus, has several representatives in the Jurassic of Southern Tanganyika. M. conocardiiformis (Krauss) occurs in strata probably Jurassic in age, below beds containing the younger members of the Indotrigonia africana species group. M. (Iotrigonia) cf. vau (Sharpe) is also apparently Tithonian as is I. cf. haughtoni (Rennie). These are all older than typical examples of the species from South Africa or Mozambique. The Jurassic M. (Rutitrigonia) dietrichi (Lange) differs slightly from the usual form of the sub-genus in possessing a marginal angulation reaching to the postero-ventral extremity though becoming obtuse in later growth, and in the apparent absence of concentric ribs on the proximal part of the area and escutcheon. Cox (1952a, p.120) reported a specimen related to M. conocardiiformis from ?Tithonian ?Neocomian Umia strata in Cutch, in which also, Kitchin (1903) reported species of Iotrigonia.

Pterotrigonia is not represented in the recent collections but has been described from the local Neocomian/Lower Aptian strata and also (see Müller, 1900) in association with Indotrigonia beyschlagi Müller. Doubts have been expressed (Dietrich, 1933, p.34) as to whether such an association could occur, but the presence of Pterotrigonia ventricosa (Krauss) in Tithonian Umia strata in Cutch (see Spath, 1927-33, pp.542, 789; Cox, 1952a, p.120) suggests that it is not unlikely.

The presence of Linotrigonia in the Lower Cretaceous is normal, as is that of Laevitrigonia and Opisthotrigonia in the Tithonian. The East African species of Laevitrigonia, L. curta, shows resemblance to the Cutch forms of the genus rather than to European forms.

Spath (1927-33, p.798) remarked that "More recent work seems to me to show that certain Jurassic forms of Trigonia cannot be satisfactorily distinguished from Cretaceous ones" (see also Spath, 1935, p.187). From the foregoing remarks, it is apparent that in Southern Tanganyika also, Trigoniids of Cretaceous aspect are surprisingly common in the Tithonian.

Trigoniids occur in large numbers in some parts of the Mandawa-Mahokondo Series and of the Tendaguru Series, but collections are not usually extensive enough to allow biometric analysis of their variation. Indeed, only in the case of the Indotrigonia has analysis of variation within a species group proved of immediate stratigraphical value (see p.48 et seq.). Other species groups could probably be of similar use, though information as to the stratigraphical relationships of their members is at present uncertain. Rutitrigonia bornhardti (Müller), R. janenschi (Lange) and R. turikirae sp. nov. are probably intergrading morphological species. The same may apply to R. kronkeli (Lange) and R. kigombona sp. nov.

Although there are strong resemblances between R. schwarzi Müller, R. nyangensis sp. nov. and R. nossae sp. nov., however, there is no suggestion of intergradation between these in the material available, and on this basis they must be regarded as biospecies.

An analysis of variation in a trigoniid species group, such as is given below for Indotrigonia africana sp. nov., has not been used before to the same extent as in this study, but the wide variation in I. africana s. lato has frequently been noted. Hennig (1937, p.173) applied biometric analysis to examples of the group, but did not carry it very far.

Variability in trigoniid species is frequently discussed in the literature. The very extensive synonymies given by Arkell (1929-37, pp.67, 81) for the Corallian species Myophorella perlata and Trigonia reticulata for example, indicate the wide range in variation of the species he recognised. He gave an interesting analysis of variation in ornament of the flank of "Trigonia" perlata Agassiz. The recognition by Cox (1952a, p.109) in Trigonia chariensis Kitchin from Cutch, of the European species T. elongata Sowerby, is another case where a wide variation is accepted for a single species. The present work has shown further variation in the same group (see p. 19 et seq.), which has not, however, proved of immediate stratigraphical value.

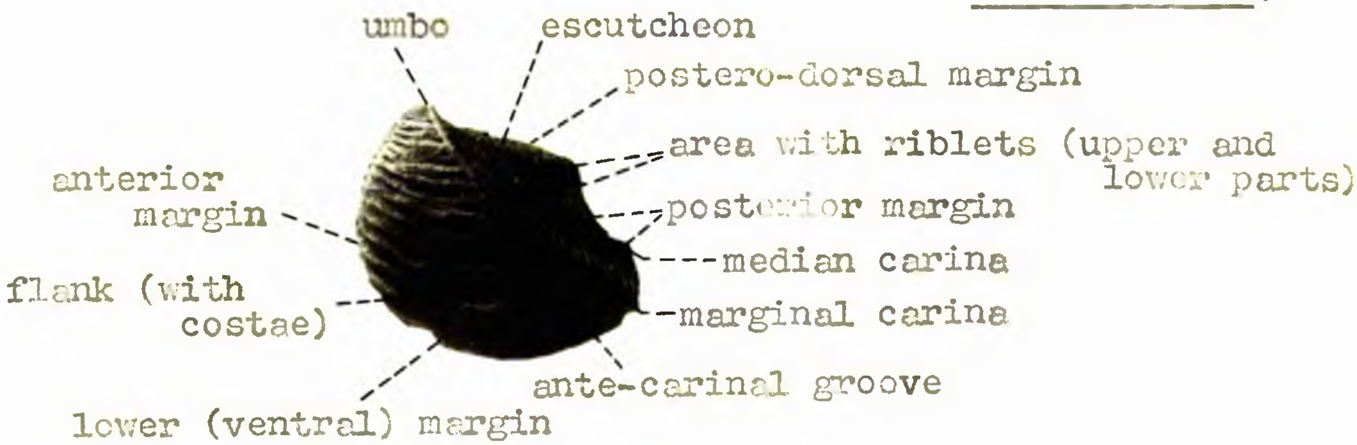
The rôle of homeomorphy in giving apparently long ranges to particular species, where the specialised nature of the ornament would suggest a short range, is unknown. Cases which require elucidation include those Trigoniids of Cretaceous aspect which occur in the Tithonian. The question of homeomorphy between the Trigoniids of Tanganyika, Western Europe and the New World also arises, for example in the case of Rutitrigonia [R. nyangensis sp. nov. and R. longa (Agassiz) var. undulatostriata (Paulke); R. bernhardti (Müller), R. longa (Agassiz) and R. laevisulcata (Lycett)].

The present study has emphasised the difficulty that occasionally arises in assigning a species to a particular genus or subgenus. In the case of (?)Prosogyrotrigonia the material available is inadequate for the assignment to this genus to be more than tentative. A juvenile specimen named as Trigonia (Trigonia) sp. (2), possessing a wide ante-carinal groove and a strong lateral component in the ornament of the area, has also affinities with Frenguelliella. "Trigonia" dietrichi is assigned to Megatrigonia (Rutitrigonia) following Cox (1952b). It differs from the typical Rutitrigonia in that no specimen available or described shows encroachment of concentric costae on to the smooth area in the umbonal region; the marginal angulation, often sharp proximally, extends throughout growth; and the concentric costae extend across the entire flank. The ornament, therefore is between that of Pleurotrigonia and Rutitrigonia, though the lunate shape and the possession of a marginal angulation, and not an upstanding carina, favours the assignment to Rutitrigonia. Rennie

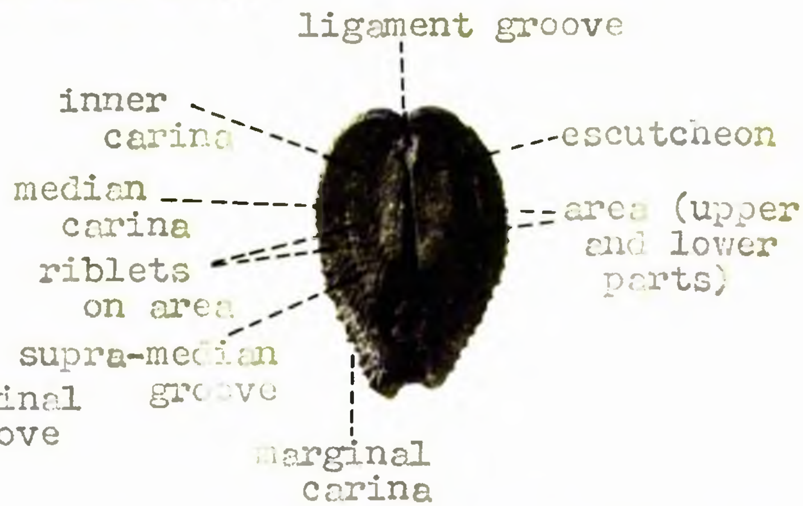
(1936, p.359) had some doubt about placing "*Trigonia" krenkeli* in *Rutitrigonia*, to which its shape and flank ornament are foreign. There is little doubt about the generic assignment, but a new sub-genus may be required. There has been some doubt too, as to whether *Laevitrigonia curta* should not be assigned to *Opisthotrigonia*, which it more closely resembles except in outline. Cox (1952a, p.116, 1952b, p.62) placed shells of a similar group from Cutch in *Laevitrigonia* and this precedent has been followed. Kobayashi and Mori (1954, p.161), (whose later, as yet incomplete, classification is not used in this paper), acknowledged the difficulty of placing the small group including *L. curta* in an established genus, by proposing for it the new genus *Eselaevitrigonia*.

Text-figure 1 shows the nomenclature used in the forthcoming descriptions of trigoniid shells. The measurement of shells involves the choice of a standard orientation, which has varied to some extent between individual observers. This invalidates comparison of the measurements quoted by different authors. In a few cases it has been found necessary to quote amended measurements for certain published figures to correspond with present usage, which is illustrated in Text-figure 1. Kitchin's (1903) practice of quoting measurements between fixed points on the shell, e.g. "between umbo and postero-ventral extremity", or such as "along marginal carina" has not been followed. All dimensions of shells quoted in the paper are given in millimetres.

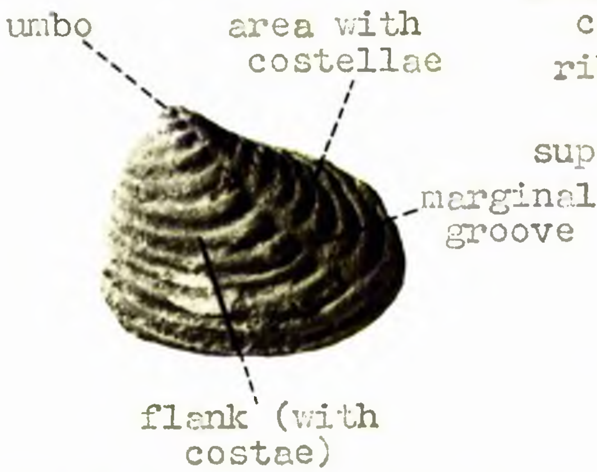
TEXT FIGURE 1.



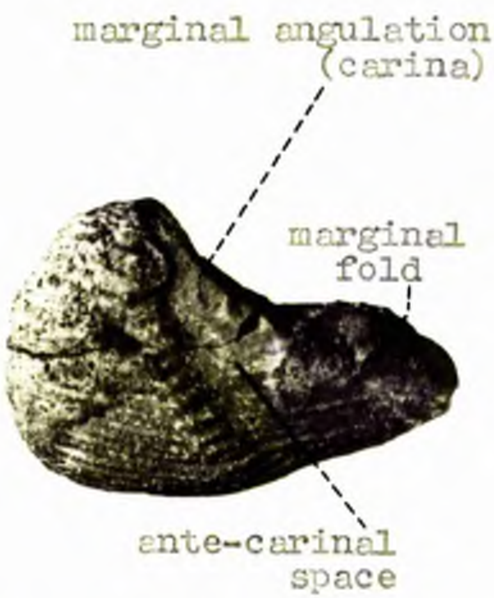
A. TRIGONIA (TRIGONIA) ELONGATA.



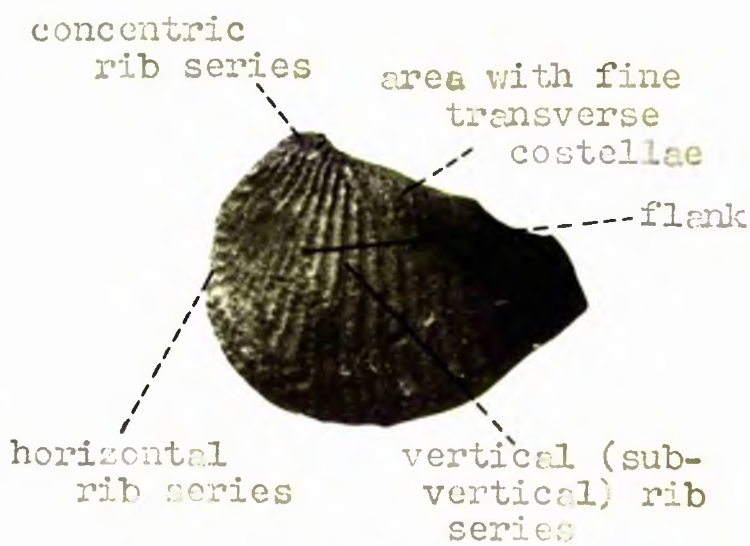
B. TRIGONIA (TRIGONIA) ELONGATA.



C. TRIGONIA (INDOTRIGONIA) AFRICANA.



D. OPISTHOTRIGONIA CURVATA.



E. MYOPHORELLA (ORTHOTRIGONIA) DUPLICATA.

The terminology used in the description of ornament is that common throughout the literature of Trigoniids, but is recognised to be inexact in some cases. For example, the term "concentric" is loosely used when "concrescent" would often seem more apt. However, the latter term could not generally replace the former, as concrescent flank ornament frequently becomes non-radially transcrescent in the anterior region of the shell. The term "radially transcrescent" could be used in reference to vertical or sub-vertical flank ribs, e.g. in Myophorella, but again the older terminology is adhered to.

Unless specifically stated, determinations of fossils mentioned in the text have been made by the author.

II. SYSTEMATIC DESCRIPTIONS

1. Genus PROSOGYROTRIGONIA Krumbeck, 1924.

Type species: Prosogyrotrigonia timorensis Krumbeck, 1924.
Upper Trias, Timor.

The genus Prosogyrotrigonia has only been reported from Triassic and Liassic strata in the Far East. Kobayashi (1954) named the sub-family Prosogyrotrigoniinae to accommodate it and the genus Prorotrigonia Cox (1952b) was tentatively associated with it in the sub-family (Kobayashi & Mori, 1954).

1. ?Prosogyrotrigonia sp. nov.

(Pl. XXIII, figs.1a, b)

A single small incomplete specimen is doubtfully regarded as a Trigoniid and resembles only Prosogyrotrigonia. It was obtained from strata dated as about Middle Kimmeridgian and hence much younger than previously known examples of the genus.

Locality and Material

Only one specimen is known (Hunterian Museum Collection No. S.11484 - see Appendix II) from Locality WA.2195 in the north of the Mandawa-Mahokondo area.

Description

The shell is small, ovately trigonal, moderately inflated. The height and length are about equal. The umbo (the umbonal apex is not preserved) is situated only a short way anterior to a median line. The anterior margin slopes forward to the foremost point which is low in this margin. There is a sharp curve into the gently convex lower margin. The postero-dorsal margin is slightly convex upwards and curves into the short nearly vertical posterior border. A sharp angulation separates the flank from the area but there is no upstanding marginal carina. (In the available specimen, a crack has developed in the shell along the line of this angulation.) The flank is ornamented by rather sharp, narrow, close-spaced concentric costae. The area appears almost parallel-sided in "escutcheon" view, and is slightly concave. It is ornamented by costellae of much the same strength and number as the costae but not always in direct continuation from them across the marginal angulation. The escutcheon is not visible, but must have been very narrow. The hinge is unknown.

Dimensions.

Length	18.0 mm.
Height	15.2 mm. (estimated)
Thickness	7.2 mm.
No. of costae	20 (assuming 5 not preserved in broken umbonal apex).

Comparison.

The shell is less quadrate than the type species, but less elevated than P. inouei (Yehara). It also differs from both in having a sharper angulation between flank and area (though this may be exaggerated by the cracking of the shell along the angulation). The new species differs from the type species in having stronger and less numerous costellae in proportion to the number of costae, but the ratio of the number of costellae to costae appears to be much the same as in P. inouei.

In the absence of information regarding the hinge, the assignment of the specimen to the Trigoniidae is a matter of doubt. The division from the flank of an area on which the costellae do not exactly correspond in numbers to and are not always in direct continuation of the costae suggests, however, that the specimen is a Trigoniid. Prosogyrotrigonia is the only Trigoniid genus to which the specimen can be compared, though the incompleteness of the umbonal region makes it uncertain if the umbones are prosogyrous.

The considerable difference in age from the known species of this genus and the distant areas in which they occur do not encourage the comparison.

Age

The specimen came from a concretion in marls close above the arbitrary upper limit of the Septarian Marl, and is believed to be Middle Kimmeridgian.

2. Genus TRIGONIA Bruguière, 1789.

Type species: Venus sulcata Hermann, 1781. Upper Lias, Alsace.

Cox (1952b, pp.50-54) discussed the type species of Trigonia, and in his taxonomic grouping of the Trigoniidae restricted the genus Trigonia to the section Costatae and its derivatives. He recognised the subgenera Trigonia s. str., Frenguelliella Leanza, Pleurotrigonia van Hoepen and Indotrigonia Dietrich[1]. Trigonia s. str., Indotrigonia and possibly Pleurotrigonia are known from southern Tanganyika. Frenguelliella has been reported in Tanganyika from Callovian strata near the Central Railway (Cox, 1937, p.198; 1952a, p.55), but not so far, from southern Tanganyika.

[1] Kobayashi (1954) established a sub-family, the Trigoniinae, which Kobayashi and Mori (1954) discussed in some detail. They regarded Cox's subgenera as genera and placed Trigonia s. str., Frenguelliella and Pleurotrigonia in the Trigonia Section of the sub-family, with a new genus Geratrigonia. Indotrigonia was placed in the Indotrigonia Section (see footnote p.48). Kobayashi and Tamura (1957, p.35) named the new genera Latitrigonia and Ibotrigonia as members of the sub-family.

Subgenus TRIGONIA (TRIGONIA).

Very large numbers of species of Trigonia s. str. have been erected both for European and extra-European forms. There has been a tendency recently, however, to regard many as synonymous, recognising a wide variation in a single species. For example Arkell (1929-37, p.81) in discussing T. reticulata of the Corallian of England, has argued that the basis of discrimination between numerous British and European Callovian species is unsound. He stated : "In the writings of the various authors who have tried to distinguish them, we repeatedly find the same uncertainty, or striving, by undue emphasis of one or two characters at the expense of the others, to differentiate two or more species. If sufficient material is examined, the various characters are found not to occur in the same combinations, and we are therefore again faced with recognizing an indefinite number of species or alternatively a single species with innumerable varieties." In uniting the Indian T. chariensis Kitchin with the European T. elongata Sowerby, in spite of wide variation, Cox (1952a, p.109) showed the same attitude.

Referring to the determination of specimens of Trigonia s. str. from the Mandawa - Mahokondo area, Hennig (1937, p.170) contended that splitting up of species of Trigonia had gone too far without consideration being given to variability, environmental effects, stage of growth and state of preservation. The variation in the small communities of shells from this area now available supports this view, suggesting that in Tanganyika, forms indistinguishable from various species from Cutch intergrade. It is not clear if the retention of these as morphic species is justified on stratigraphical grounds, either in Cutch or Tanganyika.

Previous Records in East Africa.

Previous records of Trigonia s. str. in East Africa and adjacent areas are rare. From southern Tanganyika Müller (1900, p.523, Pl.XVI, fig.5) ascribed a specimen apparently from the Septarian Marl [Lower (? -Middle) Kimmeridgian] of the Mandawa - Mahokondo Series, to T. zonata Agassiz. Kitchin (1903, p.121) was "inclined to place little reliance" on this determination. Müller (1900, p.564) also described specimens of a costate Trigonia from Cretaceous strata at Mikaramu, 35 Kms. south-west of Kilwa in southern Tanganyika (not the village of Mikaramu shown in Part I, Pl.II). Trigonia stremmei Lange, 1914 (p.224, Pl.XV, fig.21) was described from the Trigonia schwarzi Bed of the Tendaguru Series (Neocomian - Lower Aptian). On account of the lithology of the matrix of the specimens, however, Dietrich (1933, p.32) suggested they were all obtained from the Jurassic, though the same species occurred in the Lower Cretaceous of the Kiturika area to the north. Hennig (1937, p.171) reported a related species from the "Trigonia smeei" Bed in the Pindiro - Kihimbwi area.

An immature specimen of T. (Trigonia) sp. was figured by Hennig (1914b, p.172, Pl.XIV, fig.10) from the Middle Saurian Bed of the Tendaguru area. Hennig (1937, p.110) recorded specimens of Trigonia from his "Vor-Smeei-Schicht" (see Part I, p.60) believed to form part of the Callovian -

Oxfordian subdivision of the Mandawa-Mahokondo Series. They were not stated to be Trigonia s. str., but are probably the same specimens as he assigned (pp.169-171) to T. suprajurensis Agassiz and T. aff. denticulata (-silicea). These were described from Hennig's Upper and Lower Septarian Marls respectively, but from localities the numbers of which are listed (Hennig, 1937, p.112), and appear on his locality map, as in his "Vor-Smeei-Schicht". They are possibly of the same age and kind as those described below as belonging to the T. prora/T. elongata Group.

Hennig (1924, pp.31, 41-42) mentioned the occurrence of more than one species of Trigonia s. str. in the Ruvu Beds near the Central Railway Line of Tanganyika, but none was figured or adequately described. Dietrich (1925, p.6) recorded Trigonia s. str. from the Septarian Marl near Mahokondo [cf. Müller's (1900) record of T. zonata].

Venzo (1949, pp.137-147) described a number of species of Trigonia s. str. from Somalia, very close to the north-east corner of Kenya. The only species not described as new was T. brevicostata Kitchin, but he compared most of his species and varieties to Lower Callovian forms from Cutch. None of the material in the present Tanganyika collection is very similar. Venzo supposed the age of his specimens to be Bathonian, but (fide B.H. Baker, Geological Survey of Kenya) they came from strata now believed to be not older than Kimmeridgian. Trigonia cf. reticulata has been described (but not figured) from the top of the Bihen Limestone (Divisian - Argovian) and from the Wanderer Limestone (Lower Kimmeridgian) of British Somaliland, by Cox (1935a, p.161). The specimens are incomplete moulds only, however.

Newton (1895, p.82, Pl.III, fig.5) described as T. costata a specimen from northern Madagascar, in fact too youthful to be specifically identified. This was compared by Cox (1952a, p.108) to the form from Cutch ascribed by Sowerby (1840, Pl.XXI, Fig.17) to T. pullus, which Cox, however, considered indeterminate. Hennig (1924, p.42) compared one of his specimens from the area of the Central Railway Line in Tanganyika to the Madagascar specimen. Hourq (1950, p.45) mentioned Trigonia cf. costata from the Lower Bathonian of the Morondava region of Madagascar. In a summary of previous work, Besairie (1952, p.65) listed T. tenuicostata Lycett from the Bajocian of the Majunga and Betsiboka river areas, and T. costata from strata possibly of Upper Liassic age of the Kelifeli - Ikahavo Plateau. Besairie (1953, p.54) also recorded T. chariensis Kitchin from Callovian strata north of Manamana. T. tenuicostata is similar to T. prora of Cutch, and Cox (1952a, p.109) placed T. chariensis in the synonymy of T. elongata Sowerby, so that the Madagascar material may be related to the T. prora/T. elongata Group described below from Tanganyika.

Kitchin (1903) dealt at length with the Trigoniidae of the Jurassic of Cutch (India) and his work has recently been critically discussed and extended by Cox (1952a). Most of the pre-Kimmeridgian examples of _Trigonia_ s. str. in southern Tanganyika are very similar to a group of species from Cutch now termed the _T. prora_/_T. elongata_ Group.

Very few individuals of species outside this group have been found in southern Tanganyika either in the pre-Kimmeridgian or the overlying Kimmeridgian and Tithonian strata. The present collection does not include any Cretaceous examples of _Trigonia_ s. str.

1. _Trigonia (Trigonia)_ of the _prora/elongata_ Group.

The _T. prora_/_T. elongata_ Group is taken to comprise the larger species of _Trigonia_ s. str. described by Kitchin from Cutch all as new: _T. prora_, _tumida_, _propinqua_, _acuta_ and _chariensis_. Cox (1952a) did not accept _T. tumida_ as distinct but assigned it in part to _T. prora_ and in part to _T. propinqua_. He regarded _T. chariensis_ as synonymous with _T. elongata_ Sowerby, nor was he sure that _T. acuta_ (described by Kitchin from incomplete and weathered material) could be distinguished from _T. elongata_.

Localities and Material.

The numerous localities from which shells belonging to the species group were obtained all lie in the "core" of the Mandawa - Mahokondo anticline. They are listed in Appendix II under the following specimen numbers:

Hunterian Museum Collection: S.11862 - S.11984.

Geological Survey of Tanganyika Collection:
WA.1216(a); WA.1220(a), (a'); WA.1815(2); WA.1591; WA.1817(4); and WA.2221(5).

Description and Discussion.

For purposes of comparison, the diagnostic features of the Cutch species which Cox accepted, mainly as given by Kitchin (1903) (though occasionally paraphrased) are tabulated (see Table II). Table III gives dimensions measured from the illustrations of previously figured individuals of these species.

Analysis of the tabulated descriptions, with due consideration of Kitchin's (1903) and Cox's (1952a) figures and of the table of dimensions (Table III), suggests that a firm line of distinction cannot be drawn between *T. elongata*, *T. propinqua* and *T. acuta*. *T. prora* is more distinctive, but Cox's figures show that even this varies towards the other species, and it is therefore here taken to belong to the same species group. Some support for this is found in the present collection. Other species of *Trigonia* s. str. (e.g. *T. tenuicostata*, *T. denticulata*, etc.) could almost certainly be shown to have similar intergrading morphic relationships.

Although accepted as *T. elongata* on the basis of Cox's (1952a) remarks, many specimens from Tanganyika are scarcely distinguishable from *T. denticulata* as figured by Lebküchner (1932) from the Bajocian of southern Germany (and cf. the occurrence of *T.* cf. *denticulata* from British Somaliland

TABLE II. — COMPARISON OF THE MEMBERS OF THE TRIGONIA PRORA/TRIGONIA ELONGATA SPECIES GROUP OF CUTCH

T. elongata (= chariensis)	T. propinqua	T. acuta	T. prora
Ovately trigonal, moderately inflated	Well elevated, not strongly inflated	Well elevated, obliquely elongated, moderately convex	Relatively short and elevate inflated
Umbones close to the anterior end, well raised, prominent, well incurved and slightly recurved	Umbones near the anterior end, not strongly prominent, narrow, sharply pointed, well incurved and recurved	Umbones almost terminal, conspicuous, well raised, narrow, pointed, well incurved	Umbones almost terminal, pro raised, narrow, pointed, str and very slightly recurved
Cardinal margin slopes down gently from the umbo and forms a straight or slightly concave outline	Cardinal margin slopes gently back from the umbo and has a straight or very slightly convex outline	Cardinal margin relatively short (the illustration is not adequate - the shell appears in this feature to be between T. prora and T. elongata)	Cardinal margin straight and steeply sloping back from th
Frontal margin regularly convex and passes unbroken into the inferior margin which is more gently curved	Frontal margin slopes steeply down from the umbo and bulges forward to form a wide curve in profile. The inferior margin is very gently convex	Frontal margin falls very steeply from the umbo and is cut away below so as to pass by a wide curve into the convex inferior margin	Frontal margin falls at once from the umbo and continues back by a gradual curve and into the gently concave infe
Greatest height at the umbo	Greatest height at the umbo	Lowest point is posterior to a vertical line below the umbo (on illustration)	Lowest point is posterior tc line below the umbo (on illu
Costae narrow and well raised; 25-30 in a full grown specimen; nearly horizontal posteriorly curving slightly across the flank and rising more steeply to the frontal border. Not always evenly spaced. Up to 4 mm. apart at mid-growth but sometimes only 2 mm. Crowded in senility	Costae numerous, narrow and well raised, up to 40 in number. Widest interspaces not above 2 mm. Costae evenly and gently curved and rising steeply to the anterior margin. Near this margin they are attenuated and slightly wavy, and serrated when crossed by growth lines	adult. Up to 30 costae. Costae relatively closely crowded in youthful stages and well spaced in adult. Up to 30 costae. Costae delicate and crowded in youthful stage and approach the frontal margin at right angles. In the adult, they rise steeply to the anterior and are attenuated and wavy in this part. Spacing is about 3 mm. near the inferior margin of an adult	Costae are narrow, well rais are at least 26 in a fully g Spacing is 2 mm. - 2.5 mm. straight posteriorly and cur anteriorly, but are attenuat out on approaching the anter
A well marked ante-carinal groove on the left valve	A well marked ante-carinal groove, encroached on by ribs in senility	For 10 mm. from the umbo the costae of the left valve reach the marginal carina, but later there is a narrow space	Narrow ante-carinal groove c valve
Marginal carina narrow and well raised; ornamented by narrow, transversely lengthened protuberances, delicately moniliform in youth, elongated and ridge-like in the adult and scaly and imbricate in senility. Almost three times as numerous as the costae	Marginal carina narrow and fairly prominent until senility when it is blunter; ornamented by delicately moniliform protuberances in youth, which in the adult become transversely elongated. In senility they are closely crowded and imbricating scale-like ridges which cross from the flank to the area and are continuous with the growth ridges of the area	Carinal angle sharp and the carina narrow, prominent and delicately denticulated. the carina is straight in side view	The marginal carina is narrc prominent except near the pc the adult where it is rounde by narrow transverse grooves intervening rounded ridges w times as numerous as the cos
Area usually at an obtuse angle to the flank except near the umbo. The lower half is flat, the upper concave	Area usually at an obtuse angle to the flank. The lower half is flat or gently concave, the upper half is concave	Area at right angles to the flank for some distance but at a slightly obtuse angle to it at the posterior of the adult. The lower half is flat or slightly convex, the upper (broader) part is concave	Area large, at right angles to mid-growth, then at a mc angle. The lower half is s concave, the upper (broader) concave
Median carina fairly prominent, marked by close-set bead-like sculpture, scaly in senility	Median carina delicate in character	Median carina well developed as a sharp ridge in the anterior part, but blunter towards the posterior	Median carina narrow, promir
Area ornament of longitudinal ridges, 6-7 below and 8 above the median carina in the adult; at 10 mm. from the umbo 1-2 below and 4-5 (finer) above	Area ornament of delicate longitudinal ridges, 6 below and up to 12 above the median carina in the adult	Area ornament of finely denticulated raised lines. At 25 mm. from the umbo about 5 below and more above the median carina	Area ornament of narrow, we delicately beaded longitudi at posterior of adult, 6 bel above the median carina. A the umbo, 1 below and 2-3 at groove occurs above the marg carinae in the right valve, the late adult stage
Inner carina narrow with delicate bead-like or papillose ornament	Inner carina present as a narrow well defined ridge	Inner carina well raised and denticulate	Inner carina narrow, well ra prominent, ornamented by del like sculpture
Escutcheon relatively long, well excavated and of narrowly lanceolate form, marked by oblique, well raised, linear ornament (but Kitchin's figures do not show the shell with a narrow escutcheon)	Escutcheon of lanceolate form, well depressed near the inner carina, raised towards the cardinal margin. Ornament of oblique, narrow, raised ridges, minutely granular near the umbo, and continuous across the inner carina to the area. The ligament pit narrow, pointed posteriorly, about ¼ of the length of the escutcheon	Escutcheon relatively short and well depressed	Escutcheon broadly lanceolat excavated, the concave floor towards the cardinal margin. by weak, obliquely transvers The ligament pit is short, ; of the escutcheon

TABLE III - DIMENSIONS OF SPECIMENS OF TRIGONIA (TRIGONIA) FIGURED BY KITCHIN, 1903 (K) and COX, 1952a (C)

	K.Pl.1,f.3. *T.prora*	C.Pl.II,f.1 *T.prora*	C.Pl.II,f.2 *T.prora*	C.Pl.II,f.6 *T.prora*	K.Pl.1,f.1 *T.tumida* (= *T.propinqua* *fid.* Cox)	K.Pl.2,f.2 *T.propinqua*	K.Pl.2,f.3 *T.propinqua*	K.Pl.1,f.4 *T.chariensis* (=*T.elongata* *fid.* Cox)	K.Pl.2,f.1 *T.chariensis* (=*T.elongata* *fid.* Cox)	C.Pl.II,f.3 *T.elongata*	C.Pl.II,f.4 *T.elongata*
Length (L)	37.0	-	-	-	48.0	58.0	53.5	62.0	58.0	57.5	44.0
Height (H)	37.0	43.3	31.0	39.5	48.0	55.0	47.0	56.0	51.0	58.0	52.0*
Thickness (T)	12.0	-	-	-	18.0	15.5	13.0	21.0	-	-	-
Length of escutcheon	19.0	22.0	16.0	18.5	23.0*	24.0*	26.5	29.0	26.0*	30.0	24.0
Total No. of ribs	21	30	20	22	29	29	29*	24	22	21	18
No. of ribs to 35 mm.	20	24	-	19	21	19	23	16	16	12	14
Angle cardinal margin to horizontal	28°	41°	31°	32°	28°	24°*	20°	26°*	19°	35°	38°
No. of radial riblets on upper area at 10 mm.	-	-	-	-	7	-	-	-	-	-	-
No. of radial riblets on lower area at 10 mm.	-	-	-	-	2	-	-	-	-	-	-
No. of radial riblets on upper area at 30 mm.	-	-	-	-	7	-	-	-	-	-	-
No. of radial riblets on lower area at 30 mm.	-	-	-	-	5	-	-	-	-	-	-
H/L	100.0%	-	-	-	100.0%	94.8%	87.9%	90.3%	87.9%	100.9%	118.2%
T/L	32.4%	-	-	-	37.5%	26.7%	24.3%	33.9%	-		-

* Estimated

Notes on measurements of figures specimens of *Trigonia* (*Trigonia*)

1. The L and H measurements of Kitchin's specimens are based on an adjusted orientation of the illustrations to correspond with the orientation used by Cox and for the Mandawa - Mahokondo material. Correct orientation depends to some degree on the individual observer's judgment and minimises the value of comparison unless such adjustment is made. Consequently the measurements do not exactly correspond to those of the original author in all cases.

2. The measurement of the escutcheon is estimated from the lateral view of the shell (both in Kitchin's and Cox's illustrations). Kitchin's "top" views of shells do not allow measurement as it would be along the slope of the escutcheon, giving a fore-shortened length.

3. To facilitate comparison with figured specimens, the counts of rib are only of those seen in lateral view and do not include ribs in the uncurved umbonal region.

mentioned above). Adult specimens figured by Lebküchner are generally larger than the specimens from Tanganyika and Cutch assigned to T. elongata, but the range of variation in outline, flank ornament, area ornament, etc. is very similar. A slight difference is the smaller rate of increase in the spaces between successive ribs of the flank in T. denticulata. The majority of adult shells from Tanganyika are larger than most examples of T. elongata in the Blake Collection from Cutch, of which the figured specimens (Cox, 1952a, Pl.XII, figs.3, 4) are comparatively large.

Most of the Tanganyika specimens of T. elongata and many from Cutch are comparable to Lycett's (1872-79) var. lata in view of the width of the flank. Cox, however, did not use the varietal name. The variety was named by Strand (1928, p.71) T. cornbrashensis, but associated with T. elongata by Arkell (1940, p.45). The Tanganyika shells are smaller than Lycett's figured specimen of T. elongata var. lata and have less robust and widely spaced costae. Arkell's figured specimens of the variety are narrower flanked than the type and than most of the specimens from Tanganyika. However, Arkell's collection housed in the University Museum, Oxford, contains specimens more comparable to shells from Cutch and Tanganyika than those he figures, though smaller and less inflated on the whole. The costae of the Tanganyika and Cutch specimens generally rise to meet the anterior border at a much more acute angle than is illustrated in Lycett's figure, and more as in the specimens examined by Arkell.

T. elongata var. lata was reported by Lycett (1872-79, p.154) as being almost confined to the Cornbrash of Yorkshire (Callovian). Such an occurrence would agree with the position of the Tanganyika shells (mainly Callovian), but Arkell's record from the Fuller's Earth and the presence of wide-flanked examples of T. elongata in the Bathonian of Cutch suggest that the distinction of the variety is not justified on stratigraphical grounds.

Variation.

There is insufficient material to apply statistical methods to the study of variation in the group of T. prora/T. elongata, but the probability of intergradation between species and the likelihood of differentiation of communities at different horizons will be apparent from the discussion below on the small communities from Localities WA.835, WA.1226 and WA.1591 (see Appendix I).

Since the diagnostic characters of species have already been outlined (Tables II and III), it will be convenient to deal with these communities and not with the species as such. Notes on certain individual specimens will follow.

Locality WA.835 (Pl.III, figs.1-4, and Table IV).

This sample contains 11 shells [S.11869 - S.11879 (S.11873 with two valves) - See Appendix II] all identified as T. elongata. The majority agree well with this species

TABLE IV.

DIMENSIONS OF SPECIMENS OF *TRIGONIA (TRIGONIA)* FROM LOCALITY WA. 835.

	a (L.V)	b (L.V)	e^1 (L.V)	e^2 (R.V)	g (L.V)	h (L.V)	i (R.V)	j (R.V)	k (R.V)
Length (L)	50.5	51.0	47.0*	38.5	-	-	46.0	40.0	48.0*
Height (H)	51.0	55.5	51.0	38.5	49.0*	48.0	49.0	40.5	51.0*
Thickness (T)	16.5	18.5	17.0	13.0	18.0*	16.0	15.5	13.5	16.0
Length of escutcheon	26.5	26.0	-	-	-	-	25.0*	19.0	26.0
Total No. of ribs	22	23	20	18	21*	22*	18	20	19
No. of ribs to 35 mm.	16	15	14	16	17*	17*	14	18	15
Angle between cardinal margin and horizontal	33°	36°	-	-	34°	23°	39°	30°	31°
No. of radial riblets in upper area at 10 mm.	-	6	-	-	-	9	5	5	-
No. of radial riblets in lower area at 10 mm.	-	3	-	-	-	5	2	-	-
No. of radial riblets in upper area at 30 mm.	-	6	-	-	6	-	5	6	7
No. of radial riblets in lower area at 30 mm.	-	5	-	-	4	-	2	4	4
H/L	101.0%	108.8%	108.5%	100.0%	-	-	106.5%	101.25%	106.25%
T/L	32.7%	36.3%	36.2%	33.8%	-	-	33.7%	33.75%	33.3%

* Estimated.

as figured by Cox. There are no shells so elongated as Kitchin's T. chariensis (= elongata), but all are wider-flanked than the holotype. In some cases (Pl.III, fig.2) the general proportions and ornament compare closely with those of shells from Loc. WA.1591 (see Pl.II, figs.1-8), which are linked by intergradation with typical examples of T. prora.

The locality has been dated as Middle or Upper Callovian by Dr. W.J. Arkell, on ammonite evidence (see Pt.I, p.61).

Locality WA.1226 (Pl.I, figs.1-5 and Table V).

The eleven specimens (S.11902 - S.11912 - see Appendix II) from this locality are all identified as T. elongata, with which, as figured by Cox, they are clearly con-specific. Certain individuals, however, might not be so identified with certainty if seen out of their faunal context. For example, in the robustness of its ornament S.11912 (Pl.I, fig.4) is linked to T. elongata, though in size and outline it is nearer T. prora. The spacing of the costae is intermediate between that of T. prora and of T. elongata. The strong anterior undulation of the costae in S.11908 (Pl.I, fig.5) is unusual in a shell otherwise typical of T. elongata.

This locality also has been dated as Middle or Upper Callovian on ammonite evidence (see Pt.I, p.62).

Locality WA.1591 (Pl.II, figs.1-8 and Table VI).

The sample contains 12 specimens [S.11922 - S.11932

TABLE V.

DIMENSIONS OF SPECIMENS OF TRIGONIA (TRIGONIA) FROM LOCALITY WA.1226.

	a (R.V)	b (R.V)	c (R.V)	d (L.V)	e (R.V)	f (L.V)	g (R.V)	h (L.V)	i (L.V)	j (L.V)	k (R.V)
Length (L)	59.0	56.0	51.0	49.0*	39.5	49.3	-	-	60.0*	-	37.5
Height (H)	63.5*	58.0	53.0	47.0	38.0	51.7	55.0*	40.0	62.0*	-	42.0
Thickness (T)	23.0	20.5	20.5	17.5	13.0	18.0	17.0	11.5	18.5	17.0	13.5
Length of escutcheon	17.0	32.5	30.5	23.0	18.5	26.0	-	20.0	31.0	31.0	22.0
Total No. of ribs	27	24	22	17	18	22	26	18*	22	-	23
No. of ribs to 35 mm.	16	16	16	14	16	17	18	16*	15	15	19
Angle between cardinal margin and horizontal	40°	27°	32°	33°	28°	37°	29°	31°	32°	33°	36°
No. of radial riblets in upper area at 10 mm.	6	5	5	5	5	7	5	7	-	7	-
No. of radial riblets in lower area at 10 mm.	2	1	2	2	1	2	1	2	3	2	-
No. of radial riblets in upper area at 30 mm.	-	7	-	-	6	mainly trans-	5	-	-	mainly trans-	7
No. of radial riblets in lower area at 30 mm.	2	3	4	4	4	verse	3	4	-	verse	3
H/L	107.6%	103.6%	103.9%	95.9%	96.2%	104.9%	-	-	103.3%	-	112.0%
T/L	39.0%	36.6%	40.2%	35.7%	32.9%	36.5%	-	-	30.8%	-	36.0%

*Estimated.

TABLE VI.

DIMENSIONS OF SPECIMENS OF *TRIGONIA (TRIGONIA)* FROM LOCALITY WA.1591.

	a' (L.V)	a" (R.V)	b (L.V)	c (L.V)	d (L.V)	e (L.V)	f (L.V)	g (R.V)	h' (L.V)	h" (R.V)	j (R.V)	k (L.V)
Length (L)	47.0*	47.0	45.0*	45.0	-	45.0*	41.5*	-	49.0	49.0	-	-
Height (H)	52.0	52.0	47.0	45.0	-	46.0	43.0*	35.5	49.0	49.0	50.0	54.5
Thickness (T)	16.0	16.0	15.0	15.0	14.5	14.5	14.5	12.0	15.5	15.5	16.0	21.0
Length of escutcheon	22.0	22.0	22.0	22.0	22.0*	-	23.0	16.0	22.5	22.5	26.0	32.0
Total No. of ribs	25	-	21	26	-	27	25	24	25	-	26	21
No. of ribs to 35 mm.	18	18	18	22	-	21	21	24	19	-	19	16
Angle between cardinal margin and horizontal	34°	-	31°	32°	39°	-	26°	29°	27°	27°	34°	28°
No. of radial riblets in upper area at 10 mm.	6	5	4	7	5	-	6	-	5	-	7	-
No. of radial riblets in lower area at 10 mm.	2	1	2	3	1	-	2	-	2	-	1	-
No. of radial riblets in upper area at 30 mm.	6	-	5	-	7	-	-	-	5	7	6	1
No. of radial riblets in lower area at 30 mm.	3	2	4	4	3	-	3	-	4	3	3	-
H/L	110.6%	110.6%	104.4%	100.0%	-	102.2%	103.6%	-	100.0%	-	-	-
T/L	34.0%	34.0%	33.3%	33.3%	-	32.2%	34.9%	-	31.6%	-	-	-

Estimated.

WA.1581 (12)] identified as follows (see Appendix II):-

T. elongata - 3 specimens

T. aff. *elongata* - 4 specimens

T. prora - 1 specimen

T. cf. *prora* - 1 specimen

T. aff. *prora* - 2 specimens

T. aff. *propinqua* - 1 specimen

The community is distinctive in including typical examples of *T. prora* apparently intergrading with shells identical with variants in the communities of *T. elongata* from Localities WA.835 and WA.1226. It includes a wide-ribbed example of *T. elongata* (S.11922) though there are no intergrades between this and the "intermediate" form that occurs in all three of the communities discussed.

Specimen S.11925 (Pl.II, fig.4) ascribed to *T.* aff. *elongata*, but apparently linked through other specimens to *T. prora*, compares rather closely with *T. acuta* Kitchin. In view of the scanty material on which *T. acuta* was based, Cox's doubt as to whether this species can be usefully distinguished from *T. elongata* is probably justified.

Specimens S.11926 (Pl.II, fig.3) and S.11932 (Pl.II, fig.5) are relatively wide flanked, rather fine-ribbed forms. The former can safely be assigned to *T.* aff. *elongata*, but the latter appears to be nearer to *T. propinqua*. It is, however, an intermediate form between the extremes of the sample.

The community is not dated by associated ammonites.

It may occupy a higher position in the Callovian - Oxfordian subdivision of the Mandawa-Mahokondo Series than the foregoing communities and is in fact distinct from them, though there are overlapping variants.

Other Localities.

To complete the picture of variation in the T. prora/ T. elongata Group in the collection from Southern Tanganyika, illustrations are given of examples from several localities from each of which only a small number of specimens was obtained (Pls.III and IV). Little comment is required on these beyond that given in the Explanation of Plates. The additional localities from which specimens are figured are (see Appendix I): WA.924, WA.1219, WA.1220, WA.1292, WA.1804, WA.1815, WA.1817, WA.2225 and WA.2229.

Locality WA.1817 /S.11942, S.11943, WA.1817(2)/ like WA.1591 discussed above, contains specimens of both T. prora and T. elongata. Localities WA.1804, WA.1815 and WA.1817 from which the specimens S.11935, WA.1815(2), WA.1817 (4), S.11942 and S.11943 are illustrated, are on a short strike section of the Lihimaliao stream, and are presumably of much the same age. Together, the specimens from them show a variation as striking as that of the shells from Locality WA.1591.

Specimen S.11880 (Pl.III, fig.7) from Locality WA.924 is a worn, double-valved, adult shell, more elongate than the usual T. elongata of the present collection, but having an

H/L ratio within the range exhibited by Kitchin's T. chariensis. It has wider spaced costae than the specimens figured by Kitchin, but the spacing is comparable to that in specimens figured as T. elongata by Cox from Cutch and to that in T. elongata from Tanganyika. The specimen is named as T. cf. elongata, but in its poor state of preservation, is almost indistinguishable from the specimen figured by Arkell (1929-37, Pl.VI, fig.2) as T. reticulata Agassiz (? from the Lower Kimmeridge Clay of Dorset). S.11880 was not obtained in situ, but the adjacent strata could be slightly younger than the Callovian beds yielding the bulk of the specimens of the T. prora/T. elongata Group. Specimen S.11935 from Locality WA.1804 (Pl.IV, fig.3) is a small specimen, presumably not mature, which has proportions similar to S.11880. Its ornament is quite typical of T. elongata, and since it accompanies examples of this species, it is assigned without qualification to it.

Associations and Age.

Most of the specimens came from strata dated on ammonite evidence by Dr. W.J. Arkell as of Middle or Upper Callovian age. None came from strata older than this but the following localities cannot confidently be assigned a Callovian age:- WA.924*, 979*, 1259, 1261, 1322, 1323, 1804*, 1806*, 1815*, 1817*, 2297. Specimens from the localities asterisked are probably younger than the majority, but none is definitely dated as Oxfordian. Apart from specimens S. 11880 (Loc. WA.924) and S.11935 (Loc. WA.1804) discussed above, none of the shells from these localities seems essentially different from those of the definitely Callovian localities.

Examples of the T. prora/T. elongata Group occur throughout the dated Callovian strata of the Mandawa - Mahokondo Series in its type area, and possibly also in the Oxfordian. It has not been possible, with the limited material available, to put the observed variation in the gens to any stratigraphical use.

The large fauna from the Callovian and Oxfordian subdivisions of the Mandawa - Mahokondo Series is listed elsewhere (Part I, p.58), and the Callovian element, at least, can be regarded as accompanying the T. prora/T. elongata Group. The following are among the molluscs actually noted in association with it in the author's collection (ammonite determinations by Dr. W.J. Arkell: for localities see Appendix I):-

Calliphylloceras demidoffi (Rousseau) [= disputabile Zittel ?]: Locs. WA.835, 2161, 2259, 2302, 2303, ?2309.

Holcophylloceras zignodianum (d'Orbigny) [? = mediterraneum Neumayr]: Locs. WA.2019, 2161.

Ptychophylloceras euphyllum (Neumayr): Locs. WA.1005/1180, 1591, ?828.

Lytoceras adeloides Kudernatsch: Loc. WA.835.

Sindeites sp.: Loc. WA.1004.

? Subkossmatia discoidea Spath: Loc. WA.1226.

Indosphinctes pseudopatina (Parona & Bonarelli): Loc. WA.1005/1180.

I. cf. indicus (Siemiradski): Loc. WA.835.

Choffatia aff. difficilis (Buckman): Locs. WA.1218, 2019.

? Grossouvria sp. indet.: Loc. WA.1004.

Poculisphinctes aff. poculum (Leckenby): Locs. WA.2303, ?1004.

Obtusicostites cf. ushas Spath or buckmani Spath: Loc. WA.1004.

Kinkeliniceras discoideum Spath: Locs. WA.835, 2019.

Sivajiceras aureum Spath: Loc. WA.2303.

S. aff. kleidos Spath: Locs. WA.835, 2259.

S. cf. fissum (Sowerby): Loc. WA.2309.

Sivajiceras sp. juv.: Loc. WA.2019.

Hubertoceras omphalodes (Waagen): Loc. WA.828.

H. arcicosta (Waagen): Locs. WA.835, 1004, 1220.

H. dhosaense (Waagen): Loc. WA.1191.

Astarte mülleri Krenkel: Locs. WA.835, 1004, 1219, 1226, 1818, 2161, 2219, 2221, 2225, 2227, 2259, 2303, 2309.

Ceratomya concentrica (Sowerby): Locs. WA.1005, 1216, 2297, 2302.

C. telluris (Lamarck): Locs. WA.835, 982/1182/1004, 1180, 1216, 1219, 1220, 1226, 1259, 1591, 1706, 2019, 2225, 2297.

C. cf. wimmisensis (Gilliéron): Loc. WA.1005/1180.

Ceromyopsis sp. [= "Isocardia striata" of Müller (1900)] Loc. WA.1005/1180.

Grammatodon (Indogrammatodon) virgatus (Sowerby): Locs. WA.835, 924, 1226, 1817, 2225, 2227, 2259, 2303.

Modiolus glendayi Weir: Locs. WA.823, 835, 1004/1182, 1191, 1220, 1226, 2019, 2225, 2227, 2259, 2297, 2303.

Myophorella (Orthotrigonia) cf. kutchensis (Kitchin): Loc. WA.1005/1180,

together with species of Eligmus, Eopecten, Exogyra, Gervillella, Lima, Lopha, Modiolus, Ostrea, Pecten, Pholadomya, Pinna and Protocardia among others.

A Callovian age is younger than that of the specimens described by Kitchin (1903) from Cutch, which were for the most part Upper Bathonian. However, Cox (1952a, p.110) also described T. elongata from the Callovian anceps and rehmanni strata there. T. elongata is known from the Upper Cornbrash in England and (reported as T. chariensis) from the Callovian of Madagascar (see p.18).

2. Trigonia (Trigonia) sp. nov. aff. T. triangularis Goldfuss. (Pl.V, figs.4-5).

The collection contains two examples of a new species, one immature. The similarity to T. triangularis Goldfuss (well figured by Lebküchner, 1932, Pl.XIV, fig.12; Pl.XV, figs.1-7; Pl.XVI, figs.1,2) is obvious, but there are notable differences especially in the form and ornament of the flank costae.

Localities and Material.

Hunterian Museum Collection: Locs. WA.1740 (S.12114); WA.2194 (S.12115).

(See Appendix II)

Description.

The shell is of moderate size for the genus, roughly in the form of an equilateral triangle. The anterior border is straight, sloping steeply from the umbo and passing in a sharp curve into the lower border. The postero-dorsal border is long, sloping back rather steeply from the umbo and forming an obtuse angle with the posterior border, which is almost vertical. The convex lower border has a sulcus corresponding to an ante-carinal space on the flank, which is divided from the area by a very strong, nearly straight, corded, marginal carina. The flank ornament comprises strong, widely spaced, slightly nodose costae. They slope downwards and backwards from the edge of a flattened, frontal face, which they cross more or less horizontally but do not reach the anterior border. There is slight increase in thickness of the costae at the anterior angulation of the flank. The costae terminate posteriorly with a slight swelling, at the edge of a smooth, concave, ante-carinal space occupying about 1/3 of the flank. The area is set at a moderate angle to the flank. It is divided into almost equal parts by weak, finely denticulated, median carina. Both parts are slightly concave and the upper is "stepped-down" from the lower at the median carina. There are finely denticulated, radial costellae, four in each part of the area at 25 mm. from the umbo. In the adult specimen, the upper part of the area protrudes slightly behind the lower at the posterior border. The inner carina is prominent and denticulated. The escutcheon is broad, lanceolate and depressed, but the inner edge rises towards the edge of the valve. It is apparently smooth. The ligament pit is about 1/3 of the length of the escutcheon and is fairly narrow.

Dimensions.

	S.12114	S.12115
Length	55.0 mm.	18.4 mm.
Height	49.0 mm.	18.0 mm.
Length of anterior end	25.0 mm.	8.0 mm.
Thickness (single valve)	13.7 mm.	5.0 mm. (ca.)
Length of escutcheon	27.5 mm.	9.0 mm. (ca.)

Comparison.

The main differences between this form and T. triangularis Goldfuss are in the form and ornament of the costae. In T. triangularis, while the costae are said to undulate near the anterior end, they are described as meeting the anterior border at an acute angle. In the new species, a flattened frontal face is developed. The costae thicken at the angulation from the main part of the flank and thin out on crossing the frontal face. At no growth stage do they actually reach the anterior margin; on the frontal face they run nearly horizontally at mid-growth, downwards towards the margin in the upper part of the shell and upwards in later growth. In

T. triangularis the flank costae are smooth, while in the new species they are slightly nodose, and a larger node is developed at the posterior end of each rib. The development of the carinae and the form and ornament of the area and escutcheon is similar in the two species.

The adult specimen (S.12114) is incomplete at the postero-ventral extremity. From the form of the growth lines and of the sulcus corresponding to the ante-carinal space in the immature specimen (S.12115) there would appear to be no difference from T. triangularis in this part of the shell. S.12114 may also be incomplete in its lower part, and as the umbonal apex is slightly damaged, the greater elongation of the figure as compared with that of T. triangularis may be more apparent than real.

Associations and Age.

S.12114 came from a bed almost immediately below the base of the Septarian Marl and is probably Upper Oxfordian in age. S.12115 came from just above the Septarian Marl, probably from the Middle Kimmeridgian. A lamellibranch fauna associated with the ?Upper Oxfordian specimen (Loc. WA.1740) included Astarte aff. major Sowerby, Grammatodon (Indogrammatodon) cf. iddurghurensis Cox and species of Exogyra, Gryphaea, Hinnites, ?Oxytoma and Pecten.

3. Trigonia (Trigonia) tanganyicensis sp. nov.

(Pl.V, figs.1-2).

Trigonia tanganyicensis sp. nov. is erected on the basis of four specimens from a single locality. It is not comparable to any species of Trigonia described before from the East African area.

Locality and Material.

Hunterian Museum Collection: Loc. WA.812 (S.12116 - S.12118).

Geological Survey of Tanganyika Collection: Loc. WA.812 [WA.812(a)].

(See Appendix II).

Specimen S.12118 (Pl.V, figs.1a-c) is designated holotype.

Diagnosis.

Shell of medium size, ovately trigonal, elongated, rather compressed, with prominent umbo situated about $\frac{1}{4}$ of the length from the anterior end. Anterior margin strongly convex, passing in a smooth curve into the gently convex lower border, the lowest point of the shell being posterior to the umbo. Postero-dorsal margin long and straight, sloping gently back from the umbo. Posterior margin straight and oblique. Flank wide, ornamented by narrow, smooth costae, with inter-spaces slightly wider than the costae.

Marginal carina sharply rounded and smooth, but not very prominent. On the left valve, the flank costae run into a secondary carina separated from the main carina by a narrow groove. On the right valve, the ends of the flank costae are separated from the marginal carina by a fine groove. There is a sharp angle between flank and area, becoming more obtuse in later growth. Area of moderate width, ornamented by strong, slightly denticulated, radial riblets, 10-13 in number. Median and inner carinae not prominent. The upper and lower parts of the area are about equal in width, nearly flat and placed at a slight angle to each other. Escutcheon long, lanceolate, slightly depressed and at the widest point about half the width of the adjacent part of the area.

Dimensions.

	S.12118 (Holotype)	S.12117
Length	53.5*	31.0*
Height	31.4	22.0
Thickness (single valve)	9.0	7.4
Length of anterior end	12.0	8.0
Length of escutcheon	23.3	-

* Estimated.

Further Description and Discussion.

None of the available specimens is entire, the posterior end being more or less incomplete in every case. In the holotype the costae are not parallel to the lower border, but pass with some irregularity and gentle obliquity backwards and downwards from the anterior border, but at a slight angle later. The paratypes, smaller individuals than the holotype, show less irregularity of flank ornament than the latter, and the costae are nearly parallel to the pallial border.

The radial costellae of the area increase only slightly in number distally (9 at 10 mm., 10 at 20 mm. in the holotype). The only right valve paratype exhibiting detail of the area has three enlarged median costellae instead of a median carina. The detail of ornament on the escutcheon is not visible on any available specimen, and the internal features are unknown. The holotype shows slight flattening of the surface of the flank in its posterior third, but this may be an abnormality of the individual since paratypes show no such feature.

The narrow-ribbed species of _Trigonia_ s. str. described from Cutch by Kitchin (1903) are _T. tenuis_ (= _T. oomia_ Strand) and _T. parva_. _T. oomia_ (Argovian) differs from _T. tanganyicensis_ in having a fairly strong, finely corded marginal carina and a wider area, less steeply inclined to the flank. The flank is narrower and the costae more strongly curved. _T. parva_ is smaller, has no ante-carinal groove on the right valve, has a more strongly curved marginal carina, and the radial costellae of the area are much stronger. Kitchin compared _T. oomia_ to a number of European species (_T. hemisphaerica_, _etalloni_, _barrensis_, _glasvillea_, _langrunensis_, _striatissima_, praecostata), but apart from the less prominent umbones in T. oomia the differences between this and the European species appear in greater degree in T. tanganyicensis.

Lebküchner's (1932, Pl.XVI, fig.4) figure of a specimen assigned to T. siliceum resembles the holotype of T. tanganyicensis except in being slightly shorter and in its regular flank ornament (cf. paratypes). T. siliceum, however, is normally much higher and more tumid than T. tanganyicensis, with coarser ornament. Lebküchner's specimen (from South Germany) is probably not very different in age from T. tanganyicensis.

Associations and Age.

T. tanganyicensis was found associated with large numbers of T. (Indotrigonia) mandawae sp. nov. and Astarte recki Dietrich, and Anomia, Gervillella, Grammatodon, Lima and Pecten were also noted. The horizon is below the "smeei" Oolite of the Mandawa - Mahokondo area, in strata of Middle or Upper Kimmeridgian age.

4. Trigonia (Trigonia) sp. (1)
(Pl.V, figs.3a,b).

A single incomplete specimen (left valve) in the collection is superficially similar to that described by Lange (1914, p.229, Pl.XV, figs.2a,b) as Trigonia stremmei, but has several points of difference.

Locality and Material.

Hunterian Museum Collection: Loc. WA.698 (S.12119)
(See Appendix II).

Description.

The lower part of the specimen is not preserved but convex growth lines suggest that the complete shell was trigonally ovate in outline. The umbo is about 1/3 of the length from the anterior end, which is convexly curved, and the postero-dorsal margin, formed by the elevated inner edge of the escutcheon, slopes gently back to the umbo to form an obtuse angle with the slightly oblique posterior margin. The shell is moderately inflated. The flank occupies little more than half the shell's surface. It is ornamented by smooth, rather fine and closely spaced concentric costae, which are slightly downwarped anteriorly to meet the anterior margin at right angles. 13 costae are visible in lateral aspect in the first 10 mm. below the umbo and their posterior ends are linked by a fine secondary carina in front of a narrow but well-marked ante-carinal groove. The marginal carina is sharp, denticulate and rather prominent, and the moderately wide area is bounded by a well-marked, obscurely denticulated, inner carina. The area ornament is reticulate. There is no median carina, though the central of seven longitudinal rows of denticles is slightly more prominent than the others, and no supra-median groove. The very wide escutcheon is slightly depressed in relation to the area, out with its inner edge elevated; its surface has fine reticulate ornament. In the single specimen, two halts in growth are indicated by gaps in the longitudinal rows of denticles both on the area and on the escutcheon, giving two transverse grooves following the direction of the growth lines.

Comparison.

The specimen differs from Trigonia stremmei Lange in the absence of a median carina on the area and in the wider escutcheon and the lack of transverse ornament on it. Also the shell is more quadrate in appearance than T. stremmei, due to the elevated inner edge of the escutcheon. It is less elongated and more tumid than T. tanganyicensis sp. nov., with more convexly curved costae and stronger marginal carina. The area is proportionately larger with a less prominent longitudinal component of ornament and the escutcheon is less elongated.

From Hennig's "Trigonia sp. Gruppe der costata" (Hennig, 1914b, p.172, Pl.XIV, fig.10) from the Middle Saurian Bed of the Mbemkuru area and from T. parva Kitchin of the Umia Group of Cutch, it differs especially in the absence of strong radial costellae on the area. The similarity of the shell to T. pullus Sowerby, well figured and described by Lycett (1872-79, p.164, Pl.XXXIV, figs.7,7a,8,9) is striking, but the characteristic feature of this species, the transverse costellae of the anteal portion of the escutcheon, is missing. Shells from the Bathonian of Cutch are tentatively assigned to T. pullus by Sowerby (1840, Pl.XXI, fig.17), and are compared by Cox (1952a, p.108) to the specimen recorded as "T. costata Parkinson" by Newton (1895, p.82, Pl.III, fig.5) from Madagascar, but are considered too incomplete for specific determination. These differ from the Tanganyika specimen in having much more widely spaced flank costae, and in possessing essentially transverse ornament on the area and escutcheon. The shells recorded as T. pullus from Abyssinia by Douvillé (1886, p.226, Pl.XII, figs.13,14) are essentially similar to the Tanganyika specimen but for the transverse ornament on the rather smaller escutcheon and the less reticulate ornament of the area.

Age.

From an oolitic limestone near Matapua correlated with the "smeei" Oolite of the Mandawa - Mahokondo area, and taken to be of Upper Kimmeridgian or Lower Tithonian age.

5. Trigonia (Trigonia) sp. (2).
(Pl.V, figs.6a,b).

This is the only specimen of Trigonia s. str. in the present collection from strata above the "smeei" Oolite.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2140 (S.11479).

(See Appendix I).

Description.

The shell, an immature left valve, is trigonally ovate. The anterior end is convex and the anterior and lower borders form a smooth curve from the umbo (placed between 1/3 and ½ of the length from the anterior end) to a sulcus corresponding to the position of a wide ante-carinal groove. The postero-dorsal margin slopes rather steeply back from the umbo and meets the short, slightly oblique posterior margin at an obtuse angle. The ornament of the flank consists of strong concentric costae parallel to the growth lines. Nine are visible in side view. Those in the incurved umbonal area are worn. The interspaces are slightly wider than the thickness of the costae. The ante-carinal groove widens rapidly downwards, and the flank costae, which thicken to an incipient node immediately in front of the groove, encroach on it in very reduced form as slight growth rugae. There is a strong marginal carina with laterally extended tubercles. Proximally the area, which is rather narrow and set at a sharp angle to the surface of the flank, has a prominent tuberculate median carina and a rather strong supra-median groove. Its lower half is marked by one radial riblet, the upper by two, but lateral ornament tends to mask the radial ornament at an early stage. No inner carina is seen and the escutcheon is not visible.

Dimensions.

Length	18.0 mm.
Height	15.8 mm.
Thickness	5.0 mm.(ca.)
Length of anterior end	7.0 mm.

Age.

From strata of Upper Kimmeridgian - Lower Tithonian age a short distance above the "smeei" Oolite.

Comparison.

The strong ante-carinal groove, more prominent marginal carina, coarser and wider spaced costae, and the narrower area with more prominent transverse ornament, distinguish the specimen from T. stremmei. The same features distinguish it from T. (Trigonia) sp. (1) described above. T. (Trigonia) sp. (2) is not unlike the "Trigonia Gruppe der costata" described by Hennig (1914b, p.172, Pl.XIV, fig.10) from the Middle Saurian Bed in the Mbemkuru area. However, Hennig's specimen (a right valve) differs in the shape of the anterior end and has longitudinal grooving on the area not seen in the specimen under discussion. T. (Trigonia) sp.(2) differs from T. kheraensis Cox of the Bathonian of Cutch in being more ovate and more tumid. Its ovate form, the narrower ante-carinal groove and the more prominent transverse component of the ornament of the area, distinguish it from T. triangularis and related species. It rather resembles T. brevicostata of

Cutch (Bathonian) and the various small species including "T. brevicostata" of Trigonia s. str. figured by Venzo (1949) - Lyriodon according to Venzo - from Somalia. The Tanganyika specimen, however, has more robust ornament than any of these, and a more prominent ante-carinal groove. The Somalian specimens are generally higher, tending to circular outline. The strata yielding Venzo's specimens are now believed (fide B.H. Baker, Geological Survey of Kenya) to be possibly Kimmeridgian or later[1] and not Bathonian as originally supposed.

1) The associated species of "Laevitrigonia" appear to belong to Rutitrigonia of which the oldest known species from Tanganyika is R. dietrichi (Lange) of the Tithonian. This would tend to confirm the later date of the strata.

T. (Trigonia) sp.(2) is also similar to T. pullus [see above under T. (Trigonia) sp.(1)] which has the same general dimensions, but in which the costae are slightly wider spaced especially near the umbo, are less convex downwards and do not become swollen towards the ante-carinal groove. The ante-carinal groove is narrower than in the Tanganyika specimen and radial ornament of the area is obscure. The trigonally ovate shape, wide ante-carinal groove, slight sulcus on the lower margin, and the predominance of transverse over radial ornament of the area, place the specimen from Tanganyika close to Frenguelliella. All the later Jurassic specimens of

Trigonia s. str. tend to be of small size by comparison with earlier forms, and to have an ovate shape.

Subgenus PLEUROTRIGONIA van Hoepen, 1929.

Type species: Trigonia blankenhorni Newton, 1908. Albian, Zululand.

Van Hoepen (1929, p.33) described Pleurotrigonia as the sole genus of a new sub-family Pleurotrigoniinae. Rennie (1936, p.361) regarded it as a sub-genus of Trigonia and in this was followed by Cox (1952b, p.55). Kobayashi and Mori (1954, p.162) placed Pleurotrigonia in the Trigonia Section of the sub-family Trigoniinae of Kobayashi 1954, but as elsewhere in this paper, their classification is not used.

Thus far the subgenus has been regarded as monotypic, occurring only in the Lower Cretaceous of Zululand. The shells now tentatively assigned to a new species of the subgenus are Tithonian in age.

Trigonia (? Pleurotrigonia) sp. nov.
(Pl.XXIII, figs.2-8).

Of uncertain affinities are the shells of a single community of Trigoniids of a type not noted from elsewhere in the area, but the shells are tentatively assigned to Pleurotrigonia.

Locality and Material.

Hunterian Museum Collection: Loc. WA.855 (S.12083-S.12112).

Geological Survey of Tanganyika Collection: Loc. WA.855 [WA.855 (32-52)].

(See Appendix I).

The numerous specimens are crowded in a hard, fine, calcareous sandstone and are not easy to extract, so that only imperfect material is available.

Description.

The small shell is trigonally ovate to lunate with the umbo about 1/3 of the length from the anterior end. The convex anterior end passes smoothly into the convex lower border. The postero-dorsal margin, formed by the inner elevated edge of the escutcheon, is concave and its slope back from the umbo varies considerably from one specimen to another. The posterior margin is oblique, with an obtuse angle to the postero-dorsal margin and a sharp curve at the postero-ventral extremity into the lower margin. The wide flank is ornamented by strong, smooth costae with interspaces equal to the width of the costae, which are concentric or gently V-ed, and usually sharp but sometimes blunt and thickened posteriorly. Anteriorly they become horizontal, approaching the anterior border at about right angles, with slight waviness and thinning; sometimes they terminate before reaching the margin. On both valves the costae end posteriorly at an ante-carinal groove which runs most of the length of the marginal carina, but sometimes is poorly marked. The groove is often much stronger on the left valve than on the right. A strong, smooth, curved, marginal carina persists throughout the growth of the shell. The area is fairly steeply inclined to the flank but the angle between flank and area decreases with growth. The rather wide area is divided into two parts by a median groove, the lower wider than the upper, and both slightly convex. Otherwise there is no ornament on the area except obscure traces, seen on a single specimen (a mould), of very fine radial striae close to the umbo (Pl.XXIII, fig.3). The large, slightly concave escutcheon sometimes has its inner edge elevated, and is divided from the area by a delicate, finely denticulated inner carina. No detail is known of the interior or the hinge-line of the shell.

Dimensions.

No specimen is complete enough for exact measurement. A length of 35 mm., a height of 25 mm. and a thickness of about 7 mm. would seem to be about average.

Comparison.

The identification of this species as Pleurotrigonia is a matter of doubt, and is based on the costate character of the flank and marginal carina and the smoothness of the area and escutcheon. Notable differences from the type species [P. blankenhorni (Newton)] are the smaller size, less triangular shape, persistence of the marginal carina, greater regularity of the costae, absence of a frontal face ("lunule") and the much wider escutcheon. The more lunate examples are not unlike Megatrigonia (Rutitrigonia) dietrichi (Lange), but the more prominent and extensive marginal carina and the ante-carinal groove distinguish them. These points also distinguish the species from R. dietrichi (Dietrich, 1933, non Lange), though the presence of radial ornament on the proximal part of the otherwise smooth area in Dietrich's specimens emphasises the similarity.

Cox (1935b, p.18, Pl.II, fig.16) described as Trigonia sp. a costate Trigoniid with smooth area from the Attock District of Pakistan. Kobayashi and Mori (1954, p.165) accept this as a Trigonia s. str. in which the area ornament is obsolete, though comparing it with Pleurotrigonia. The smooth area and escutcheon distinguish the more ovate forms from the similarly shaped T. (Trigonia) spp. figured elsewhere in this paper (Pl.V, fig.6) and by Hennig (1914b, Pl.XIV, fig.10) and Venzo (1949, Pl.II).

Association and Age.

The specimens of (?) Pleurotrigonia sp. nov. are crowded in a hard calcareous sandstone with equally numerous examples of Iotrigonia cf. haughtoni. There are numerous other molluscan remains, all fragmentary. The locality lies just above the "smeei" Oolite of the Mandawa - Mahokondo area in strata of probable Tithonian age.

Subgenus INDOTRIGONIA Dietrich, 1933.

Type species: Trigonia smeei Sowerby, 1840. Argovian, Cutch, India.

a. Content of Indotrigonia.

In addition to Trigonia smeei as interpreted by himself, Dietrich (1933, p.30) included in Indotrigonia[1] the

1) Kobayashi and Mori (1954, p.160) gave Indotrigonia generic status and placed it in the Indotrigonia Section of the sub-family Trigoniinae Kobayashi, 1954 along with Nototrigonia, Opisthotrigonia, Pacitrigonia and a new genus Eselaevitrigonia.

species T. krenkeli Lange and T. dietrichi Lange. With some hesitation, T. krenkeli was assigned by Rennie (1936, p.358) to Rutitrigonia [a subgenus of Trigonia according to Rennie, but placed in Megatrigonia by Cox (1952b, p.59)]. Cox (1952b, p.59) accepted this assignment and also regarded T. dietrichi as a Rutitrigonia. Examples of these two species in the present collection are discussed under Rutitrigonia.

Indotrigonia has not been recorded outside the Indian and East African areas[2]. In addition to the type species,

2) See note on T. burckhardti on p.51 below.

it comprises I. beyschlagi Müller (= crassa Kitchin), together with the new species mandawae, africana, robusta, v-striata and a new Aptian species now described.

b. History.

Trigonia smeei (spelt "smeeii" in the original work, but not since) was first described by J. de C. Sowerby (1840, p.715, Pl.LXI, fig.5) from Cutch. Pl.VI, fig.1 is a reproduction of Sowerby's figure, photographically enlarged to show the full dimensions of the specimen. The strata from which the holotype came, previously thought to be Tithonian or even Neocomian, have been dated as Argovian by Spath (1935, pp.186-7) on ammonite evidence. The species has also been recorded from a locality on the south-east coast of India (Medlicott and Blanford, 1879, p.148).

Müller (1900, p.543, Pl.XIX, fig.1) described Trigonia beyschlagi from near the Nkundi Stream, 29 Kms. north-west of Kiswere in the southern coastal area of Tanganyika (see footnote p.100). This is within the region described in Part I of the thesis.

Kitchin (1903, p.44, Pl.IV, figs.4-6; Pl.V, figs.1-3) described T. crassa from Cutch, and (1903, p.40, Pl.III, fig.9; Pl.IV, figs.1-3) dealt with T. smeei in some detail, regarding both as degenerate derivatives of the Costatae. Discussing the relation of T. beyschlagi to T. crassa (1903, pp.121-2), he concluded that they were best regarded as separate species, but considered that they illustrate similar stages in removal from the ancestral (costate) plan. He further suggested that though T. smeei probably represents a line quite distinct from that of T. crassa, it probably represents a stage in development intermediate between the costate plan and that of _T. crassa_ and _T. beyschlagi_.

Krenkel (1910, p.209, Pl.XX) figured and commented on "_T. beyschlagi_" (= _Indotrigonia africana_ sp. nov) from the Mbemkuru Valley in southern Tanganyika. He compared it with _T. smeei_ and _T. crassa_ and recognised its close relationship especially to the latter. Krenkel's specimens had been collected by Fraas (1908) who had recognised "_T. beyschlagi_" in the area. Krenkel (1910, p.212) also described _T. matapuana_ from the same beds, but recognised that his two examples might represent young or diseased specimens of "_T. beyschlagi_".

Lange (1914, p.225, Pl.XX, figs.8-13; Pl.XXI, figs.1-7) described and figured a number of specimens from the Mbemkuru Valley area as _Trigonia smeei_ (= _Indotrigonia africana_ or _I._ aff. _africana_, except Pl.XXI, fig.1 = _Indotrigonia_ aff. _mandawae_ sp. nov.). He regarded _T. beyschlagi_ as synonymous with _T. smeei_, stating that intergrading examples of the two forms are found at the same horizon near Tendaguru. He also regarded _T. crassa_ as a synonym of _T. smeei_. In discussing the geographical distribution of _T. smeei_ Lange (1917, p.492) suggested that the South Argentinian "_T. burckhardti_" Jaworski (= _Myophorella (Jaworskiella) burckhardti_: see Cox, 1952b, p.57) is closely related to it. This was refuted by Dietrich (1933, p.30), though Kitchin (1926, p.464) had not criticised the suggestion.

(See also under Megatrigonia (Rutitrigonia) krenkeli (Lange) p.201).

Kitchin (1929, p.207) regarded it as "uncritical" to group together T. smeei and T. crassa of Cutch with the East African "T. smeei" and T. beyschlagi. He suggested that Lange's (1914) figures might indicate that more than one off-shoot "species" showing closely similar characters of degeneration are present in the "Trigonia smeei" Bed of the Tendaguru area of southern Tanganyika. He pointed out the variability and instability of the East African "T. smeei" and of T. crassa of Cutch, while T. smeei of Cutch shows a more stable character. In respect of the development of the carinae and ornament of the area, the East African "T. smeei" was said to "stand in a position somewhat intermediate between T. smeei and T. crassa of Cutch."

Dietrich (1933, p.30) designated T. smeei J. de C. Sowerby as the type of a new subgenus Indotrigonia. He supported Lange's view of the wide variation of "T. smeei" in all communities in East Africa, T. crassa occurring together with the local "T. smeei". He emphasised that specimens taken from various levels in the "Trigonia smeei" Bed have the same fundamental plan no matter how great the variation. He figured as T. smeei (see Dietrich, 1933, Pl.III, figs.54 and 56) a form with depressed squamose costae, even more divergent than any of Lange's (see p.108 below). Kitchin's (1903, p.39) view that Indotrigonia represents a degenerate costate stock he thought not proven, contrary to Rennie (1936, p.355) who favoured Kitchin's concept.

Hennig (1937, p.173) gave measurements of a number of specimens of "_T. (Indotrigonia) smeei_" from different horizons in the Tendaguru Series which indicate a tendency for stratigraphically lower examples to have a lower height/length ratio - examples from the _Nerinea_ Bed are more elongated than those from the "_Trigonia smeei_" Bed. Although his figures do show a general increase in height in specimens from successively higher horizons in the "_smeei_ Zone" and in specimens claimed to be from the _bornhardti_ Zone (Lower Cretaceous), there are exceptions to the rule and the specimens are too few for the figures to have statistical significance. Hennig did not, however, suggest specific separation of the stratigraphically lower specimens, as is justified in the case of material from the Mandawa - Mahokondo area (see below p. 59 _et.seq._ and under _T. (Indotrigonia) mandawae_ sp. nov., p. 87).

Cox (1952a, p.115) separated _Indotrigonia smeei_ from _I. beyschlagi_ and regarded _I. crassa_ as synonymous with the latter. He accepted the East African "_I. smeei_" (of Lange, Dietrich and Hennig) as conspecific with _I. smeei_ (Sowerby) of Cutch.

c. _Stratigraphical Distribution._

Indotrigonia has been recorded from strata of Argovian to Aptian age, but previous records of its occurrence in the

Cretaceous (especially post-Valanginian) have been questioned.

Kitchin (1903) believed that both T. smeei and T. crassa in Cutch come from Umia strata of Tithonian or Neocomian age. Later (1929, p.208) he concluded that both belong to the Lower Cretaceous. Spath (1935, pp.286-7) however, has shown on ammonite evidence that the localities from which T. smeei was obtained are Argovian, and not in Umia strata[1]. Cox

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[1] Aitken (1954, p.4), in assuming a Tithonian age for T. smeei in Cutch, overlooked Spath's demonstration that the localities from which Kitchin described T. smeei were not, as that author supposed, in Umia strata.

(1952a, p.115) confirmed the age of T. crassa (= beyschlagi according to Cox) as Tithonian? to Neocomian.

Müller (1900, p.543) dated T. beyschlagi from Tanganyika as Neocomian. Krenkel (1910, p.209) also so dated "T. beyschlagi"[2] (= "smeei" auctt. of East Africa; = africana s.l.

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[2] As Dietrich (1933, p.29) pointed out, the labelling of Krenkel's (1910) Plate XX(I) is incorrect. Figure 9, an example of Rutitrigonia bornhardti, is wrongly labelled Trigonia beyschlagi.

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sp. nov.) from the Mbemkuru River depression. Lange (1914, pp.228,269) dated the East African "T. smeei" (including beyschlagi of Müller, 1900 and Krenkel, 1910) as mainly Tithonian, but extending also into the Upper Neocomian -

Lower Aptian Trigonia schwarzi Bed. Kitchin (1929, pp.206, 218) contended that the balance of evidence for the age of the "T. smeei" Bed of southern Tanganyika favours its being assigned to the Lower Cretaceous, and doubted if any part of the Tendaguru Series is Jurassic. Later authors (Dietrich, 1933; Spath, 1927-33; Hennig, 1937; Aitken, 1954), however, have upheld the older views of Lange (1914) and other members of the German Tendaguru Expedition that "T. smeei" of East Africa is essentially or entirely Jurassic. Apart from other objections, there is no indication that numerous associated Jurassic ammonites are derived fossils as Kitchin suggested (Dietrich, 1933, p.7).

Dietrich (1933, p.29) indicated that the original reports (Lange, 1914; Hennig, 1914a) of "T. smeei" in the Lower Cretaceous of the Tendaguru area, were likely to be in error. He also supported Lange's view that the holotype of T. beyschlagi from the north-west of the Mandawa - Mahokondo area came from Jurassic and not Cretaceous strata as suggested by Müller (1900, p.543). He supposed that in the original collection, specimens from more than one locality in the neighbourhood of the Mkundi Stream had been mixed, and that the T. beyschlagi described did not in fact occur in association with the "T. ventricosa", a typically Lower Cretaceous form which he referred to a new species T. mülleri Dietrich. (See also Part I, p.87).

Hennig (1937, p.172) strongly upheld that "T. (Indotrigonia) smeei" ranges up into the Neocomian, not only into the Upper Saurian Bed which he regarded as Cretaceous in part, but into the lower ("T. bornhardti") subdivision of the Trigonia schwarzi Bed. Although he reported the Indotrigonia only a few metres below beds containing a rich Trigonia schwarzi Bed fauna in the south of the Mbemkuru Valley area (Luvubu), there is no indisputable evidence of its occurrence actually in association with such a fauna[1].

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1) See also p. 98.

In accepting the identity of "I. smeei" of East Africa with I. smeei (Sowerby) of Cutch, Cox (1952a, p.115) gave the range of this form as from Argovian to Portlandian [accepting Spath's (1927-33, p.820) dating of the Jurassic part of the Tendaguru Beds as wholly Portlandian]. As mentioned above, he accepted the age of I. crassa (= beyschlagi according to Cox) as Tithonian? to Neocomian. However, he recalled as significant that Lange (1914, p.229) and Dietrich (1933, p.30) had reported intergradation of "T. smeei" and "T. crassa" at an horizon in Tanganyika intermediate between the horizons in Cutch at which the forms occur separately.

Indotrigonia occurs throughout the Jurassic (and ? lowermost Cretaceous) strata in the Mandawa - Mahokondo area overlying the Septarian Marl and extending to some hundreds of feet above the "smeei" Oolite. This sequence totals over

2000 feet and ranges from about Middle Kimmeridgian possibly into the lowermost Cretaceous. Locally, shells occur in gregarious habit. The specimens in the collection as a whole show much the same range of variation as does the East African "T. smeei" of Lange (1914) including T. beyschlagi of Müller (1900) and Krenkel (1910), but there are related forms outwith this range. A single specimen of a new species (see Indotrigonia sp. nov., pp.115-118) has also been collected which is probably of Aptian age, and is quite distinct from the East African "T. smeei".

Though insufficient specimens are available for a statistical study of their variation at each horizon throughout the sequence, enough are available for some impression to be gained of differences in the Jurassic assemblages at different levels. There is evidence to suggest that for the most part, Indotrigonia from the various horizons in the Mandawa - Mahokondo area represents one evolving stock, and that the differences between communities are to be accounted for by modal shift in a limited number of biocharacters. The difficulties inherent in dealing with the nomenclature of specimens and communities of highly variable animals on different time planes in an evolving plexus of descent, have been dealt with by Trueman and Weir (1946, p.xv) in connection with Carboniferous non-marine lamellibranchs. These authors recognise that the discrimination of biospecies is not practicable when dealing with such a stock, but advocate the distinction of morphological species as an aid to stratigraphy. They illustrate that scatter diagrams of two or more such species may overlap and that individuals may occur with equal affinity to two or more morphological species. Eagar (1956, p.112) has commented on the convenience of this system in the progressive refinement of nomenclature it permits.

The same approach seems justified for the evolving stock represented by most of the Indotrigonia from Tanganyika. The resultant nomenclature is such as might follow from Kitchin's (1929, p.207) suggestion, based on a study of Lange's (1914) illustrations, of the existence of a number of off-shoot "species" at different levels in the "Trigonia smeei" Bed of the Tendaguru area. Concerning the occurrences of the East African "Indotrigonia smeei" Dietrich (1933, p.30) said: "Many- and few-ribbed, narrow- and broad-ribbed, irregularly- and regularly-ribbed specimens are found intermingled in all communities, an argument that one is dealing with varieties".[1)] Analysis of the Mandawa - Mahokondo material (pp.59-81), possibly derived from strata covering a greater range in age than that described by Dietrich, does not support his implication that communities at different stratigraphical levels are not separable. It is recalled that Hennig (1937, p.173) recognised some developmental

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1) Author's translation.

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change in "Indotrigonia smeei" from successive horizons in the Tendaguru area (see p.52).

New morphological species of Indotrigonia named in the evolving stock are I. mandawae, I. africana and I. robusta. I. beyschlagi (Müller) belongs to the same species group. Since I. africana is the most common and persistent form, the species group is named after it. Another new species I. v-striata sp. nov. occurs in association with large communities of I. africana without there being any variant of the latter approaching it. It may therefore be regarded as a distinct biospecies, outside the I. africana gens.

The author's collection of Indotrigonia includes specimens which can match most previously figured examples of "I. smeei" from the Tendaguru Beds. The Tendaguru "I. smeei" is usually close to I. africana, as is "Trigonia beyschlagi" of Krenkel (1910)[1]. Exceptions are the specimens in Lang's

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1) Krenkel refers figures 6,8 and 9 of his Plate XX to T. beyschlagi. As has been pointed out by Dietrich (1933, p.29), figure 9 has been so labelled in error. It is clearly an illustration of Megatrigonia (Rutitrigonia) bornhardti (Müller).

Plate XXI, figure 1, which is close to I. mandawae sp. nov., and Dietrich's (1933) Plate III, figures 54 and 56, which appear to represent a new morphological species of the I. africana gens.

Plate XIX is included to illustrate a community from the "Smeei-pflaster" in the Tingutinguti Stream outside the area mapped in Pt.I, Plate II, near Tendaguru Hill (see Hennig, 1937, fig.3b), which is taken to be typical of the "Trigonia smeei" Bed in its type area. Most of the specimens are referred to I. africana, or are close to this form, and none can be referred to I. mandawae.

d. Variation in the Species Group of Indotrigonia africana.

The greater part of the author's collection came from the Mandawa - Mahokondo area, and the following analysis of variation refers largely to shells from there. Collecting done in the Makangaga - Ruawa and the Mbemkuru areas was less exhaustive, but some of the communities from these areas supplement the information obtained in the Mandawa - Mahokondo area. Some stratigraphical correlations suggested elsewhere (Pt.I, pp.144-146, Pl.VIII) between the three areas are based on the succession of forms of Indotrigonia established in the Mandawa - Mahokondo area.

(1) THE MANDAWA - MAHOKONDO AREA.

The horizon within the strata containing the species-group of I. africana that can be recognised fairly certainly throughout this area is the base of the "smeei" Oolite. A first subdivision is therefore made into those specimens obtained from below the Oolite and those from above its base.

(i) Indotrigonia from below the "smeei" Oolite (see Plates VII-IX).

Specimens have been obtained from the following localities, none immediately below the base of the oolite:-

Hunterian Museum Collection:- WA.793 (20 specimens - S.11557 - S.11576); WA.971 (37 specimens - S.11520 - S.11556); WA.1676 (1 specimen - S.11585); WA.1852 (6 specimens - S.11577 - 11582); WA.2002 (1 specimen - S.11583); WA.2189 (1 specimen - S.11584).

Geological Survey of Tanganyika Collection:- WA.793 [WA.793 (21-23)]; WA.971 [WA.971 (4, 11, 40-62)]; WA.2002 [WA.2002(b)].

Localities WA.793 and WA.971 from which the majority of the specimens derive, are certainly close stratigraphically and their horizon is possibly nearly identical, as the feature on which the latter crops out can be followed southwards approximately to Locality WA.793 in the Mandawa River. The specimens from each show a similar variation pattern, into which also the few specimens from the other localities fit, with the possible exception of that from Locality WA.1676 (see Pl.IX, fig.4).

Table VII gives dimensions of measurable specimens. The low height/length ratio (usually below 70%) and the shortness of the anterior end are of particular note. The communities from below the "smeei" Oolite appear to be specifically separable by these two features alone from those above it (cf. Tables VIII & IX). Hennig's (1937, p.173) comparative figures relating to "Indotrigonia smeei" from the Nerinea Bed and from higher members of the Mesozoic sequence

TABLE VII.

DIMENSIONS OF SPECIMENS OF INDOTRIGONIA FROM BELOW THE "SMEEI" OOLITE.

	L	H	T	A	E	H/L	T/L	A/L
(Locality WA.971 - T. (Indotrigonia) mandawae sp. nov.)								
WA.971* (4)	104.5	77.0	20.0	21.0	60.0	73.7%	19.1%	20.1%
S.11520	105.0	70.0	25.0	17.0	62.5	66.7%	23.8%	16.2%
S.11521	105.5	70.0	19.0	21.8	54.0	66.4%	18.1%	20.7%
S.11522	102.4	67.7	18.5	15.6	64.0	66.1%	18.1%	15.2%
S.11523	95.0	66.5	19.5	16.8	62.5	70.0%	20.5%	17.7%
S.11524	105.1	66.4	20.0	10.5	68.0	63.2%	19.1%	10.0%
S.11525	86.5	56.0	19.5	12.0	-	64.7%	22.6%	13.9%
S.11526	98.8	70.0	17.5	16.0	-	70.9%	17.7%	16.2%
S.11527	108.0	75.8	23.0	18.3	60.5	70.2%	21.4%	16.9%
(Locality WA.793 - T. (Indotrigonia) mandawae sp. nov.)								
S.11557	91.0	62.2	18.0	14.5	60.5	68.4%	19.8%	15.9%
S.11558	97.3	67.8	22.0	15.8	52.0	69.7%	22.6%	16.2%
S.11559	102.5	65.8	18.0	18.0	-	64.2%	17.6%	17.6%
(Locality WA.1852 - T. (Indotrigonia) mandawae sp. nov.)								
S.11577	84.9	51.3	15.0	12.7	43.5	60.4%	17.7%	15.0%
S.11578	98.7	64.0	17.5	14.2	-	64.7%	17.7%	14.4%
S.11580	103.0	70.5	17.0	24.4	-	68.4%	16.5%	23.7%
S.11582	96.6	59.0	15.0	14.8	-	61.1%	15.5%	15.3%

*Geological Survey of Tanganyika Collection.

in the Tendaguru area appear significant. The height/length ratios in his three Nerinea Bed specimens (71%, 66%, 64.5%(?)) are in about the same range as in those from below the "smeei" Oolite of the Mandawa - Mahokondo area. The same applies to a specimen figured by Lange (1914, Pl.XXI, fig.1) which also would appear to be derived from the Nerinea Bed or below, near Tendaguru. It cannot be said whether in other respects Hennig's unfigured specimens resemble those from a low horizon in the Mandawa - Mahokondo area, but Lange's figured specimen is generally similar.

The similarities between shells from above and below the base of the "smeei" Oolite are obvious, but it is believed that the specimens from below the Oolite can be specifically separated from those high in or above it, and for the older shells the new species Indotrigonia mandawae is erected (pp.87-92).

The shell of I. mandawae is triangular, due to the obliqueness of the posterior border which passes with a very obtuse angle from the postero-dorsal margin, and the abrupt truncation of the anterior end of the shell. The triangularity is further emphasised by a rather straight lower border. There is an abrupt angulation of the flank anteriorly to give a well-marked, flattened, frontal face, across which the flank ribs do not often extend to the anterior commissure. If present, the ribs pass more or less horizontally across the flattened frontal face, and turn abruptly upwards to meet the anterior commissure. In some instances there is thickening of the costae at the angulation of the flank.

The costae vary in coarseness and spacing within the range figured for "T. smeei" by Lange (1914) and others. They are generally concentric, either gently curved or more usually, very obtusely V-ed, the posterior limb of the V being the longer. The V-ing is sometimes more acute near the umbo, and slight irregularity of the rib sequence occurs when normal concentric habit is adopted in later growth. In some cases, there is a gradual thickening of costae and a widening of the interspaces posteriorly. Some crowding and thinning of the costae towards the lower border is usual.

The area is always distinct from the flank of the shell. An ante-carinal groove can be traced to at least mid-growth, but the distinction is mainly by reason of a definite though increasingly obtuse angle between their surfaces throughout growth, and a difference in ornament. On the area, one or sometimes two transverse costellae are intercalated between other similar costellae which are more or less continuous with flank costae, and are little thinner than these costae. A denticulated marginal carina is visible in a number of examples, extending up to 35 mm. from the umbo. A trace of an inner carina is also visible to about the same stage, but generally the escutcheon is not well differentiated from the area, and many of the transverse costellae pass unbroken from the area obliquely across it. Radial ornament of the area is sometimes visible in the form of two or three faint radial riblets extending for about 20 mm. from the umbo (see Pl.VII, fig.1c). The extension of a median groove visible near the umbo, is the line along which a change in direction of the costellae is visible almost to the siphonal border in many instances.

A few specimens of I. mandawae show a distinct interruption or sharp warping of a series of several costae along the same line (see Pl.VIII, figs.4,5). The costae of these are wider than normal and flattened, with a thin central groove. The case is reminiscent of T. (Indotrigonia) matapuana Krenkel[1], but is less definite, and is taken as an abnormality not sufficient to justify specific separation. In some instances the feature is no more marked than in certain specimens figured by Lange (1914, Pl.20, fig.11; Pl.21, fig.1a) as "T. smeei".

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1) Krenkel (1910, p.212) described and figured T. matapuana as a distinct species from the "Trigonia smeei" Bed of the Mbemkuru Valley area, on the basis of two specimens, but recognised that they might in fact be young or diseased specimens of "T. beyschlagi".

(ii) The Indotrigonia africana Species Group from above the Base of the "smeei" Oolite.

Specimens have been obtained from the following localities (see Appendix II):-

Hunterian Museum Collection: WA.878 (S.11809); WA.938 (S.11810); WA.940 (S.11811 - S.11812); WA.961 (S.11697 - S.11722); WA.963 (S.11813); WA.1265 (S.11814 - S.11819); WA.1318 (S.11820); WA.1474 (S.11821); WA.1479 (S.11822); WA.1483 (S.11823); WA.1516 (S.11824); WA.1519 (S.11825); WA.1628 (S.11587 - S.11696); WA.1656 (S.11764 - S.11792); WA.1779 (S.11826 - S.11831); WA.1782 (S.11832); WA.1826 (S.11833 - S.11835); WA.2148 (S.11586); WA.2154 (S.11793 - S.11808); WA.2176 (S.11738 - S.11748); WA.2179 (S.11723 - S.11737); WA.2266 (S.11836 - S.11841); WA.2267 (S.11842 - S.11843); WA.2312 (S.11844); WA.2313 (S.11845); WA.2315 (S.11846 - S.11849).

Geological Survey of Tanganyika Collection: WA.961 [WA.961(8), (15), (22), (23), (31)-(41)]; WA.963 [WA.963 (2), (4), (6)]; WA.1265 [WA.1265(4)]; WA.1628 [WA.1628 (29), (37), (83), (95), (113), (116)]; WA.1656 [WA.1656(1), (22), (32)-(41)]; WA.2154 [WA.2154(4), (5)]; WA.2176 [WA.2176(3), (4)]; WA.2542 [WA.2542(1)]; WA.2548 [WA. 2548(1)-(9)].

In most cases where only a single or a few specimens are available from a particular locality, these generally conform to the plan of variation exhibited by the communities from Localities WA.961, 1628, 1656 and WA.2154, 2176, 2179 (see Tables VIII and IX). Exceptions are single damaged specimens from Locs. WA.1318 and WA.2542 both low in the oolite sequence. The former is named I. cf. mandawae on account of the straightness of the costae on the posterior part of the flank (of which the anterior part is not preserved). The specimen from Locality WA.2542 appears to have the elongation of shells occurring below the oolite, but the lack

TABLE VIII DIMENSIONS OF SPECIMENS OF <u>INDOTRIGONIA</u> FROM ABOVE THE BASE OF THE "<u>SMEEI</u>" OOLITE.

	L	H	T	A	E	H/L	T/L	A/L
(Locality WA.1628 - <u>T. (Indotrigonia) africana</u> sp. nov.)								
WA.1628 (29)*	85.4	61.0	20.5	21.4	-	71.4%	24.0%	25.1%
WA.1628 (37)*	80.0	55.7	18.0	17.3	40.0	69.6%	22.5%	21.6%
S.11587	81.5	62.7	22.0	20.0	40.0	76.9%	27.0%	24.5%
S.11588	71.3	53.8	19.5	14.3	37.0	75.5%	27.4%	20.1%
S.11589	82.2	60.0	18.0	20.0	-	73.0%	21.9%	24.3%
S.11596	105.6	73.6	23.5	20.8	53.7	69.7%	22.3%	19.7%
S.11597	71.4	53.9	19.5	22.1	-	75.5%	27.3%	31.0%
S.11598	80.3	57.0	20.8	19.0	-	71.0%	25.0%	23.7%
S.11599	80.0	58.0	20.5	20.0	38.5	72.5%	25.6%	25.0%
S.11600	58.0	45.0	13.0	19.1	24.0	77.6%	22.4%	32.9%
S.11602	77.5	59.0	18.5	19.0	40.0	76.1%	23.9%	24.5%
S.11603	75.0	60.0	19.5	20.0	27.5	80.0%	26.0%	26.7%
S.11606	66.7	50.0	18.3	16.0	-	75.0%	27.4%	24.0%
S.11607	69.4	51.6	15.8	16.0	36.5	74.4%	22.8%	23.1%
S.11620	87.0	64.0	19.0	17.7	49.0	73.5%	21.8%	20.3%
S.11625	83.2	62.3	18.0	22.8	-	74.9%	21.6%	27.4%
S.11626	25.7	20.0	7.0	7.0	-	77.8%	27.2%	27.2%
S.11627	83.0	57.8	17.0	19.1	35.0	69.8%	20.5%	23.0%
S.11629	42.5	34.0	11.5	10.0	-	80.0%	27.1%	23.5%
S.11633	57.8	44.0	14.5	12.3	30.5	76.1%	25.1%	21.3%
S.11636	40.7	34.3	11.0	11.5	17.0	84.3%	27.0%	28.3%
S.11639	37.3	31.0	9.5	10.3	16.0	83.1%	25.5%	27.6%
S.11642	76.3	56.0	19.0	20.2	36.5	73.3%	24.9%	26.5%
S.11644	81.8	62.5	17.5	19.3	-	76.4%	21.4%	23.6%
S.11645	61.8	46.0	13.0	13.1	-	74.4%	21.0%	21.2%
S.11648	73.0	54.6	15.5	19.0	-	74.8%	21.2%	26.0%
S.11650	85.3	62.0	17.5	20.4	-	72.7%	20.5%	23.9%
S.11651	86.8	63.0	20.0	19.5	-	72.6%	23.0%	22.5%
S.11669	73.0	57.0	20.0	20.0	-	78.1%	27.4%	27.4%

* Geological Survey of Tanganyika Collection.

TABLE IX DIMENSIONS OF SPECIMENS OF *INDOTRIGONIA* FROM ABOVE THE BASE OF THE "*SMEEI*" OOLITE.

	L	H	T	A	E	H/L	T/L	A/L
Locality WA.2176 - *T. (Indotrigonia) beyschlagi* Müller								
*WA.2176(3)	61.2	52.4	19.5	15.8	32.0	85.6%	31.9%	25.8%
*WA.2176(4)	73.9	54.5	16.5	16.0	-	73.7%	22.3%	21.7%
S.11730	65.5	51.6	15.5	17.0	32.0	78.8%	23.7%	26.0%
S.11739	73.0	55.4	17.0	23.7	35.0	75.9%	23.3%	32.5%
S.11740	74.4	59.6	23.0	20.0	37.0	80.1%	30.9%	26.9%
S.11741	84.5	57.7	19.0	12.3	42.5	68.3%	22.5%	14.6%
S.11742	85.0	64.3	22.0	19.0	41.5	75.6%	25.9%	22.4%
S.11743	71.4	54.5	18.5	16.3	34.0	76.3%	25.9%	22.8%
S.11745	58.5	45.0	13.0	10.0	26.5	76.9%	22.2%	17.1%
S.11748	79.5	60.3	19.0	17.5	43.5	75.8%	23.9%	22.0%
Locality WA.1656 - *T. (Indotrigonia) africana* sp. nov. (a) *T. (Indotrigonia)* aff. *beyschlagi* Müller (b)								
*WA.1656(1) (a)	107.3	76.0	29.3	21.0	57.0	70.8%	27.3%	19.6%
S.11765 (b)	104.0	77.0	28.5	21.0	52.5	74.0%	27.4%	20.2%
S.11767 (a)	87.5	62.5	20.0	18.3	-	71.4%	22.9%	20.9%
S.11768 (a)	91.0	63.0	20.5	20.4	48.7	69.2%	22.5%	22.4%
Locality WA.961 - *T. (Indotrigonia) robusta* sp. nov. (a) *T. (Indotrigonia)* aff. *robusta* sp. nov. (b) *T. (Indotrigonia)* aff. *africana* sp. nov. (c)								
S.11713 (b)	60.0	47.0	13.7	9.0	32.7	78.3%	22.8%	15.0%
S.11708 (a)	86.0	65.0	20.0	23.5	39.5	75.6%	23.3%	27.3%
S.11715 (b)	83.5	56.0	-	15.0	-	67.1%	-	18.0%
S.11719 (c)	91.0	64.0	22.2	22.3	48.5	70.3%	24.4%	24.5%
Locality WA.2179 - *T. (Indotrigonia)* aff. *africana* sp. nov.								
S.11724	70.0	52.0	16.5	13.0	35.8	74.3%	23.6%	18.6%
S.11725	68.5	50.0	17.0	11.0	36.2	73.0%	24.8%	16.1%
S.11727	85.0	62.0	18.0	15.0	39.5	72.9%	21.2%	17.6%
S.11728	85.0	57.5	19.0	15.0	43.0	67.6%	22.4%	17.6%
Locality WA.2154 - *T. (Indotrigonia)* aff. *africana* sp. nov. (a) *T. (Indotrigonia)* aff. *beyschlagi* Müller (b)								
S.11808 (b)	69.0	52.6	13.5	14.0	31.0	76.2%	19.6%	20.3%
S.11800 (a)	77.5	56.5	15.5	13.0	-	72.9%	20.0%	16.8%
S.11802 (a)	93.5	65.8	19.6	15.2	42.3	70.4%	21.0%	16.3%

* Geological Survey of Tanganyika Collection.

of angularity of those higher in the sequence. Similar cases occur outside the Mandawa - Mahokondo area (see pp. 73,74).

The stratigraphical relation between the two groups of localities mentioned above is not clear since the latter is in the faulted-off area of the north-west of the anticline and the sequence exposed there is slightly different from that to the east of the structure. It is supposed that WA.2154, 2176 and 2179 are slightly younger than the others since a greater thickness of strata separates them from the "smeei" Oolite. WA.2154 is the youngest and WA.2179 the oldest of the three upper localities.

Locality WA.1628. (Pl.X, figs.1-4; Pl.XI, figs.1-6).

The collection of Indotrigonia from this locality is the largest from the Mandawa - Mahokondo area. Within it can be matched a large proportion of the shells of "I. smeei" figured from East Africa. Exceptions are those figured by Lange (1914, Pl.XXI, fig.1) and Dietrich (1933, Pl.III, figs. 54 & 56). The shells in the community are less elongated than those from below the "smeei" Oolite; they are less pointed posteriorly and less truncated anteriorly. The anterior end is usually longer and the more convex curve of the anterior border passes smoothly into the relatively more convex curve of the lower border. The anterior angulation of the surface of the flank is less marked, the frontal face characteristic of the specimens from the lower horizon being less well developed. The flank costae of the shells from the higher horizon are generally stouter but not necessarily wider spaced. They are regularly curved, but successive costae are not always of equal strength. A slight thickening of costae towards the ante-carinal (or marginal) groove may occur, and may be matched by a similar thickening of transverse costellae of the area. There is no V-ing of the costae.

A marginal carina is sometimes developed in the umbonal region of the shell, but does not extend more than about 10 mm. from the umbo (cf. the stratigraphically lower examples). The marginal groove generally persists to some extent throughout the shell's growth. The costae of the flank and the costellae of the area are of similar thickness, and the ratio of their numbers is 2 : 3 and frequently 1 : 1 especially in later growth stages. Occasionally the ends of the costellae are off-set from the ends of costae, even if they are no more numerous.

There is often a change in growth direction of the costellae at a position that would correspond to a median groove on the area, but no radial ornament of the area is preserved in any of the specimens examined. The escutcheon is marked off from the area only in being less ornamented. Sometimes it is nearly smooth, but as a rule a number of the costellae of the area cross it obliquely.

Locality WA.1656. (Pl.XII, figs.1-5).

Almost all shells of Indotrigonia from this locality can be matched with examples from WA.1628. A few individuals from WA.1656 are larger than any from WA.1628, and specimen S.11777 (Pl.XII, fig.2) appears to be larger than any example of Indotrigonia in the present collection or figured elsewhere. S.11764 (Pl.XII, fig.4) has rather swollen costae and compares with specimens from WA.961 (I. robusta sp. nov.) in this respect. Two specimens (S.11765 and S.11766 - Pl.XII, fig.5) are more comparable to I. beyschlagi than to shells common in the sequence at about Localities WA.1656 and WA.1628.

Locality WA.961. (Pl.XVIII, figs.1-7).

The notable characteristic of Indotrigonia from this locality is the very robust and thickened ornament in some specimens. This has led to their designation as a new morphological species I. robusta sp. nov. The tendency to swelling of the costae and the costellae towards the marginal groove is so marked in some cases as to give them a bulbous appearance, with consequent emphasis of the groove. Individuals occur however, similar to the more usual Indotrigonia africana of localities WA.1628 and WA.1656, with gradations to the robust form.

Shell outline is variable. Some individuals have a relatively long convex anterior end and convex lower border; others have a short, truncated, anterior end and a rather straight lower border. There are not sufficient well-preserved specimens for this observation to have much significance, but it appears that the shells with more markedly swollen costae tend to be of the latter type. These also appear to have the frontal face more developed. The ratio of numbers of costae to costellae varies from 2 : 3 to 1 : 1.

No radial ornament is present on the area of any individual observed, possibly due to the poor state of preservation. The proportions of the escutcheon in the swollen-ribbed shells are as in the normal I. africana form. The costellae continue obliquely across the escutcheon.

The hinge is not visible in any specimen from this locality.

Locality WA.2176. (Pl.XV, figs.1-5 ; Pl.XVI, fig.1).

The collection from this locality, near stratigraphically and geographically to that which yielded the holotype of T. (Indotrigonia) beyschlagi Müller, contains specimens very similar to this. Plate XIV, fig.1 and Table IX show that there is some considerable variation from the proportions of the holotype. However, there is no specimen strictly comparable with the dominant Indotrigonia (I. africana) of Localities WA.1628 and WA.1656, though some specimens from these localities are not unlike I. beyschlagi. Notable differences from the I. africana form are:-

(i) The less prominent, rather depressed and rounded costae and costellae, except in the later growth stages of some larger individuals. This gives a smoother appearance to the shell not to be accounted for only by weathering.

(ii) The very early disappearance of any trace of the marginal carina and ante-carinal groove.

(iii) The bifurcation of the costae on crossing to the area, each pair of costellae occupying about the same width as the flank rib. The costellae are thus unevenly spaced, while in I. africana the costellae are evenly spaced, closer than the costae and of a width comparable to them.

(iv) As a consequence of (ii), there is lack of clear separation of the flank and area.

(v) The area is generally smaller in comparison to the flank than in I. africana.

(vi) The absence of any concavity of the cardinal margin such as occurs in I. africana.

(vii) The absence of notably elongated individuals.

The area shows no radial ornament. Proximally, the escutcheon is somewhat depressed in relation to the area, and is smooth; in later growth many of the transverse costellae pass obliquely across the ill-defined escutcheon. There is no inner carina.

In no specimen is the hinge well enough exposed for detailed comparison with specimens elsewhere, but the visible part of the hinge of specimen S.11739 (see Pl.XV, fig.4) makes it clear that in this respect there is no great difference either from beyschlagi or africana.

WA.2176 is the only known locality at which a considerable community of I. beyschlagi occurs unmixed with elements close to I. africana.

Locality WA.2179. (Pl.XIII).

Locality WA.2179 is close to Locality WA.2176, lying stratigraphically about 120 feet below it.

The shells of Indotrigonia are usually of medium elongation, with the anterior end rather straight and sloping steeply from the umbo, which is not quite terminal. They have the general aspect of I. africana with the marginal carina present to about 10 mm. from the umbo and the antecarinal groove usually extending to mid-growth of the shell or beyond. A few shells are rather small, elongated and stout, and rather pointed at the anterior end (Pl.XIII, fig.4).

The costae are broader than in the normal shells from Localities WA.1628 and WA.1656 and are somewhat depressed, but they are not usually so much rounded and smoothed-off as in I. beyschlagi from Locality WA.2176. The costellae increase beyond the number of costae by intercalation between those corresponding to flank costae. The costae tend to be obtusely V-ed rather than normally convex, except in late growth stages. Occasionally there is slight thickening of flank costae and areal costellae towards the marginal groove.

In some shells there is a thickening of the costellae at the inner margin of the area, giving a demarcation of the long lanceolate escutcheon, which extensions of a few of the costellae cross obliquely. The hinge is not exposed in any specimen.

Locality WA.2154. (Pl.XVI, figs.2-4; Pl.XVII).

Specimens both of I. aff. africana sp. nov. and I. aff. beyschlagi (Müller) occur in the community from this locality. There is fairly pronounced V-ing of the costae in some of the specimens of I. aff. africana, with sudden adoption of normal concentric ribbing in later growth. These shells tend to have a high, rather pointed umbo, and to have a less roundly curved anterior end than I. africana s. str. (cf. specimens from Localities WA.1623 and WA.1656). There is gradation from the forms with normally concentric ribs, and the shells are quite distinct from I. v-striata sp. nov. in which the apices of the much more acute V's are anterior to the umbo, and the costae are not continuous.

A specimen of I. aff beyschlagi (Pl.XVI, fig.2) has a more strongly convex lower border and is shorter than typical material.

(2). THE MAKANGAGA - RUAWA AND MBEMKURU AREAS.

Indotrigonia of the I. africana species group has been noted at a number of localities in the Makangaga - Ruawa and Mbemkuru areas, but seldom in the good preservation of many communities from the Mandawa - Mahokondo area. Exceptions to this are the communities from the vicinity of Tendaguru (Loc. WA.766, outside the area mapped in Plate II of Part I) and from near Mtapaia (Locs. WA.582 and WA.781) which are discussed separately below.

(i) Indotrigonia from the type area of the "Trigonia smeei" Bed.

A community of Indotrigonia is illustrated in Plate XIX from 60 yards upstream of the water-hole in the Tingutinguti Stream near Tendaguru Hill. The stratum there is taken to be the "Smeei pflaster" indicated by Hennig (1937, fig.3b) and the community to be typical of the "Trigonia smeei" Bed in its type area. Table X gives dimensions of measurable specimens. The community is very similar to those of I. africana sp. nov. at Locs. WA.1628 and WA.1656 above the "smeei" Oolite in the Mandawa - Mahokondo area, and does not contain I. mandawae sp. nov. which would be expected in strata equivalent to those below the "smeei" Oolite, where Hennig (1914a, 1937) supposed the "Trigonia smeei" Bed to lie.

There is insufficient measurable material to indicate whether the quoted height/length ratios of the shells are significant in the light of the apparent decrease in this ratio in shells of I. africana in ascending the succession. A fairly consistent difference between specimens from the Tingutinguti Stream and type material from the Mandawa - Mahokondo area is the greater number of the areal costellae in the former, and their appearance of slight imbrication.

TABLE X DIMENSIONS OF SPECIMENS OF <u>INDOTRIGONIA</u> FROM THE TYPE AREA OF THE "<u>TRIGONIA SMEEI</u>" BED.

	L	H	T	A	E	H/L	T/L	A/L
(Locality WA.766 - <u>T. (Indotrigonia) africana</u> sp. nov. (a) <u>T. (Indotrigonia)</u> aff. <u>africana</u> sp. nov. (b)								
WA.766(1) (a)	91.7	69.5	20.3	22.5	-	75.8%	22.1%	24.5%
WA.766(7) (b)	100.0	70.0	23.0	20.0	44.0*	70.0%	23.0%	20.0%
WA.766(8) (b)	92.0	65.0	20.6	19.0	49.3	70.7%	22.4%	20.7%
WA.766(24) (a)	90.5	66.0	18.5	25.5	53.0	72.9%	20.4%	28.2%

* Estimated.

Apparently from the outcrop area of the _Nerinea_ Bed in the same stream section (Loc. WA.767), though not _in situ_, two specimens have been collected of the type "intermediate" between _I. africana_ and _I. mandawae_ that occur near Mtapaia (see below).

The specimens from Locs. WA.766 and WA.767 suggest that the "_smeei_" Oolite is older than the "_Trigonia smeei_" Bed in its type area, not younger as supposed by Hennig (see also Part I, p. 146).

(ii) Indotrigonia _from the Mtapaia Area_.

Communities of _Indotrigonia_ from near Mtapaia Village close to the road to Tendaguru [Locs. WA.582, WA.781 - Specimens WA.582(1) - (25); WA.781(1) - (49)] are illustrated in Plates XX and XXI. The communities are from adjacent horizons of sandstone with ooliths and of oolitic limestone similar to the "_smeei_" Oolite of the Mandawa - Mahokondo area. Table XI shows the dimensions of measurable specimens, which suggest intergrading of the forms found above and below the "_smeei_" Oolite of the Mandawa - Mahokondo area (_I. africana_ and _I. mandawae_ respectively). Specimens intermediate in shape occur - shells with the elongation of _I. mandawae_ but with the rounded anterior end, convexity of lower border and concavity of postero-dorsal margin of _I. africana_. There are, however, specimens that can be assigned fairly certainly to one or other of the two species (see Appendix II).

TABLE XI DIMENSIONS OF SPECIMENS OF <u>INDOTRIGONIA</u>
FROM THE MTAPAIA AREA.

<u>T. (Indotrigonia) africana</u> sp. nov. (a)
<u>T. (Indotrigonia)</u> aff. <u>africana</u> sp. nov. (b)
<u>T. (Indotrigonia) mandawae</u> sp. nov. (c)
<u>T. (Indotrigonia)</u> aff. <u>mandawae</u> sp. nov. (d)

<u>Locality WA.582</u>

		L	H	T	A	E	H/L	T/L	A/L
WA.582(1)	(b)	93.5	64.5	19.0	18.3	40.0	69.0%	20.3%	19.6%
WA.582(2)	(c)	97.5	64.2	19.0	19.0	52.0	65.8%	19.5%	19.5%
WA.582(3)	(a)	91.0	68.0	21.5	17.5	51.0	74.7%	23.6%	19.2%
WA.582(4)	(b)	107.0	74.3	22.8	23.0	51.3	69.4%	21.3%	21.5%
WA.582(5)	(d)	117.0	77.0*	25.0	23.2	-	65.8%	21.4%	19.8%
WA.582(7)	(b)	93.5	63.6	22.1	19.0	48.2	68.0%	23.6%	20.3%

<u>Locality WA.781</u>

		L	H	T	A	E	H/L	T/L	A/L
WA.781(1)	(b)	98.0	75.0	-	20.2	-	76.5%	-	20.6%
WA.781(2)	(b)	93.0	63.6	17.0	17.0	42.8	68.4%	18.3%	18.3%
WA.781(3)	(b)	100.8	67.0	16.0	19.5	49.6	66.5%	15.9%	19.3%
WA.781(5)	(b)	112.8	73.5	17.0	22.0	57.5	65.2%	15.1%	19.5%
WA.781(6)	(a)	90.7	64.0	17.0	18.6	49.0	70.6%	18.7%	20.5%
WA.781(7)	(d)	94.0	65.2	20.3	21.5	48.9	69.4%	21.6%	22.9%
WA.781(8)	(b)	94.7	64.0	20.0	22.1	47.0	67.6%	21.1%	23.3%
WA.781(11)	(a)	95.0	69.0	16.4	20.0	49.5	72.6%	17.3%	21.1%
WA.781(12)	(a)	91.5	69.0	17.2	22.0	50.0	75.4%	18.8%	24.0%
WA.781(13)	(d)	106.6	74.6	19.0	22.0	58.0	70.0%	17.8%	20.6%
WA.781(14)	(a)	86.4	60.5	16.2	20.0	41.0	70.0%	18.7%	23.1%
WA.781(16)	(a)	95.0	66.4	21.6	23.0	48.0	69.9%	22.7%	24.2%
WA.781(17)	(b)	100.7	69.0	22.0	21.0	-	68.5%	21.8%	20.9%
WA.781(20)	(a)	94.2	68.0	20.5	20.0	42.0	72.2%	21.8%	21.2%
WA.781(21)	(a)	83.5	60.0	16.8	20.5	-	71.9%	20.1%	24.6%
WA.781(40)	(a)	92.0	65.3	14.5	23.0	-	71.0%	15.8%	25.0%

*Estimated.

The exact equivalence of the oolite at Mtapaia to any particular horizon in the Mandawa - Mahokondo area cannot be established. The presumption is that the Indotrigonia community is of an age intermediate between those of I. mandawae and I. africana there, and belongs to a level near the base of the "smeei" Oolite, from which no large community has been recorded in the Mandawa - Mahokondo area. Possibly, however, the single "intermediate" specimen from Loc. WA.2542 (see p.64), low in the "smeei" Oolite there, came from about the same horizon. Mention is made above of similar material from the Tendaguru area below the "Trigonia smeei" Bed.

(iii) Indotrigonia from other Localities (see Appendix II for determinations of individual shells).

From two localities in the Makangaga - Ruawa area communities of generally incomplete shells have been collected from near the local base of the oolite sequence [Locs. WA.1838 (S.11857) = Loc. WA.2544 (WA.2544(1)-(14)]; WA.2547 [(WA. 2547(1)-(13)]. In both cases, the ornament and general contour is as for I. africana, but the height/length ratios of measurable specimens show overlap with I. mandawae in this feature, as in examples from Mtapaia, though the shells themselves are smaller. The communities possibly come from the same horizon as Loc.WA.2542 (see p.64) in the Mandawa - Mahokondo area where a single specimen collected shows the same feature.

The dimensions of measurable specimens are:-

	L	H	H/L
WA.2544(4)	70.0 mm.	47.0 mm.	67.1%
(6)	72.0	50.0	69.4%
(8)	66.0	45.0	68.2%
(9)	84.0	60.0	71.4%
(13)	80.0	53.0	66.25%
WA.2547(2)	63.0	46.0	73.0%
(5)	94.0	58.0	61.7%

Also from the oolite sequence of the Makangaga - Ruawa area, but at a higher level in it, is a community from Loc. WA.2305 (S.11858 - S.11861) from which all the specimens have been assigned to I. aff. africana. The only other Indotrigonia collected in this area (Loc. WA.2533) came from below the oolite sequence. The specimen is damaged, but shows the typical triangular elongated shape, with almost straight lower border and with a distinct frontal face, of I. mandawae.

The only locality in the Mbemkuru area, other than Mtapaia, from which shells comparable to I. mandawae occur, is Loc. WA.2556 in the lowermost part of the oolite sequence in the Kikundi escarpment. Two large damaged shells resemble this species and a third fragment has ornament comparable to that of I. africana.

Locality WA.2404 [Hunterian Museum Collection S.11850 - S.11851; Geological Survey of Tanganyika Collection WA.2404(3) - (12)] contains both I. africana and I. aff. africana of elongated form.

Localities WA.2412 [S.11855 - S.11856; WA.2412(1)] and WA.2496 [S.11852 - S.11854; WA.2496(1)] lie some way above the oolite, and the shells are comparable or related to I. africana.

Three adjacent localities well above the top of the oolite sequence on Mbambala Hill (Locs. WA.2560 - WA.2563) have yielded fragmentary specimens of Indotrigonia, some with ornament reminiscent of I. beyschlagi, some of I. aff. africana such as occurs high in the Jurassic (or lowermost Cretaceous) sequence at Loc. WA.2154 in the Mandawa - Mahokondo area (see p.71). Fragmentary specimens from Locs. WA.2496 [S.11852 - S.11854; WA.2496(1)], WA.2534 and WA.2558, also presumed to be high in the sequence, show similar characteristics.

It seems evident that Indotrigonia in the Makangaga - Ruawa and Mbemkuru areas follows the same sequence in pattern as in the Mandawa - Mahokondo area. The communities of specimens intermediate between I. mandawae and I. africana obtained from the oolite sequence there is evidence for the continuity of development of the I. africana gens not available from the latter area[1].

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[1] After preparation of this paper, attention has been drawn to an account by Agrawal (1956, pp.13-19, Pl.I, figs.2,3) of a new species from Cutch, Trigonia (Indotrigonia) katrolensis Agrawal. This was described as intermediate between I. smeei

(Sowerby) and I. beyschlagi (Müller) and came from Kimmeridgian strata. Two specimens were illustrated, the one almost complete and the other broken posteriorly. The height/length ratio of ·69% is based on the incomplete length of 72.5 mm. and a tentative reconstruction of the shell suggests an original length of at least 75.0 mm. This would give a height/length ratio of 66.7%, within the range for I. mandawae sp. nov. of Tanganyika (see pp.87-92 and Table VII), to which the first of Agrawal's figured specimens bears much resemblance, though the flank costae are more evenly convex except in the upper part of the shell. Agrawal's second (incomplete) specimen, though an elongate shell, is more rounded in outline than I. mandawae and its postero-dorsal and lower margins are more nearly parallel. Were the two Cutch specimens to have been found in Southern Tanganyika, they would suggest an horizon close to the base of the "smeei" Oolite, by comparison with communities from near Mtapaia (Locs. WA.582 and WA.791 - see p.73) where both I. mandawae and the more rounded and less elongate I. africana sp. nov. (see pp. 93-98) occur, but the bulk of the specimens are intergrades between these. The shells of the communities from Localities WA.2544 and WA.2547 (see p.74) in the Makangaga - Ruawa area are closer in size to I. katrolensis and include specimens of I. aff. africana tending towards I. mandawae in their height/length ratios.

e. Relations of the Indotrigonia africana Species Group to Indotrigonia in Cutch.

For comparative purposes the holotype of T. (Indotrigonia) smeei J. de C. Sowerby [British Museum (Natural History) collection] was examined, and other typical specimens of this form and of "I. crassa" from Cutch were obtained for study from the British Museum.

I. smeei from Cutch is of Argovian age and is older than any of the material from East Africa. With the exception of a single specimen of a new (?)Aptian species (see p. 115), the greater part of the Tanganyika collection comes from the Jurassic part of the Tendaguru Series. The I. mandawae communities from below the "smeei" Oolite in the Mandawa - Mahokondo area may be slightly older than any known material from the Tendaguru Series in its type area.

I. smeei from Cutch differs from any figured East African examples ascribed to this species, and from comparable specimens from the Mandawa - Mahokondo area, in being more elongated, having a longer anterior end, less prominent umbones and a more gentle backward slope of the cardinal margin. In the species from Cutch the anterior end is obliquely truncated and the slightly developed frontal face slopes forward and downward, so that the foremost point of the shell is at the sharp curve between the anterior and lower borders. As a result, the general outline of the shell is quadrangular and not roughly triangular as in most East African examples. The area is larger and less steeply inclined to the flank, over much of the shell's growth, than in the East African shells, and the escutcheon is narrower. Where the shell is suitable preserved (see Pl.VI, fig.4) radial ornament of the area of the Cutch species appears to persist in the form of grooving, to a far greater extent than in the East African specimens.

Kitchin (1929, p.220) and Cox (1952a, p.115) implied that the older Tanganyika material might be expected more to resemble I. smeei of Cutch and the younger shells to approach more closely to I. beyschlagi (= I. crassa). This is so in the case of the younger shells (? Tithonian/Neocomian in both areas), but not the older.

In I. mandawae the numerical ratio of areal costellae to the costae of the flank is comparable with that in I. smeei s. str. (often about 5 : 2), as is the elongation of the shell. In I. mandawae too, the radial ornament of the area persists to a later stage than in the younger East African examples of Indotrigonia, though not to the same extent as in I. smeei. However, in the triangular outline, abrupt anterior truncation, often pointed posterior, strong development of the frontal face, rather frequent interruption of flank ribbing, relative smallness of the area in comparison with the flank, and the non-persistence of the ante-carinal and median furrows, these stratigraphically lower examples from Tanganyika differ more from the Argovian T. smeei of Cutch than do many examples from communities above the "smeei" Oolite.

Surprisingly, too, the new (?) Aptian species of Indotrigonia mentioned above, in many respects resembles the holotype of I. smeei more than do the shells of the essentially Jurassic I. africana species group.

The differences between any available or figured East African Indotrigonia and I. smeei (J. de C. Sowerby) of Cutch, are sufficient to warrant specific separation. Most East African shells of Indotrigonia and not only those of younger communities, more closely resemble I. beyschlagi (= crassa) than I. smeei. Table XII gives comparisons between I. smeei. I. beyschlagi and the East African "I. smeei" (= the I. africana species group).

Dietrich (1933, p.31) said: 'In all respects it ("T. smeei") is a form showing individual variation. One may be permitted, further, to assume that the general behaviour of the African T. smeei was different from the Indian; it is a case of geographical differentiation of the same species.'[1]

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1) Author's translation.

In making this statement, Dietrich was probably unaware that the T. (Indotrigonia) smeei of Cutch is Argovian, and did not come from Umia strata of Tithonian or even later age as had been supposed by Kitchin (1903, p.42) - i.e. that it is of

(Cutch) (Holotype and 3 Blake Collection specimens)	(Tanganyika) (Communities from Locs. WA.793, WA.971, WA.1852)	(Tanganyika) (Communities from Locs. WA.1628 and WA.1656)	(Tanganyika and Cutch) (Holotype and community from Loc. WA.2176)	(Tanganyika) (Holotype and paratype - Loc. WA.961)	(Tanganyika) (Incomplete figure reconstructed)
H/L = 57.2% - 65.8% A/L = 21.9% - 23.7 T/L = 17.5% - 19.7%	H/L = 60.4% - 73.7% A/L = 10.0% - 25.7% T/L = 15.5% - 23.8%	H/L = 69.2% - 84.5% A/L = 19.6% - 32.9% T/L = 20.5% - 27.6%	H/L = 68.5% - 85.6% A/L = 14.6% - 32.6% T/L = 22.2% - 31.9%	H/L = 75.6% - 78.5% A/L = 15.0% - 27.5% T/L = 22.8% - 25.3%	H/L = 72.2% A/L = 22.2% ————
Umbones not elevated	Umbones rather elevated	Umbones generally elevated	Umbones elevated	Umbones elevated	Umbones elevated
Outline essentially quadrangular	Outline essentially triangular	Outline rounded trigonal	Outline essentially triangular	Outline rounded trigonal	Outline rounded trigonal
Area over ½ size of flank	Area ⅓ - ½ of size of flank	Area ½ or less of size of flank	Area about ⅓ of size of flank	Area ½ size of flank or over	Area less than ½ size of flank
Marginal groove extends to postero-ventral extremity	Marginal groove extends to mid-growth or beyond but not to postero-ventral extremity	Marginal groove extends to mid-growth or beyond and often to postero-ventral extremity	Marginal groove absent or very short	Marginal groove extends to postero-ventral extremity	Marginal groove extends to postero-ventral extremity
Numerical ratio of costellae : costae 3:2 to 5:2	Numerical ratio of costellae : costae 2:1 to 5:2	Numerical ratio of costellae : costae 1:1 to 3:2	Numerical ratio of costellae : costae 1:1 to 3:2	Numerical ratio of costellae : costae generally 1:1	Numerical ratio of costellae : costae about 2:1
Costellae always thinner than costae; sharp, slightly imbricate	Costellae generally thinner than costae; sharp or rounded, occasionally slightly imbricate	Costellae often as thick as costae; rounded	Costellae often as thick as costae; rounded	Costellae generally as thick as costae; swollen	Costellae thinner than costae; rounded, imbricate
Continuation of costae into costellae very uncommon	Continuation of costae into costellae not uncommon	Continuation of costae into costellae common	Continuation of costae into costellae usual	Continuation of costae into costellae very uncommon	Continuation of costae into costellae uncommon
Radial striae on area to 20-25 mm. from umbo	Radial striae on area sometimes present to 15-20 mm. from umbo	Radial striae on area sometimes present to 10 mm. from umbo, generally obscure	Radial striae not present on area	Radial striae not present on area	————
Inner carina present over much of growth	Inner carina present to about mid-growth	No inner carina	No inner carina	No inner carina	————
Median groove extends throughout growth and other radial grooves on area to past mid-growth	Median groove may extend to ½ of growth and other radial grooves on area to 20 mm. from umbo	Median groove usually present to 10-20 mm. from umbo, sometimes more; often obscure or absent; no other radial grooves on area	Median groove obscure or absent; no other radial grooves on area	No radial grooves on area	No radial grooves beyond 20 mm. from umbo; possibly none present
Escutcheon narrowly lanceolate, not well defined; crossed by broken extensions of areal costellae	Escutcheon usually narrowly lanceolate, fairly well defined, slightly depressed; crossed by broken extensions of some of areal costellae	Escutcheon broadly lanceolate, well defined, depressed; crossed by extensions of some of areal costellae or sometimes nearly smooth	Escutcheon broadly lanceolate, depressed, sometimes ill-defined; crossed by extensions of some areal costellae	Escutcheon very narrow, ill-defined; crossed by extensions of some of areal costellae	————
Frontal face not strongly developed; costae rise across it to anterior commissure	Frontal face strongly developed; costae usually horizontal across it, not reaching anterior commissure, or reappearing as weak lines rising at the anterior commissure	Frontal face of varying development; costae rise across it to anterior commissure	Frontal face of varying development; costae sometimes nearly horizontal, but upturned near anterior commissure; sometimes rising across it to the commissure	Frontal face strongly developed; costae rise across it to anterior commissure	————
Costae concentric, rounded, regular	Costae concentric or obtusely V-ed; rounded except in lower part of shell where sharp and always concentric; sometimes irregular	Costae generally concentric sometimes very obtusely V-ed; rounded, regular. (Related forms sometimes with costae more strongly V-ed.)	Costae concentric or very obtusely V-ed; usually depressed and smoothed-off except in later growth	Costae concentric, rounded and swollen, regular	Costae roughly concentric, irregularly thickened, depressed, squamose
Angle between flank and area very obtuse over most of growth	Angle between flank and area often a right angle or less, nearly to mid-growth	Angle between flank and area fairly obtuse except near umbo	Angle between flank and area not very obtuse	Angle between flank and area fairly obtuse except near umbo	Angle between flank and area fairly obtuse except near umbo

considerably different age from the East African form he was discussing.

f. Descriptions of Species.

1. Trigonia (Indotrigonia) smeei J. de C. Sowerby (Pl.VI, figs.1-4).

Trigonia smeeii J. de C. Sowerby, 1840, pp.715-718, Pl.LXI fig.5.

Trigonia smeei H.B. Medlicott and W.T. Blanford, 1879, Pl.XII, fig.11.

Trigonia smeei F.L. Kitchin, 1903, pp.40-44, Pl.III, fig.9; Pl.IV, figs.1-3.

non Trigonia smeei auctt. of East Africa.

Trigonia (Indotrigonia) smeei J. de C. Sowerby is the only species of the subgenus restricted to the Indian Peninsula. It has not been found in Tanganyika, the so-called "Trigonia smeei" of the Tendaguru region there being distinct. T. (Indotrigonia) smeei has been discussed on pp.78-80, but in view of its status as type species, it will be formally described along with the African species to complete this account of Indotrigonia.

Localities.

The holotype came from Shapoor in Cutch. Kitchin (1903, p.42) recorded it, partly on the basis of other authors' reports, from Kukrooa, Chobaree, Trummo and Bururia in Cutch and from the Tripetty Beds on the south-east coast of India. To these, Spath (1935, p.185) added the Idder

Scarp (Iddurghur) and Kantcote, and Cox (1952a, p.115) recorded it from the Kass Escarpment.

Description.

Sowerby's (1840) diagnosis was as follows:-

"Trigonia smeeii. Transversely much elongated, posteriorly truncated, convex, concentrically ribbed; the posterior surface distinguished by an obscure ridge, and furnished with twice as many ribs as the other part; ribs obtuse, seldom interrupted; beaks near the anterior extremity, which is rounded. Length 2 inches 5 lines, width 4 inches."

Kitchin (1903) dealt at length with T. smeei and the following description is based on his figures and account, as well as on specimens from the Blake collection that were obtained for study from the British Museum (Natural History):-

The shell is large, elongated and quadrangular in outline, the well incurved umbones not very prominent and placed about $\frac{1}{4}$ of the length from the anterior end. The anterior margin is strongly convex and passes smoothly into the convex lower border. The foremost point is low on the anterior border and the lowest point well behind a vertical below the umbo. The slightly concave postero-dorsal margin slopes gently back from the umbo, curving gently into the long oblique posterior margin. The postero-ventral extremity forms a sharp curve. Large shells are more elongate than youthful individuals.

The flank occupies 2/3 or less of the shell's surface and the angle between flank and area becomes increasingly obtuse with growth. There is an ill-defined frontal face and sometimes the upper part of the anterior commissure is sunken between protruding shoulders of the shell. The marginal carina is pronounced to 2 - 3 cm. from the umbo, but then degenerates into a fold marked for some distance by obscure nodes. A strong ante-carinal groove extends in a line concave upwards, from the umbo to the postero-ventral extremity. The costae are strong, rounded, and concentric with the growth lines; their width is about equal to that of the interspaces. They reach the anterior margin which they generally approach at an acute angle. They are more crowded and sharper in the lower part of large shells and here may be slightly irregular, with occasional intercalation of a rib posteriorly. Towards the posterior the costae become wider and flatter. In a shell illustrated by Kitchin (1903, Pl.III, fig.9) there is bifurcation in some cases just in front of the ante-carinal groove. Except in later stages of growth, there is a complete break at the groove and the costae do not pass into the areal costellae.

The ratio of costae to costellae varies from 3 : 2 to 5 : 2. The costellae may be slightly imbricate towards the posterior and are always thinner than the costae. Sometimes a pattern of bifurcation from corresponding costae is apparent, with further costellae intercalated between the pairs; sometimes the series of costellae is quite independent of the costae. Radial ornament on the area in the form of denticulate striae extends for 20 - 25 mm. from the umbo, a median carina sometimes further; a supra-median groove extends almost to the posterior end. Crossing the area, the costellae are diverted forwards above the supra-median groove and may or may not be completely "pinched-out" at the groove. Other less prominent grooves (2 - 4 in number) are sometimes present on the lower part of the area, extending as far as ¾ of the shell's growth. The escutcheon is well marked-off from the area in the proximal part of the shell at least, by a denticulated inner carina. Kitchin (Pl.IV, fig.1a) illustrated a specimen showing the inner carina becoming increasingly nodose, extending throughout the growth of the shell and separating a long, slightly depressed, rather narrow, lanceolate escutcheon from the area. Often the escutcheon is not well defined, however. The areal costellae cross it obliquely, sometimes broken up into elongated nodes, and in the proximal part resolved into rows of denticles. Kitchin described some shells as having a smooth inner portion of the escutcheon behind the ligament. The ligament pit is rather elongated (over 1/3 of the length of the escutcheon).

Kitchin described the dentition (which is not visible in any of the specimens obtained for study) as follows:-
"The cardinal teeth of the left valve are massive and prominent. Those of the right valve are elongated and lath-like, and are

inclined to one another at an angle of about 60°. The posterior tooth closely follows the cardinal border, and exceeds in length the anterior tooth; the latter terminates at the limit of, and defines posteriorly, the slightly raised platform whereon is situated the attachment of the anterior adductor muscle."

Dimensions.

Dimensions of the holotype (Sowerby, 1840, Pl.LXI, fig.5) and of examples in the Blake Collection housed in the British Museum (Natural History) are as follows:-

	L	H	T	A	E	H/L	A/L	T/L
Holotype	102.5	58.7	-	24.3	-	57.3%	23.7%	-
L.75420	76.0*	50.0	15.0	16.0	11.0	65.8%	21.1%	19.7%
L.75421	77.7	46.2	14.5	17.5	14.0	59.5%	22.5%	18.7%
L.75422	96.0	61.3	16.8	21.0	17.0	63.9%	21.9%	17.5%

* Estimated.

Comparison.

Comparison between I. smeei and the species group of I. africana is given in a separate section (see especially Table XII). I. smeei has more features in common with I. africana s. str. and I. mandawae than with the younger members of the group (cf. Spath's remark quoted below, p. 87 on the "intermediate position" of the Tendaguru Trigonia "smeei").

With the new (?)Aptian Indotrigonia sp. (S.12121) (see p.115 et seq.) from Tanganyika, I. smeei has a remarkable number of features in common. They are alike in shape and relative size of flank and area, though the (?)Aptian shell is much smaller. The relation of the concentric ornament of the flank and area is similar, and slight imbrication of the costellae is present in the new species as in I. smeei. In the new species there are proportionately wider interspaces between costae, and the radial ornament of the area is less prominent. The anterior extremity of the single example of the new species is not preserved.

Associations and Age.

Kitchin (1929, p.208) recorded the important element of the lamellibranch fauna associated with I. smeei as "large conspicuous shells of Astartid relationships" including Astarte major J. de C. Sowerby. He also recorded Trigonia oomia Strand (= T. tenuis Kitchin), Exogyra imbricata, Gervillea cf. dentata, Cucullaea and Seebachia. He believed this fauna to be from Umia strata of Neocomian age. However, he recognised that it was distinct from the fauna associated with T. beyschlagi (= T. crassa Kitchin) and had regarded the Umia strata as Jurassic at the time of writing his (1903) monograph of Trigonia in Cutch.

Spath (1935, p.186) recorded Planites aff. ernesti P. de Loriol and Torquatisphinctes sp. in association with essentially the same fauna, which he assigned to the Argovian. In reference to this age determination he criticised Kitchin's dating of I. smeei on the basis of its "morphological position, viewed from the evolutionary standpoint". He commented on "the unsatisfactoriness of arguments based on the principle that the stage of evolution attained by certain fossils can be used for exact (as opposed to merely approximate) dating of the beds in which they occur". In his concluding remarks he said: 'But what Kitchin called the "intermediate position" of the Tendaguru Trigonia "smeei" (between the Argovian true T. smeei and the late T. crassa) will now be appreciated, since I have shown that all the five Tendaguru beds are probably to be included in the Portlandian'.

2. Trigonia (Indotrigonia) mandawae sp. nov.

(Pl.VII, figs.1-3; Pl.VIII, figs.1-5; Pl.IX, figs.1-4; Pl.XX, fig.2; Pl.XXI, fig.3).

Indotrigonia mandawae sp. nov. is characteristic of that part of the Jurassic sequence in the Mandawa - Mahokondo area below the "smeei" Oolite and above the Septarian Marl, and sometimes occurs gregariously.

Localities and Material.

Hunterian Museum Collection: Locs.WA.793 (S.11557 - S.11576); WA.971 (S.11520 - S.11556); WA.1852 (S.11577 - S.11582); WA.2002 (S.11583); WA.2189 (S.11584); WA.1676 (S.11585).

Geological Survey of Tanganyika Collection: WA.582 [WA.582(2)]; WA.793 [WA.793(21)-(23)];, WA.971 [WA.971(4), (11), (40-(62)]; WA.2533 [WA.2533(1)].

(See Appendix II)

Hunterian Museum specimen S.11820 (Loc. WA.1381) is designated I. cf. mandawae.

Comparable or related shells (Geological Survey of Tanganyika Collection) have been obtained from the following localities (see Appendix II for individual determinations):- WA.582, WA.731, WA.2002, WA.2556.

Specimen S.11524 (Plate VII, fig.1) is selected as holotype.

Diagnosis.

Shell large, massive, elongated, trigonal with rather prominent, near-terminal umbones, and steeply truncated anterior end passing in a sharp curve into the long, gently convex or nearly straight lower border. Postero-dorsal margin long, slightly concave or nearly straight sloping back from the umbones at a moderate angle and curving into the short, oblique, posterior margin. Marginal carina extending up to about 15 mm. from the umbo, the ante-carinal groove to mid-growth of the shell or beyond. Flank, occupying 2/3 to 3/4 of the shell's surface, with pronounced frontal face. Costae strong, generally slightly V-ed except in later growth, with interspaces about equal to width of costae. Costellae generally thinner than costae from which some pass unbroken, and 2 to 2½ times as numerous. Radial ornament of the area confined to the umbonal region. Escutcheon large, marked off near the umbo by an inner carina extending to about mid-growth, and crossed obliquely by extensions of areal costellae.

Dimensions.

See Table VII.

Further Description and Discussion.

Relevant comment is given above on '*Indotrigonia* below the "*smeei*" Oolite' (pp.60-63). Communities of *Indotrigonia* have not been observed in several hundred feet of strata above those containing *I. mandawae* in the Mandawa - Mahokondo area. *I. mandawae* does not occur above the "*smeei*" Oolite even as an extreme variant, in any of the communities studied. However, the communities illustrated from near Mtapaia Village in the Mbemkuru River depression (Pl.XX, figs.1-3; Pl.XXI, figs.1-4 and see p.73) contain *I. mandawae*, *I. africana* and intermediate forms. The horizon of these communities cannot be precisely determined with respect to the Mandawa - Mahokondo sequence, but is probably within the range of the "*smeei*" Oolite. In view of the existence of the intermediate forms, *I. mandawae* can be regarded as an early member of the *I. africana* species group.

Comparison.

Table XII outlines the differences between *I. mandawae* and other members of the species group of *I. africana*.

No figure of the so-called "*T. smeei*" of East Africa appearing in the literature strictly corresponds to *I. mandawae*. The specimen illustrated by Lange (1914, Pl.XXI, fig.1) is very close, but is stouter and less pointed posteriorly. It may be named I. aff. mandawae. The V-ing of the costae which is common in this species is much less marked than in I. v-striata sp. nov. described below, and the line of the apices of the V's runs obliquely backwards from the umbo. The species are distinct in detail of ornament although the height/length ratios are similar. Gentle V-ing of flank costae, especially in earlier stages of growth, is not unusual throughout the whole I. africana species group, and does not appear to be of taxonomic significance.

The triangular outline is somewhat reminiscent of some of the elongated specimens of the I. beyschlagi community from Locality WA.2176 (see p.68), but the height/length ratio is generally lower, the ornament not smoothed-off, and the frontal face much more developed. Also, the area is more clearly marked-off from the flank by angulation. There is much more distinct intercalation of transverse costellae in I. mandawae, and these are more numerous in relation to the flank costae. No East African example of I. beyschlagi available or figured is as large as the average I. mandawae, though "T. crassa" from Cutch (= I. aff. beyschlagi) may reach the same dimensions.

Associations and Age.

It is possible that a lower horizon is represented by at least some of the beds containing I. mandawae in the Mandawa - Mahokondo area than any in the type area of the Tendaguru Series. This is suggested by the occurrence of

Aspidoceras, likened by Dr. W.J. Arkell (personal communication) to A. mombasense (Spath) or A. iphiceroides Waagen and dated as Lower or Middle Kimmeridgian, from a locality (WA. 2188 - see Appendix I) north-east of Mahokondo. The specimen was not in situ but was of local origin and derived from strata of the same age or younger than a specimen (S.11584) of I. mandawae from the immediate vicinity. Another ammonite found below the "smeei" Oolite but above the main concentration of I. mandawae, has been likened by Dr. W.J. Arkell to Perisphinctes (?Pachysphinctes) staffi (Zwierzycki) of the Nerinea Bed of the Tendaguru Series.

Lange (1914) gave the locality of his specimen now named I. aff. mandawae as "Mahimbwi Flussbett", and from a comparison of the "Locality Map of Invertebrate Collections" of the German Tendaguru Expedition (Janensch and Hennig, 1914, p.4) and the geological map of the Lindi - Kilwa Hinterland (Hennig, in Branca et al. 1914), the locality appears to be very low in the Tendaguru Series, below the Nerinea Bed, though Lange described it from the "Trigonia smeei" Bed. From the same locality, however, is figured a specimen of I. africana sp. nov. This suggests a mixed fauna at a low horizon, but possibly confusion has arisen, if not in drafting of the locality map, in the statement of the locality of the specimens, which are recorded as having been collected by natives.

Megatrigonia (Rutitrigonia) dietrichi (Lange), described by Dietrich (1933, p.32) as characteristic of the lower part of the "Trigonia smeei Stage" at Tendaguru, is not apparently associated with I. mandawae in the Mandawa - Mahokondo area. The only other Trigoniid noted with I. mandawae is the costate form T. tanganyicensis sp. nov. (see p.33 above) found at Locality WA.793 (= WA.812, = WA.2001).

Associated with I. mandawae at both known localities (WA.793, 971) where it occurs gregariously, is Astarte recki Dietrich. This has previously been reported only from low in the Tendaguru Series (according to the two German Tendaguru Expedition maps referred to above), and is associated with I. aff. mandawae at the locality "Mahimbwi Flussbett". Another associated bivalve is Pinna (Stegoconcha) g-mülleri (Loc. WA.971) reported from an uncertain horizon in the Tendaguru Series by earlier authors, but only from the Nerinea Bed by Dietrich (1933). This is not a guide fossil of the lowermost marine strata of the Tendaguru Series, as a specimen has been noted above the "smeei" Oolite in the Mandawa - Mahokondo area.

Other lamellibranchs noted in association with I. mandawae include species of Anomia, Grammatodon, Gervillella, Lima, Lopha, Ostrea, Pholadomya, Pinna s. str. and (?)Trichites.

The lowest occurrence of I. mandawae is above the Lower Kimmeridgian Septarian Marl, and on the basis of the Aspidoceras mentioned above is taken to range upwards from Middle Kimmeridgian. The uppermost locality is probably Upper Kimmeridgian.

3. Trigonia (Indotrigonia) africana sp. nov.

(Pl.X, figs.1-4; Pl.XI, figs.1-6; Pl.XII, figs.1-3; Pl.XIII, figs.1-4; Pl.XVI, figs.3,4; Pl.XVII, figs.1-6; Pl.XVIII, fig.7; Pl.XIX, figs.1-6; Pl.XX, figs.1,3; Pl.XXI, figs.1, 2,4).

Trigonia beyschlagi E. Krenkel, 1910, p.209, Pl.XX(I), fig.8.

Trigonia smeei E. Lange, 1914, p.225, Pl.XX, figs.8-13;
Pl.XXI, figs.2, 3, ? figs.4-7, non fig.1.

Trigonia (Indotrigonia) smeei W.O. Dietrich, 1933, p.30,
Pl.III, fig.55, non figs.54, 56.

The majority of specimens previously figured as "Trigonia smeei" from East Africa belong to I. africana sp. nov.. Much of the discussion on the East African "T. smeei" (pp.48-55) is therefore relevant to I. africana.

Localities and Material.

Hunterian Museum Collection: WA.963 (S.11813); WA.1265 (S.11814 - S.11819); WA.1479 (S.11822); WA.1483 (S.11823); WA.1519 (S.11825); WA.1628 (S.11587 - S.11696); WA.1656 (S.11767 - S.11792); WA.1782 (S.11832); WA.1826 (S.11833); WA.2312 (S.11844); WA.2313 (S.11845); WA.2315 (S.11846 - S.11849).

Geological Survey of Tanganyika Collection: WA.582 [WA.582(3), (6), (20)]; WA.766 [WA.766(1), (6), (21), (22), (24)]; WA.781 [WA.781(6), (10)-(12), (14)-(16), (18), (20)-(21), (29), (40), (43), (49)]; WA.1628 [WA.1628(29), (37), (83), (95), (113), (116)]; WA.1656 [WA.1656(1), (22)]; WA.2404 [WA.2404(5), (12)]; WA.2544 [WA.2544(5), (6), (9), (13)]; WA.2547 [WA.2547(1), (2), (8)].

(See Appendix II)

Comparable or related shells have been obtained from the following localities (see Appendix II for individual determinations):

Hunterian Museum Collection: WA.878 (S.11809); WA.938 (S.11810); WA.940 (S.11811 - S.11812); WA.961 (S.11718 -

S.11722); WA.1474 (S.11821); WA.1516 (S.11824); WA.1779 (S.11826 - S.11831); WA.1826 (S.11834 - S.11835); WA.1838 (S.11857); WA.2148 (S.11586); WA.2154 (S.11793 - S.11807); WA.2179 (S.11723 - S.11735); WA.2305 (S.11858 - S.11861); WA.2404 (S.11850 - S.11851); WA.2412 (S.11855 - S.11856); WA.2496 (S.11852 - S.11854).

Geological Survey of Tanganyika Collection: WA.582, WA.766, WA.767, WA.781, WA.961, WA.963, WA.1265, WA.1656, WA.2154, WA.2404, WA.2412, WA.2496, WA.2534, WA.2542, WA.2544, WA.2547, WA.2548, WA.2556, WA.2558, WA.2560, WA.2562, WA.2563.

Specimen S.11599 (Plate X, figs.1a-c) is designated holotype.

Diagnosis.

Shell large, massive with height/length ratio usually between 70% and 80%, strongly inequilateral and moderately inflated. Umbones prominent, moderately incurved and about ¼ of the length from anterior end. Anterior margin convex, passing in a smooth curve into convex lower border. Postero-dorsal margin long, slightly concave, sloping back from the umbo at a moderate angle. Posterior margin rather long and oblique. Flank, comprising about 2/3 or more of the total surface of shell, ornamented by strong, rounded, concentric or slightly V-ed costae, with interspaces about the same width as the costae. Frontal face not strongly developed, with flank costae rising steeply across it to the anterior border.

Area well marked-off from the flank by angulation and by a marginal groove often extending to mid-growth or beyond, frequently to the postero-ventral extremity. Marginal carina and traces of radial ornament on the area often developed to about 10 mm. from the umbo, the marginal carina and median groove sometimes farther. Areal costellae of similar strength to costae, sometimes passing unbroken from them in later growth stages; seldom more than 1½ times as numerous and increasing in number over costae by intercalation. Escutcheon large, lanceolate, somewhat depressed, generally crossed obliquely by extensions of some of the areal costellae, but occasionally almost smooth. Ligament pit narrowly lanceolate, about 1/3 of the length of the escutcheon. Dentition very massive, typically trigoniid.

Dimensions.

See Table VIII for dimensions of the holotype and numerous paratypes, and Tables IX-XI for those of numerous other specimens.

Further Description and Discussion.

See comments on communities from Localities WA.1628 (p.65), WA.1656 (p.67), WA.2179 (p.70) and WA.2154 (p.71) in the introductory paragraphs above on Indotrigonia.

Comparison.

Table XII and the associated text outline the differences between I. africana, the other members of the same species group, and I. smeei.

Associations and Age.

The following Trigoniidae have been found in association with I. africana s. lato in the Mandawa - Mahokondo area (for localities see Appendix I):-

Indotrigonia robusta sp. nov. (Loc. WA.961)

I. aff. robusta sp. nov. (Locs. WA.1656)

I. aff. beyschlagi (Müller) (Loc. WA.2266, 2154, 1656)

I. v-striata sp. nov. (Locs. WA.963, 1265, 1628, 1782)

Trigonia (Trigonia) sp. juv. (Loc. WA.2140)

Laevitrigonia curta sp. nov. (Locs. WA.1656, 1779)

Opisthotrigonia curvata sp. nov. (Locs. WA.961, 1628, 2179)

Megatrigonia (Rutitrigonia) dietrichi (Lange) (Locs. WA.1628, 1656)

M. (Iotrigonia) cf. vau Sharpe (Loc. WA.2315)

?Myophorella (Myophorella) sp. (Loc. WA.2154)

?Yaadia sp. (Loc. WA.963)

Trigonia (?Pleurotrigonia) n. sp., Megatrigonia (Megatrigonia) conocardiiformis (Krauss), M. (Iotrigonia) cf. haughtoni (Rennie) and a Trigoniid gen. et sp. indet. have also been noted in the same squence of strata.

Other molluscs in the author's collection associated with I. africana s. lato (ammonite determinations by Dr. W.J. Arkell) include:-

Virgatosphinctes cf. communis Spath (Loc. WA.961)

Micracanthoceras sp. (Loc. WA.881)

Arcomya robustissima Dietrich (Loc. WA.961/2261)

Astarte krenkeli Dietrich (Loc. WA.2179)

Corbis (Sphaera) subcorrugata (Locs. WA.961/2261, 1656, 2548/2550)

Cucullaea (Megacucullaea) eminens Cox (Locs. WA.961/2261, 2548/2549)

Seebachia janenschi Dietrich (Locs. WA.1628, 1779, 1782)

cf. Thracia incerta Agassiz (Loc. WA.1628)

together with species of Anomia, Astarte, Exogyra, Gervillea (Gervillella), Hinnites, Lima, Modiolus, Ostrea, and Pecten.

The extensive fauna of the "Trigonia smeei" Bed of the Tendaguru Series (see especially Lange, 1914; Dietrich, 1914, 1933; Zwierzycki, 1914; and the compiled lists of Quennell, McKinlay and Aitken, 1956) is associated with I. africana s. lato or occurs in the same sequence. Notable additions to this in the writer's collection are the two ammonites mentioned above, on the basis of which the strata from which they came were dated by Dr. Arkell as Tithonian, probably slightly younger than the "Trigonia smeei" Bed in its type area. The record of Cucullaea (Megacucullaea) eminens is also new for East Africa.

Cox (1952a, p.114), discussing the range of Indotrigonia smeei, with which he included the East African form now differentiated as I. africana sp. nov., concluded (following Spath, 1927-33, p.820) that the East African material ranges up to the Portlandian. He accepted Dietrich's (1933, p.29) belief that previous reports (Lange, 1914, p.268) of its occurrence in the Lower Cretaceous were in error, as Lange himself (1917, p.496) had hinted. Not mentioned by Cox is Hennig's (1937, pp.112, 172) evidence from the south of the Mbemkuru River depression (the area of the Luvubu Stream) of the occurrence of "I. smeei" only a few metres below strata containing the Upper Neocomian Megatrigonia (Rutitrigonia) bornhardti (Müller). Even this is not conclusive proof of its actually occurring in the upper part of the Neocomian, since there is evidence of pre-Upper Neocomian disturbance and erosion in an area not far to the north (see Pt.I, p.165) which might suggest an unobserved disconformity in the Luvubu Stream area, separating Upper Neocomian from Jurassic with "I. smeei".

However this may be, there has been no indication in the present survey of I. africana occurring in the Upper Neocomian. The evidence is still not clear, nevertheless, that the uppermost beds containing I. africana s. lato do not belong to the lowermost part of the Cretaceous. Locality WA.2154 in the Mkundi Stream, close to that of the holotype of I. beyschlagi, is stratigraphically immediately above Locality WA.2148 yielding Megatrigonia conocardiiformis (see pp.144-148) usually ascribed to the Neocomian. Cox (1952a, p.120), however, has described M. aff. conocardiiformis from the Umia Beds of Cutch, possibly not younger than Tithonian. Also, specimens comparable with M. (Iotrigonia) vau Sharpe of the Neocomian Uitenhage Beds of South Africa accompany I. africana at Localities WA.2312 and WA.2315 in the west flank of the Mandawa - Mahokondo anticline, in a position in the sequence apparently not stratigraphically higher than Locality WA.961 (see p.97), dated as Tithonian on ammonite evidence.

4. Trigonia (Indotrigonia) beyschlagi Müller

(Pl.XII, figs.5a-c; Pl.XIV, figs.1-4; Pl.XV, figs.1-5; Pl.XVI, figs.1-2).

Trigonia beyschlagi G. Müller, 1900, p.543, Pl.XIX, figs.1-3.

Indotrigonia beyschlagi belongs to the species group of I. africana sp. nov. which includes all the shells hitherto described as "I. smeei" from Tanganyika. It has been suggested above (p.80) that all these are more closely related to I. beyschlagi Müller than to the holotype of I. smeei.

Müller's (1900) diagnosis of I. beyschlagi (author's translation) was as follows:-

"The completely asymmetric, elongated, triangular shells have the sharp pointed and incurved umbones right at the anterior border. The anterior end is cut off perpendicularly. The anterior border curves into the long, slightly curved, lower border. The posterior border has three rounded angles. The whole surface of the shell is covered with strong, rounded, concentric ribs, which however, bifurcate towards the posterior end, linking up with each other like a net.

"The area is not marked off."

Cox (1952a, p.115) regarded I. crassa (Kitchin) from the Umia Beds of Cutch (? Tithonian - Neocomian) as synonymous with I. beyschlagi. Specimens from Cutch appear as Pl.XIV, figs.3-5. Kitchin described I. crassa as a very variable species and actually mentioned an "elongated form", a "medium form" and a "short form", each showing variation in ornament. I. beyschlagi Müller no doubt falls within this range of variation though Kitchin (1903, p.120) regarded it as distinct from crassa. Kitchin did not designate a holotype of I. crassa, and it is thus convenient to follow Cox's grouping of I. crassa with I. beyschlagi. Kitchin's figured specimens of I. crassa could for the most part be named I. aff. beyschlagi and the Blake Collection specimens now figured could equally well be designated I. aff. beyschlagi or I. aff africana.

Localities and Material.

Müller described the holotype from 0.8 Kms. north of the Mkundi Stream, 29 Kms. north-west of Kiswere. This locality is too vaguely described to be fixed with certainty, but specimens in the present collection were obtained from localities close to that from which Bornhardt (1900, p.279)[1] collected the holotype.

1) During field work it was not possible to ascertain even what stream Bornhardt named the "Nkundi-Bache". It is the local custom to give to all the minor streams rising from one hill area the name of that area. Several such small streams are named "Mkundi" (not "Nkundi"). Even the larger watercourse now generally named the Nalwehe is sometimes referred to as the Mkundi. Specimens were obtained from the uppermost exposed shell bed in the Nalwehe Stream and from the uppermost shell bed in the largest of a number of watercourses named "Mkundi".

The present collection includes specimens from the following localities, identified as I. beyschlagi:-

Hunterian Museum Collection: Loc. WA.2176 (S.11738 - S.11748).

Geological Survey of Tanganyika Collection: Loc. WA.2176 [WA.2176 (3), (4)];

and identified as I. aff beyschlagi:-

Hunterian Museum Collection: Locs. WA.1656 (S.11765 - S.11766); WA.2154 (S.11808); WA.2179 (S.11736 - S.11737); WA.2266 (S.11836 - S.11841).

Geological Survey of Tanganyika Collection:- Loc. WA.2562 [WA.2562(1), (4)].

(See Appendix II)

Description.

The holotype of I. beyschlagi is a large, massive, trigonal shell, more elevated than is usual in the sub-genus. The umbones are high and prominent, placed about ¼ of the length from the anterior end[1]. The anterior margin slopes

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1) There is some discrepancy between Müller's figure and his description of I. beyschlagi. The figure of the holotype would have to be "tilted forward" to make the umbones appear terminal and the anterior margin perpendicular as described by Müller. The attitude of the shell as figured by Müller corresponds approximately to the attitude in which shells have been placed for measurement in the present study.

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steeply back in a straight line from the umbo to the foremost point of the shell low on the anterior margin, which curves rather sharply into the gently convex lower border. The postero-dorsal margin also slopes rather steeply from the umbo, and curves into the short, slightly oblique posterior margin. The postero-ventral extremity forms a sharp curve. There is no marginal carina or ante-carinal groove and the small area (about ¼ of the shell's surface) is poorly marked-off from the flank, mainly by difference in ornamentation. The costae of the flank are strong, rounded, rather depressed, about 2.5 mm. wide, with interspaces considerably narrower. They are concentric with the growth lines. There is a fairly well developed frontal face, over which the ribs pass completely only in later stages of growth. Over the marginal convexity between flank and area, the costae bifurcate to form the areal costellae, which are only slightly less robust than the costae. Each pair remains distinct, and may even converge again on the surface of the area. The lowermost costae pass undivided on to the area, as do occasional costae earlier in the shell's growth. On crossing the marginal convexity there is a slight swelling of the costellae, and some also swell up immediately below the edge of the escutcheon. The surface of the area is convex, with no radial ornament. The escutcheon is poorly separated from the area and is crossed by some of the costellae which are usually broken into elongated nodes, while some pinch out at its edge. The dentition is massive, typically trigoniid, the large tooth 3a, crenulate on both sides, rising from a massive platform, almost vertically below the umbo. 3b is long and narrow, also crenulate on both sides, and lies close below the postero-dorsal margin of the shell. 5a is smooth and almost rudimentary.

The majority of specimens closely related to _I. beyschlagi_ in the present collection belong to a community from Locality WA.2176 (see Pl.XV, figs.1-5 and p.68 above) close to that of the holotype. About half of the specimens correspond approximately to the triangular shape of the holotype, while the remainder grade to a more elongated and inflated form which has a shorter anterior end and a more quadrangular shape due to the longer posterior margin. The postero-dorsal margin remains straight, and in this and the ornamentation, the shells remain distinct from _I. africana_. Often the costae are depressed and more smoothed-off than in the holotype except in the lower part of the shell. One specimen, S.11738 (Pl.XV, fig.2), otherwise rather similar to the holotype except in its smaller size, shows slight V-ing of the costae in the upper part of the shell. In the shells of this community, the costae often pass unbroken into the areal costellae there being no marginal groove except near the umbo. If they bifurcate, there is often a notable difference in the strength of the two costellae of the pair. The community is also discussed above (p.68). It is suggested that the range of variation exhibited by it should be that accepted for _I. beyschlagi_ s. str.

The same combination of features is not common in shells of any other community represented in the collection. Only one specimen from each of the stratigraphically close communities from WA.2154 (Pl.XVI, fig.2) and WA.2179 (Pl.XVI, Fig.1) is assigned to I. aff. beyschlagi, the remainder being closer to I. africana.

From lower in the sequence I. beyschlagi (s. lato) is most uncommon, and occasional isolated specimens (e.g. S.11766, Pl.XII, fig.5) should possibly be regarded as homeomorphs.

Dimensions.

Dimensions of the holotype (Müller, 1900, Pl.XIX, fig.1) are as follows, and those of other examples are given in Table IX:-

Length (L)	90.0 mm.
Height (H)	71.0
Thickness (one valve) (T)	23.0
Length of anterior end (A)	23.0
H/L	78.9%
A/L	25.6%
T/L	25.6%

Comparison.

Table XII outlines the differences between I. beyschlagi and the other members of the species group of I. africana. The relationship between I. crassa Kitchin and I. beyschlagi has been briefly dealt with above.

Associations and Age.

Müller (1900, p.541) cited the following in association with I. beyschlagi:- Rhynchonella tornquisti Müller; Avicula lieberti Müller, Arca uitenhagensis Müller, Arca sp., Trigonia ventricosa Krauss, Astarte cf. numismalis d'Orbigny, Protocardia schenki Müller.

Mainly on the basis of the specimen of "T. ventricosa" [renamed "T. mülleri" by Dietrich, (1933) and more lately assigned to Pterotrigonia] the collection described by Müller was assigned to the Neocomian. Dietrich (1933, p.34), however, suggested that specimens from two distinct horizons in the Mkundi Stream area had been mixed in Bornhardt's (1900) collections. Since Spath (1927-33, p.542; 1935, p.189) has recorded "T. ventricosa" in association with a Lower Tithonian ammonite fauna in Cutch, there is no necessity to postulate such an error.

According to Kitchin (1903, p.47), I. beyschlagi (= I. crassa) in Cutch is accompanied by Pterotrigonia ventricosa (Krauss), Laevitrigonia spissicostata (Kitchin) and Yaadia mammilata (Kitchin). Spath (1927-33, p.856) suggested that I. beyschlagi (= I. crassa) in Cutch could be Jurassic in part at least, and not Cretaceous as supposed by Kitchin (1926, p.468; 1929, pp.206-214), and this age is tentatively assigned to the Tanganyika specimens.

5. Trigonia (Indotrigonia) robusta sp. nov.

(Pl.XII, fig.4; Pl.XVIII, figs.1-6).

This species is based on rather ill-preserved material from only two localities, though forms with affinity to it occur elsewhere. The massive nature of the ornament as compared with I. africana sp. nov. (with which it appears to intergrade) seems to justify its separation as a morphological species.

Localities and Material.

Assigned to I. robusta s. str. are specimens from the following localities:-

Hunterian Museum Collection: Loc. WA.961 (S.11697 - S.11711).

Geological Survey of Tanganyika Collection: Locs. WA.961 [WA.961(8), (15), (23), (31), (32), (34)-(37), (40)]; WA.2548 [WA.2548(1)-(8)].

(See Appendix II).

With affinity or compared to the species are shells from the following (see Appendix II for individual determinations):-

Hunterian Museum Collection: Locs. WA.961 (S.11712 - S.11717); WA.1656 (S.11764); WA.2267 (S.11842 - S.11843).

Geological Survey of Tanganyika Collection: Loc. WA.961 [WA.961(39)].

Specimen S.11708 (Plate XVIII, figs.1a-c) is designated holotype.

Diagnosis.

Shell large, massive, quadrangular to trigonal, inequilateral, moderately inflated. Umbones prominent, high, moderately incurved, from nearly terminal to about 1/3 of the length from the anterior end. Anterior margin straight, oblique or nearly vertical, passing in a sharp curve into the straight or slightly convex lower border. Postero-dorsal margin nearly straight, sloping back rather steeply from the umbo. Posterior margin of variable length, usually convexly curved. Flank, comprising 2/3 or less of the shell's surface, ornamented by strong concentric costae, with interspaces up to twice the width of the costae on the anterior part of the flank but less posteriorly. Frontal face sometimes well developed, with some swelling of the costae at the angulation of the flank. Costae weaken anteriorly, some failing to reach the anterior border towards which they rise abruptly, and increase in thickness posteriorly, becoming swollen in appearance towards a prominent marginal groove, which extends throughout the growth of the shell. Areal costellae almost equal in strength to the costae, but slightly more numerous; not always placed opposite the ends of the costae, like which they become swollen towards the marginal groove. Escutcheon long, narrow, lanceolate, slightly depressed, and crossed obliquely by extensions of some of the areal costellae.

Dimensions.

The dimensions of the holotype and of a number of paratypes are given in Table IX.

Further Description and Discussion.

Most of the specimens of I. aff. robusta differ from the type material in showing less tendency to thickening and wide-spacing of the ornament. However the two specimens from Locality WA.2267, while similar to I. robusta in general outline, wide spacing of the ornament and the very marked development of the marginal groove, have rather sharp costae and costellae instead of the bulbous ornamentation of the typical I. robusta. However, one shell [WA.2548(3)] approaching this form has been noted along with typical material.

See also comments above (p.67) on the community of Indotrigonia from Locality WA.961.

Comparison.

Table XII outlines the differences between I. robusta and other species of Indotrigonia.

No previously figured Indotrigonia corresponds to I. robusta. The shells figured by Dietrich (1933, Pl.III, figs.54, 56) as I. smeei show thickening of the costae and areal costellae towards a prominent marginal groove, but in this case the ornament is close-spaced, widened, but not much raised, and is irregular and somewhat squamose. Dietrich's figured specimens should probably be assigned to a new morphological species.

Associations and Age.

Associated with I. robusta at Locality WA.961 is Virgatosphinctes cf. communis, which (Arkell, 1956, p.331) dates the locality as Lower Tithonian. This locality appears to lie above the horizons where entire communities are composed essentially of I. africana s. str.. No Indotrigonia comparable to I. robusta has been found below the "smeei" Oolite in the Mandawa - Mahokondo area.

Trigoniidae associated with I. robusta (s. lato) in the present collection are I. africana (s. lato) (Locs. WA.961, WA.1656), I. aff. beyschlagi (Locs. WA.1656, WA.2267), Laevitrigonia curta sp. nov. (Loc. WA.1656), Opisthotrigonia curvata sp. nov. (Locs. WA.961, WA.2267), Megatrigonia (Iotrigonia) cf. vau (Loc. WA.2267), M. (Rutitrigonia) dietrichi (Loc. WA.1656). Other associated lamellibranchs at Localities WA.961 and WA.2548 include Cucullaea (Megacucullaea) eminens Cox, and Corbis (Sphaera) subcorrugata Dietrich together with species of Arcomya, Astarte, Gervillella, Hinnites, Lima, Modiolus, Pecten and (?)Thracia.

costae, the apices generally anterior to the umbo, the posterior limb of each rib stronger and less steep than the anterior, and sometimes nodose. Ornament changing abruptly in later growth to concentric ribbing, often crowded. Marginal carina extending to about 1/3 of shell's growth and prominent ante-carinal groove, present on both valves, extending over most of the shell's growth but less clearly marked posteriorly.

Area ornamented by regular transverse costellae 1½ to 2 times as numerous as costae, and by traces of radial ornament proximally, including median and inner carinae extending about 20 mm. from umbo, with nodosity of the ends of the areal costellae extending beyond this distance. Median groove persistent almost to the posterior margin. Escutcheon long, lanceolate, slightly concave, almost as wide as the area, sometimes ornamented by very obliquely transverse, interrupted ridges corresponding to a few of the areal costellae, sometimes nearly smooth. Ligament pit short, narrowly lanceolate, extending about 1/5 of the length of escutcheon.

Dimensions.

	L	H	T	A	E	H'	H/L	T/L	A/L
S.11749	90.0*	58.0	15.5	13.5	52.0	44.0	64.4%	17.2%	15.0%
S.11755	-	48.0	13.0	12.5	43.0*	46.5	-	-	-
S.11757	-	51.8	17.0	16.5	-	44.0	-	-	-

* Estimate from restored figure.

L Length
H Height
T Thickness (one valve)
A Length of anterior end
E Length of escutcheon
H' Height to start of concentric ribbing.

Further Description and Discussion.

The outstanding feature of the shell is its V-ed flank ornament in the upper portion, changing abruptly to concentric ribbing in later growth. There are occasional costae intercalated between the shorter anterior limbs of the complete V's. The costae do not quite reach the anterior border, but turn upwards and thin out on the flat frontal face, anterior to a thickened portion corresponding to the anterior angulation of the flank. Posterior to this thickening the costae curve sharply down into the short anterior limb of the V, and may thin downwards or show slight irregularity of growth. Above the place of onset of concentric ribbing, additional ribs are inserted posteriorly, parallel to the long limbs of the V-ed ribs. The concentric ribbing is close-spaced and often interrupted.

In several respects the species more resembles I. mandawae from below the "smeei" Oolite than I. africana with which it is associated, e.g.:-

(i) in elongation

(ii) in the near-terminal position of the umbones

(iii) in the frequent abrupt truncation of the anterior end (not so marked in the holotype as in others), and

(iv) in the strong development of the frontal face (present, but generally less marked in I. africana from above the "smeei" Oolite).

The hinge of I. v-striata is imperfectly known, but appears to be of the typical massive trigoniid pattern of other species of Indotrigonia.

At Localities WA.1265 and WA.1628 there are no transitional forms between I. v-striata and the large associated communities of I. africana. They may therefore be regarded as distinct biospecies.

The definition of the sub-genus Indotrigonia Dietrich (1933, p.30) is as follows[1]:-

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[1] Author's translation.

"An elongated Trigonia; in early stage as Lyriodon, but with increasing age, in all parts of the shell, possessing irregular, continuous or interrupted concentric ribs of variable breadth".

In spite of the acutely V-ed costae, and in view of the normal concentric habit of the costae adopted in later growth, there seems no doubt that v-striata is correctly assigned to Indotrigonia, though the scope of the sub-genus may thereby be slightly widened.

Comparison.

At Locality WA.2154 (see Pl.XVII) a community of I. aff. africana contains forms with quite marked V-ing of the flank costae, thus showing some similarity to I. v-striata. The same abrupt change from V-ed ribbing to concentric, convexly curved ribbing occurs in the lower part of the flank. However, there are several features that clearly distinguish these shells from I. v-striata, among them:-

(i) The V-ing is less acute, the anterior limb of the V longer and less steep and the apices of the V'es posterior to umbones.

(ii) There is little tendency to nodosity of the flank costae or to thinning towards the apices of the V's on the anterior limb.

(iii) There is no sharp angulation of the flank to the much less developed frontal face.

(iv) The area is not so distinct from the flank; the marginal carina and ante-carinal groove are not strongly developed, and no other radial ornament is visible in the area.

The ornament of the flank is sufficient to distinguish I. v-striata from any other species of the subgenus.

Associations and Age.

All examples of I. v-striata so far found have been associated with I. africana above the "smeei" Oolite in the Mandawa - Mahokondo area, in strata regarded as of Tithonian age. Its observed range is limited and it does not occur associated with I. beyschlagi s. str. in the younger strata yielding the I. africana species group, though at Locality

WA.2266 I. aff. beyschlagi occurs with it. Other associated Trigoniidae noted have been Megatrigonia (Rutitrigonia) dietrichi (Lange), Opisthotrigonia curvata sp. nov. and (?)Yaadia sp. together with the usual lamellibranch fauna accompanying I. africana s. str.

7. Trigonia (Indotrigonia) sp. nov.
(Pl.XXIII, figs.9a,b).

A single example of a new species of Indotrigonia was obtained from a small isolated exposure of Lower Cretaceous (? Upper Aptian) rocks near the extreme southern end of the Mandawa - Mahokondo anticline.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2328 (S.12121).
(See Appendix II).

Description.

The shell is rather smaller and less massive than usual in Indotrigonia and is elongate, strongly inequilateral and moderately inflated. The umbones are not prominent and are placed less than ¼ of the length from the anterior end. The anterior end of the single specimen is not fully preserved, but apparently was slightly convex, passing smoothly into the gently convex lower border. The postero-dorsal margin is almost straight, very slightly convex, sloping gently back from the umbo and the posterior margin fairly short and nearly vertical. No marginal carina is visible, but the umbonal region of the shell is eroded. A marginal groove extends from the umbo to the postero-ventral extremity. The flank, occupying just over half the surface of the shell, is ornamented by strong, sharp costae concentric with the growth lines, increasing slightly in prominence towards the posterior, and separated by interspaces of about twice the width of the costae. The crests of the costae are about 2 mm. apart at mid-flank, but are crowded towards the lower part of the shell. The area is large, slightly convex, ornamented by sharp, transverse costellae nearly as strong as the costae, and about 1½ times as numerous. The costae and costellae form distinct series, the costellae having no appearance of being formed by bifurcation of the costae. The costellae are thickened near the marginal furrow, and in the upper part of the shell each forms a convex curve towards the posterior end while in later stages they are nearly straight and are slightly imbricating towards the posterior. No radial ornament is visible on the area except slight grooves near the umbo, but the proximal part of the area is eroded. There is no inner carina, but slight swelling of the upper ends of the costellae mark the inner edge of the area. The escutcheon is long, lanceolate and slightly depressed, but the inner edge is elevated to form the shell's slightly convex postero-dorsal margin. It is ornamented by attenuated extensions of some of the areal costellae which run obliquely across it. The ligament groove is rather obscure, but appears to be almost $\frac{3}{4}$ of the length of the escutcheon. The internal features of the shell are not exposed.

Dimensions.

Length*	41.5 mm.
Height	29.5 mm.
Thickness (1 valve)	9.2 mm.
Length of anterior end*	9.0 mm.
Length of escutcheon*	25.5 mm.

*Estimated.

Remarks and Discussion.

This new form seems quite typical of the subgenus, though the incompleteness of the only specimen anteriorly and at the umbonal apex makes it uncertain if any radial ornament besides the slight grooving is present on the area near the umbo, and if the frontal face characteristic of Indotrigonia is developed. In spite of its small size the shell would appear to be mature, since there is crowding of the costae near the pallial border, though not so much as would suggest senility. The ornament of flank and area is sharper than usual in Indotrigonia. In outline and relative size of flank and area, the shell is nearer to the Argovian I. smeei of Cutch than to the generally more elevated Kimmeridgian - Tithonian East African species. It is however, much smaller, less massive, less compressed and apparently shorter at the anterior end than I. smeei though the slightly imbricate appearance of the later areal costellae is again reminiscent of the Argovian form.

Probably also of Aptian age (? Lower Aptian) is Megatrigonia (Rutitrigonia) krenkeli (Lange). Dietrich (1933, p.31), who regarded this form as an Indotrigonia, contended that it is "a morphological continuation of the evolution of T. smeei - in simplification of the sculpture, and reduction and coarsening of the costae". If this view were at all acceptable, it would have to be supposed that a conservative element of the subgenus continued in parallel development to the stock giving rise to "T. krenkeli". However, reasons for the assignment of T. krenkeli Lange to Rutitrigonia are given elsewhere (p. 201).

Associations and Age.

The single example of this new species was obtained from a gritty, calcareous sandstone boulder, apparently associated with massive blocks of white Orbitolina-bearing limestone. The only other macrofossils obtained were brachiopods, as yet not determined. Almost certainly the sandstone blocks are of the same age as the limestone, probably Upper Aptian. Lower Cretaceous occurs here as an outlier, presumably of the series of Neocomian - Aptian sediments, including Orbitolina-bearing limestones, which lap round the south end of the Mandawa - Mahokondo anticline.

3. Genus MYOPHORELLA Bayle, 1878.

Type species: _Myophorella nodulosa_ Bayle, 1878. Oxfordian, Normandy.

Crickmay (1932, p.458) recognised _Myophorella_ as one of the genera of the Trigoniidae and designated the type species. Cox (1952b, p.55) accepted the genus and regarded _Vaugonia_ Crickmay, _Scaphotrigonia_ Dietrich, and _Jaworskiella_ Leanza as subgenera, naming _Orthotrigonia_ as a new subgenus. _Myophorella_ s. str. and _Orthotrigonia_ are recognised in the present collection.

Kobayashi (1954, p.68) considered that _Vaugonia_ and _Myophorella_ are two independent stocks, and Kobayashi and Mori (1955, p.76) regarded _Orthotrigonia_, _Vaugonia_ (with subgenera _Vaugonia_ s. str. and _Hijitrigonia_), _Scaphotrigonia_ and _Jaworskiella_ as genera in the subfamily Vaugoniinae Kobayashi, 1954. In the subfamily Myophorelliinae Kobayashi, 1954, Kobayashi and Tamura (1955, p.89) placed the genera _Myophorella_ (with subgenera _Promyophorella_, _Myophorella_ s. str. and _Haidaia_), _Yaadia_ and _Linotrigonia_ (all in the Clavellatae section of the subfamily), and _Steinmanella_, _Oistotrigonia_ and _Quadratotrigonia_ (in the Quadratae section). As elsewhere in this account, Cox's classification is adopted.

Subgenus MYOPHORELLA (MYOPHORELLA).

Cox (1952b, p.55) regarded _Scaphogonia_ Crickmay, _Haidaia_ Crickmay, _Clavotrigonia_ Lebküchner and _Clavitrigonia_

Leanza as synonymous with Myophorella s. str.

1. ?Myophorella (Myophorella) sp.
(Pl.XXIV, figs.1a,b).

A single small specimen from the Mandawa - Mahokondo area is assigned to this subgenus tentatively.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2154 (S.11483) (See Appendix II).

Description.

The shell is small, ovately trigonal, rather compressed, very inequilateral, with low umbones placed at about $\frac{1}{4}$ of the length from the anterior end. The anterior margin is convex and passes smoothly into the convex lower margin, of which the lowermost point is behind the umbo. The posterior extremity is not preserved, but evidently the posterior margin was short. The flank is ornamented by very steep, fine, slightly nodose, evenly spaced costae, curving upwards at the anterior margin. The ornament is not preserved in the umbonal region but was presumably concentric. The narrow area is separated from the flank by a blunt, straight, sparsely denticulated, marginal carina and from the escutcheon by a similar inner carina. There is a trace of a median groove, but no other ornament is preserved on the area except for traces of the growth lines. The escutcheon is long and narrow, with strong, widely spaced, slightly denticulated transverse ridges. The assignment of the shell of Myophorella s. str. is rather tentative in view of its poor preservation, especially the worn nature of the area.

Dimensions.

Length	12.5 mm.*
Height	11.0
Thickness (one valve)	3.0*
Length of anterior end	2.8
Length of escutcheon	8.3

*Estimated.

Comparison.

In that the area is very narrow and steeply inclined to the flank, the umbones depressed and the ornament not strongly nodose, the shell is not typical of the subgenus. In outline and general form it is reminiscent of Linotrigonia venusta van Hoepen. However in this species, the area is ornamented in the umbonal region by posteriorly directed costellae giving a chevron effect in combination with the flank costae, which is characteristic of Linotrigonia. Also, L. venusta has no inner carina and the marginal carina is slightly concave upwards.

Associations and Age.

The specimen of ?Myophorella s. str. was associated with a community of Indotrigonia aff. africana and I. aff. beyschlagi and is regarded as Tithonian in age. A large ammonite

/acceptable as Tithonian though inconclusive according to Dr. W.J. Arkell in litt. to W.G. Aitken (2 Dec. 1954)_7 was also found at the locality, and immediately below it, a community of Megatrigonia conocardiiformis (Krauss), which has not been reported before from the Tithonian in Africa.

Subgenus MYOPHORELLA (ORTHOTRIGONIA) Cox, 1952.

Type Species: Trigonia duplicata J. Sowerby (1819), Inferior Oolite, England.

From Southern Tanganyika three species of Orthotrigonia are known. O. discordans was described (as Clavotrigonia) by Hennig (1937, p.174) from the Kimmeridgian. It is of the same general character as the type species, in that the costae of the flank are tuberculate but not resolved into separate tubercles. This species is not represented in the present collection. It is suggested elsewhere (Pt.I, p.66) that it may have been incorrectly dated. The species now reported for the first time from Southern Tanganyika are O. cf. kutchensis (Kitchin)[1] and Orthotrigonia sp. nov.

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1) Kobayashi and Tamura (1957, p.41) regarded kutchensis and the similar hispida as belonging to Scaphotrigonia Cox not Orthotrigonia, but Cox's (1952b, p.55) assignment of these to the latter is presently accepted.

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1. Myophorella (Orthotrigonia) cf. kutchensis (Kitchin) (Pl.XXIV, figs.2-8).

The following is a reference to typical material: Trigonia kutchensis F.L. Kitchin, 1903, p.84, Pl.VIII, figs.7-9.

A number of specimens, none complete and many ill-preserved, from the strata in the core of the Mandawa - Mahokondo Anticline, have been assigned to O. cf. kutchensis.

Localities and Material.

Hunterian Museum Collection: Locs. WA.943 (S.12124); WA.1180 (S.12127, S.12135); WA.1242 (S.12125); WA.1245 (S.12131); WA.1252 (S.12137); WA.1346 (S.12128); WA.1634 (S.12129); WA.1810 (S.12132, S.12136); WA.2016 (S.12130, S.12133); WA.2218 (S.12126); WA.2230 (S.12134).

Geological Survey of Tanganyika Collection: Locs. WA.1180 [WA.1180(1)]; WA.1634 [WA.1634(1)].

(See Appendix II)

Comparison with Type Material.

The material available is not well preserved, and information is lacking especially as regards detail of the escutcheon. A number of specimens are worn casts with no shell material preserved. Some specimens are larger than O. kutchensis from Cutch.

Kitchin (1903) differentiated between two species, O. hispida and O. kutchensis which Cox (1952a, p.117) placed in Scaphotrigonia, but later (1952b, p.56) in Orthotrigonia, to which the present material compares closely. In contrast to the type species and O. discordans, the costae of these forms are largely resolved into separate tubercles. In size and shape the two Cutch species are similar. Slight differences in the descriptions of the escutcheon and carinae seem negligible. Only differences in the form and arrangement of the flank ornament can be used for discrimination. In both there are the three series of costae characteristic of

Orthotrigonia: (a) a concentric series in early growth (3-4 in O. kutchensis, 6-7 in O. hispida); (b) a vertical series occupying most of the flank (of which the one most anterior in O. kutchensis and the four most anterior in O. hispida extend only mid-way up the flank from the lower border, the remainder reaching the marginal carina); (c) a horizontal anterior series of short ribs extending only a few mm. from the anterior border (wider spaced in O. kutchensis than in O. hispida). The posterior ends of the ribs of this series sometimes meet the ends of ribs of the vertical series, but the two series are often quite distinct (see Plate XXIV, fig.7b). In O. hispida a frontal face was described, over which the concentric ribs do not pass; in O. kutchensis, there is no frontal face and the concentric ribs reach the anterior border of the shell. The inflation of O. kutchensis was described as "weak", that of O. hispida as "moderate". In other features, the descriptions of the two species are more or less equivalent. Kitchin (1903, p.92) mentioned that the description of O. hispida was based on only two imperfectly preserved specimens.

On the basis of these differential characters, the majority of the Tanganyika specimens would best be compared to O. kutchensis, but three require further consideration:-

S. 12130 (Pl.XXIV, fig.2)

Only the upper part is preserved, but the detail of the escutcheon ornament is not seen. Six concentric ribs are visible near the umbo. The spacing of the later ribs rapidly increases, becoming similar to that of shells of O. cf. kutchensis from the same beds, of which the umbonal apices are not preserved. The question arises, therefore, whether less well preserved shells did not also have a similar number of ribs, which is characteristic of O. hispida, in the concentric series. There is a small frontal face over which the concentric ribs do not pass and the ribs of the anterior horizontal series are widely spaced. The lower part of the shell is not preserved to show the nature of the antero-ventral ornament.

S. 12126 (Pl.XXIV, fig.3).

This is a large specimen and slightly distorted. Accretion of unornamented shell material has occurred at the anterior margin, possibly a senile development. The umbonal apex of the shell is not preserved and the detail of the escutcheon cannot be seen, but much of the remainder of the shell is visible. Over four costae occur in the concentric series, which do not reach to the anterior border. However, a frontal face is present. The ribs of the anterior series are widely spaced, and the ribs on the antero-ventral portion of the flank are so broken up into tubercles as to be indistinct. One vertical rib of the series appears to extend from the lower border only to the middle of the flank.

S. 12134 (Pl.XXIV, fig.4).

The shell is incomplete posteriorly. The umbonal apex is worn and detail of the ornament of the escutcheon is not visible. The ornament of flank and area is fairly clear. There are over four concentric ribs near the umbonal apex which do not reach to the anterior margin, though there is no distinct frontal face. The horizontal anterior ribs are widely spaced. There is some irregularity of the ribbing in the antero-ventral part of the flank, and there is only one rib extending from the lower border only to the middle of the flank.

Those three shells, to which the other less well-preserved specimens conform to a greater or less extent, show characters of both O. kutchensis and O. hispida. The number of ribs in the concentric series, and the development in some of a frontal face, recalls O. hispida. There is similarity to O. kutchensis in the wide spacing of the anterior horizontal ribs and the presence of only one vertical rib in the antero-ventral region reaching only to mid-flank.

O. kutchensis was described originally from more abundant and more fully preserved material than O. hispida. Discrimination between them relies on features which are intermingled in some of the specimens in the present collection. It is proposed to compare all the specimens from the Mandawa - Mahokondo area to O. kutchensis.

Dimensions.

Almost all the specimens are damaged, but the following dimensions of a single almost complete example, larger than most (S.12126 from Locality WA.2216 - Plate XXIV, fig.3), serve to illustrate the proportions:-

Length	55.5 mm.
Height	45.5
Thickness (single valve)	16.0
Length of anterior end	14.5

Comparison.

Orthotrigonia cf. kutchensis from Tanganyika bears comparison with the group of shells from Cutch comprising O. jumarensis, O. gracilis, O. exortiva and O. hispida (all first described by Kitchin). The relationship to O. hispida has been discussed above. O. jumarensis is smaller and more compressed. The concentric element of flank ornament is much more extensive than in the Tanganyika shells and its area ornament, instead of consisting of fine transverse ridges throughout, has much stronger ridges for 10 mm. from the umbo with only delicate, thread-like, transverse lines beyond this, with an occasional transverse furrow. O. gracilis is also smaller and more compressed than O. cf. kutchensis. The costae are finer and less tuberculate and the area ornament differs in the same way as that of O. jumarensis, though the wide-spaced ridges are less numerous. O. exortiva, while comparable in size and shape to O. cf. kutchensis, has finer, less tuberculate and more regular flank ornament, with the vertical component preponderating.

Associations and Age.

A number of the localities from which O. cf. kutchensis has been obtained have been dated on ammonite evidence as Callovian, some more precisely as anceps or rehmanni zone (fide Dr. W.J. Arkell in litt. to W.G. Aitken, 16 Dec. 1954). Others, by reason of their proximity to dated localities can certainly be accepted also as Callovian, and probably all are of this age. Hitherto O. kutchensis has not been recorded outside Cutch, though O. hispida is listed by Besairie (1953, pp.50, 52) from the Upper Bathonian or Lower Callovian of Madagascar.

The following molluscs from the author's collection are among the fossils noted in association with O. cf. kutchensis (ammonites determined by Dr. W.J. Arkell - see Appendix I for localities):-

Ptychophylloceras euphyllum (Neumayr): Loc. WA.1005/1180.

Indosphinctes pseudopatina (Parona & Bonarelli): Loc. WA.1005/1180.

Choffatia aff. balinensis (Neumayr): Loc. WA.1634.

Grossouvria cf. gracilis (Siemiradzki): Locs. WA.2016, 2230.

Astarte mülleri Krenkel: Loc. WA.2244.

Ceratomya concentrica (J. de C. Sowerby): Loc. WA.1346.

C. telluris (Lamarck): Locs. WA.1005, 1180.

C. cf. wimmisensis (Gillieron): Locs. WA.1005/1180, 1346, 2230.

Ceromyopsis sp. ("Isocardia striata" of Müller, 1900): Locs. WA.1005/1180, 1346, 1634, 2230.

Grammatodon (Indogrammatodon) virgatus (J. de C. Sowerby): Locs. WA.1005/1180, 1346, 1810.

Modiolus glendayi (Weir): Locs. WA.1346, 1810.

Trigonia aff. elongata Sowerby: Locs. WA.1005/1180, and species of Eligmus, Eopecten, Exogyra, Lima, Lopha, Pecten and Pholadomya.

The species probably occurs throughout the Callovian strata of the area, with the considerable fauna listed elsewhere (Part I, pp.61-64).

2. Myophorella (Orthotrigonia) sp. nov.
(Pl.XXIV, figs.9-10)

The collection contains four specimens of a new species of Orthotrigonia, none complete. Only the specimens housed in the Hunterian Museum are discussed as the others are fragmentary.

Localities and Material.

Hunterian Museum Collection: Locs. WA.2244 (S.12123); WA.2274 (S.12122).

Geological Survey of Tanganyika Collection: Locs. WA.2244 [WA.2244(1)]; WA.2545 (= WA.2274) [WA.2545A]
(See Appendix II).

Description.

The shell is rather small, ovately trigonal, rather compressed and very inequilateral with prominent, slightly incurved and recurved umbones placed about ¼ of the length from the anterior end. The anterior margin of the shell is convex, and apparently passes smoothly into the convex lower border (the shells are all incomplete in this part) and the lowest point on the lower border lies well behind the umbo. The long, straight postero-dorsal margin curves into the very slightly convex posterior margin, which runs in a curve into the lower border. As is typical of <u>Orthotrigonia</u>, the flank costae are in three series: (a) 7 - 9 concentric costae near the umbo, reaching from the marginal carina to the anterior border; (b) short horizontal costae confined to the anterior end; (c) sub-vertical costae over the greater part of the flank. All the costae are delicately tuberculate, the concentric series more noticeably so. Interspaces are of about the same width as the costae. Some inter-crossing of the rib series occurs in the upper part of the shell. The anterior horizontal costae meet successive members of the sub-vertical series downwards over much of the height of the shell, nearly at right angles, with some horizontal costae not matched. The marginal carina is obtuse, especially in later growth. The area is broad and inclined to the flank at a very obtuse angle posteriorly; it is nearly flat but has an obscure median furrow near the umbo, placed just above the mid-line of the area, and is ornamented by fine, close-spaced, straight or slightly curved transverse costellae. There is an obscure inner carina. The escutcheon is long and rather broad, depressed in relation to the area, but elevated at the dorsal margin, and ornamented by strong, delicately tuberculate, widely spaced transverse ridges.

The flank ornament differs slightly between the useful specimens from the two localities, in that the concentric rib series is more extensive in S. 12123, and these costae are individually thicker and the series more numerous than in the other specimen. The tuberculation of the concentric costae extends as fine lines into the interspaces. The short horizontal anterior rib series appears to be a continuation of the concentric series, terminated progressively earlier by the sub-vertical ribs. This conception is supported by the inter-crossing of the two rib-series in the upper part of the shell. In S. 12123, two concentric ribs commencing at the marginal carina, are terminated anteriorly by the sub-vertical series. The sub-vertical ribs are straight, in S. 12123 finer than the concentric ribs, but in S. 12122 and WA.2545A of about equal strength. In the anterior portion of the flank they slope forwards and downwards, in the posterior, backwards and downwards.

Dimensions.

The dimensions given refer to S. 12122 which is the most complete specimen.

Length	27.0 mm.
Height	24.0 mm.*
Thickness (single valve)	6.7 mm.
Length of anterior end	6.8 mm.
Length of escutcheon	14.0 mm.

*Estimated.

Comparison.

Orthotrigonia sp. nov. bears a strong resemblance to the two apparently similar species *O. discordans* (Hennig) (not well figured) and *O. exortiva* (Kitchin), and to *O. duplicata* (Sowerby). It differs in its:-

(a) smaller size,

(b) closer spacing of the finer costae (except for the concentric series in S. 12123),

(c) greater extent of inter-crossing of the horizontal (or concentric) and sub-vertical rib series,

(d) (in S. 12123 only) greater number and extent of concentric ribs,

(e) development of the series of horizontal ribs right down the anterior end, as against the development of only a few truly horizontal ribs in the other species,

(f) nearly rectangular meeting of the distinct sub-vertical and the horizontal rib series throughout the height of the shell, as against the obtuse-angle meeting of sub-vertical and sub-horizontal elements in the other species.

The new species is apparently closest to *O. duplicata*, but lacks the tendency of the latter to lunate shape. Of the two specimens, S. 12122 is closer than the other to *O. duplicata*. The two specimens differ in geological age, and it is possible that the difference in development of the concentric series of ribs may prove of taxonomic importance.

Associations and Age.

S. 12123 was obtained from strata not far below dated anceps or rehmanni zone (Callovian) strata, the lowest in the Mandawa - Mahokondo Series to have been dated on fossil evidence. It is not certain if the specimen is as old as O. exortiva of Cutch, but it is certainly much older than Kimmeridgian, the age Hennig (1937, p.175) assigns to O. discordans (possibly in error - see Part I, p.66). S. 12123 is probably Upper Bathonian or Lower Callovian and younger than O. duplicata (Bajocian in England). The age of the strata from which S. 12122 and WA.2545A came is not established, nor their relation to the immediately underlying Pindiro Shales. A Bajocian age is suggested in view of the similarity of the specimen to O. duplicata and on stratigraphical grounds, but a Bathonian age is possible.

Associated fossils are poor oyster, belemnite and gastropod fragments in the case of S. 12122 and WA.2545A, and Astarte sp. in the case of S. 12123.

Genus YAADIA Crickmay, 1930.

Type species: Yaadia lewisagassizi Crickmay, 1930. Neocomian, British Colombia.

Crickmay (1930, p.50) instituted two similar genera Yaadia and Steinmanella, Yaadia being distinguished from Steinmanella, the true Pseudoquadrate form, by the "two discrepant sets of costae separated by a radial smooth space" on the flank. He regarded them as genera independently evolved, Yaadia in the North Pacific area and Steinmanella in the Indo-Pacific, both in the Lower Cretaceous. Cox (1952b, p.57) combined Steinmanella, along with Transitrigonia Dietrich and Quadratotrigonia Dietrich, in Yaadia. Of these Rennie (1936, p.345) had already combined Transitrigonia with Steinmanella.

Kobayashi and Amano (1955, pp.193-196) discussed the relation of the Quadratae and the Pseudoquadratae and concluded that they are separate off-shoots of Myophorella. They accepted the terms Quadratotrigonia for the European offshoot and Steinmanella for that of the Austral province. They did not accept Cox's combination of these with Yaadia, of which they pointed out that the type specimen is strongly deformed, but is probably another aberrant offshoot of Myophorella. Kobayashi and Tamura (1955, p.89) placed Yaadia Crickmay 1930 non Cox 1952b, along with Myophorella and Linotrigonia in the Clavellatae section of the subfamily

Myophorellinae Kobayashi, 1954. <u>Steinmanella</u>, <u>Oistotrigonia</u> and <u>Quadratotrigonia</u> were placed in the Quadratae section of the subfamily.

Neither Cox nor Kobayashi and Amano mentioned Stoyanow's (1949, pp.67-79) discussion of forms from Arizona which he described as in many respects intermediate between the Quadratae and Pseudoquadratae. Stoyanow's conclusion was that "the species of pseudo-quadrate Trigoniae clearly indicate a gradual trend in the development culminating in the Quadratae".

As in other instances where, in the recent discussion of Japanese Trigoniids by Kobayashi and various co-authors, there is disagreement with Cox's (1952b) conclusions, Cox's classification has been followed meantime, as being the latest complete and comprehensive work.

1. <u>Yaadia hennigi</u> (Lange)
(Pl.XXV, figs.1,2)

<u>Trigonia hennigi</u> E. Lange, 1914, p.238, Pl.XIX, fig.3.

<u>Trigonia transitoria</u> E. Lange, 1914, p.237, Pl.XIX, fig.2.

<u>Trigonia (Transitrigonia) hennigi</u> W.O. Dietrich, 1933, p.37.

<u>Trigonia (Steinmanella) hennigi</u> J.V.L. Rennie, 1936, p.347, Pl.XLIII, figs.1-3; Pl.XLIV, fig.1.

<u>(Clavo) Trigonia transitoria</u> E. Hennig, 1937, p.176.

Five specimens of the present collection, not all complete or well preserved, have been assigned to <u>Yaadia</u>

hennigi, though they differ in minor respects. They derive from localities close to that at which Lange's (1914) "Trigonia transitoria" was found.

Localities and Material.

Hunterian Museum Collection: Loc. WA.2494 (S.11476-S.11478).

Geological Survey of Tanganyika Collection: Locs. WA.2494 [WA.2494(4)]; WA.2565 [WA.2565(A)].

(See Appendix II).

One juvenile specimen (left valve) is nearly complete, one adult (left valve) lacks about the posterior third of the shell, another (right valve) is broken away below and the remainder (a left and right valve) are nearly complete but worn and partly concealed by matrix.

Description.

The three nearly complete specimens are shorter in relation to their height than any of those figured by Lange (1914) or Rennie (1936) and their height/length ratios cannot be matched in the list of dimensions of Zululand specimens given by Rennie. The variation in this respect in the similar species Yaadia transitoria figured by Weaver (1931) suggests that such a discrepancy is not of much taxonomic importance.

The present specimens have roughly the rectangular shape of the holotype. Specimen WA.2494(4) (Pl.XXV, fig.1), though less elongate, has the "cut-away" lower anterior margin passing into a convex lower margin, such as is figured in Lange's (1914) "Trigonia transitoria" and Rennie's (1936) specimens from Zululand. The other examples have the more rectangular shape of the holotype, but are slightly convex at the anterior end. There is no well-marked, flattened, smooth, frontal face as figured by Rennie (1936, Pl.XLIII, fig.3) in a Zululand specimen, and described by Lange (1914, p.238) for the holotype. The strong tuberculate flank costae do, however, terminate before reaching the anterior margin of the shell, leaving a narrow smooth strip at about right angles to the commissure between the valves.

The flank costae reach from the ventral margin to the marginal fold as in Rennie's figures, and as Rennie (1936, p.35) argued they would in the holotype were it uneroded (though Lange used it as a point of distinction from his Trigonia transitoria that they extend only about one third of this distance). The nodose flank costae are more concave towards the anterior than in any previously figured specimen of Y. hennigi, but Rennie (1936, p.348) has commented on the variability of the Zululand specimens in this respect, and their spacing and size is similar to figured specimens.

The present specimens are all eroded near the umbo and the detail of the early (? concentric) ribbing, and other detail near the umbonal apex (such as the lunule described by Rennie on his specimens) is not visible.

Where visible the area is much as described by Lange and Rennie for the species, but only on the immature specimen (S.11477) is the median furrow accompanied by a distinct carina. This extends throughout the length of the area as described by Lange, but is not mentioned in the Zululand material except to about 30 mm. from the umbo. Specimen WA.2565(A) (Pl.XXV, fig.2) shows a marginal carina formed of a row of tubercles extending to about 30 mm. from the umbo just below a longitudinal furrow at the lower edge of the area, as described by Rennie. On this shell, too, there are traces of tubercles forming an inner carina marking-off the escutcheon from the area to past mid-growth of the shell as in the Zululand material, but the ornament of the escutcheon is obscure. As far as can be observed, the detail of the escutcheon on other shells of the collection, apart from its relative shortness compared to the height of the shell, is as described for the species elsewhere. Two adult specimens exhibit traces of the dentition, typically trigoniid, heavily masked by matrix.

Dimensions.

Three specimens, one immature, are complete enough for measurement:-

	S.11476	S.11477	WA.2494(4)
Length (L)	90.5	57.0*	93.0
Height (H)	74.0	50.5	70.8
Thickness (T)	20.0	17.0	18.0
Length of escutcheon (E)	50.0	-	-
H/L	81.8%	88.6%	76.1%

*Estimated.

Comparison.

The East African specimens are to be distinguished from the South American Yaadia transitoria (Steinmann) in outline, and most notably in that the area of the typical Y. transitoria is ornamented by coarse, crowded, transverse costellae over most of its length, while in Y. hennigi the area has at most a few growth wrinkles. Rennie (1936, pp.330-355) fully discussed the relations of the East African, Zululand, South African, Cutch and South American species that would now be assigned to Yaadia. None are likely to be confused with Y. hennigi, especially in view of the smooth area in this species.

Associations and Age.

Yaadia hennigi in the present collection is accompanied by:- Megatrigonia (Rutitrigonia) nossae sp. nov., M. (Rutitrigonia) nyangensis sp. nov., M. (Rutitrigonia) cf. bornhardti (Müller), Astarte sp., A. brancai Dietrich, Cardium (Tendagurium) rothpletzi (Krenkel), Gervillea alaeformis (Sowerby) var. percrassa Müller, Corbis (Sphaera) corrugata Sowerby and Lopha sp. (all at Loc. WA.2494); and M. (Rutitrigonia) turikirae sp. nov., Astarte stuhlmanni Müller and Ptychomya robinaldina d'Orbigny var. hauchecornei (Müller) (at Loc. WA.2565).

The age probably varies between the two localities. The large community of M. (Rutitrigonia) turikirae at Loc. WA.2565 probably indicates a low horizon in the Neocomian -

Lower Aptian sequence, while the assemblage from Loc. WA.2494 is thought to belong to the upper part of this sequence [see discussion on the age of M. (Rutitrigonia) nossae sp. nov. (p. 187).

2. (?) Yaadia sp.

(Pl.XXV, fig.3).

A single specimen, visible only in interior aspect, and only imperfectly outlined by erosion of the matrix filling the shell, is tentatively assigned to Yaadia.

Locality and Material.

Hunterian Museum Collection: Loc.WA.963 (S.11485).

(See Appendix II).

Description.

The shell, a left valve, has been preserved lying flank downwards in such an attitude that the margin and dentition have been exposed by erosion on a bedding plane of the rock. The hard matrix in which it is embedded fills the interior of the shell.

The outline is roughly rectangular [length 53.5 mm. (ca.); height 39.0 mm. (ca.)] with nearly terminal umbones. The slightly convex anterior margin passes in a smooth curve into the gently convex lower border. The postero-dorsal margin is long, straight and nearly horizontal. The greatest posterior extension of the shell as preserved is at the postero-dorsal extremity, and the posterior end of the shell slopes slightly forward and passes downwards smoothly into the lower border. This shape is rather reminiscent of some examples of Yaadia transitoria figured by Weaver (1931, Pl.21) from the Lower Cretaceous of Argentina, but Weaver's specimens are less rectangular. The Tanganyika shell has 3 - 4 crenulations along the worn postero-ventral margin, presumably corresponding to the ends of steep flank costae. The typically trigoniid nature of the dentition is clear from the worn massive hinge exposed.

Age and Associations.

The specimen of (?) Yaadia sp. was accompanied by Trigonia (Indotrigonia) africana sp. nov. and T. (Indotrigonia) v-striata sp. nov. and by species of Astarte and Pecten; its age is Tithonian. If it is correctly ascribed to Yaadia, this occurrence of the genus in Jurassic strata is unique for Africa, though it has been recorded from the Malone Jurassic Formation of Texas (see Cragin, 1905; Stoyanow, 1949) and from the ?Tithonian ?Neocomian Umia Beds of Cutch.

5. Genus MEGATRIGONIA van Hoepen, 1929.

Type species: Megatrigonia obesa van Hoepen, 1929. Lower Cretaceous, Zululand, Natal.

Cox (1952b, pp.58, 59) included as subgenera of Megatrigonia, van Hoepen's genera Iotrigonia and Rutitrigonia and established Apiotrigonia as a new subgenus. Kobayashi and Mori (1955, p.76) regarded Megatrigonia and Iotrigonia as separate genera in the subfamily Megatrigoniinae Kobayashi, 1954. They did not mention the other subgenera of other authors. As elsewhere in this paper, Cox's classification is followed.

Representatives of Megatrigonia s. str., Iotrigonia and Rutitrigonia are known from southern Tanganyika.

The genus is essentially Cretaceous, but Cox (1952b, p.58) mentioned a Tithonian species M. carrincurensis Leanza from Argentina, and had previously recorded (Cox, 1952a, p.120, Pl.XII, fig.17) M. aff. conocardiiformis from the Umia Beds of Cutch (Tithonian or Neocomian). He also included the Kimeridgian/Tithonian "Trigonia" dietrichi Lange from southern Tanganyika in Rutitrigonia. R. dietrichi, Iotrigonia cf. vau and I. cf. haughtoni now described from Tanganyika are Upper Jurassic as probably also is M. conocardiiformis. The species of Megatrigonia recorded from southern Tanganyika are shown in Table I, and their distribution is discussed below.

Subgenus MEGATRIGONIA (MEGATRIGONIA).

Megatrigonia s. str. is represented in the present collection by one species only, M. conocardiiformis (Krauss). This form and M. staffi (Lange) have previously been recorded from the Neocomian - Lower Aptian sequence of the area (Lange, 1914, pp.235, 236).

1. Megatrigonia (Megatrigonia) conocardiiformis (Krauss).
(Pl.XXVI, figs.1-4).

Lyrodon conocardiiformis F. Krauss, 1850, p.454, Pl.XLIX, figs.1a-d.

Trigonia conocardiiformis J. Lycett, 1878-79, p.120, text-fig.

Trigonia conocardiiformis C. Burckhardt, 1903, p.72, Pl.XIII, figs.3-5.

Trigonia conocardiiformis F.L. Kitchin, 1908, p.119, Pl.VII, figs.2-4.

Trigonia conocardiiformis E. Lange, 1914, p.235, Pl.XIX, figs.1a,b.

Trigonia (Megatrigonia) conocardiiformis J.V.L. Rennie, 1936, p.337, Pl.XL, figs.1-3.

The available specimens of M. conocardiiformis are smaller than is usual for the species, though Kitchin (1908, Pl.VII, fig.2) illustrated one shell of comparable size. There are considerable differences in size, shape and ornament in specimens from the Uitenhage Series from which the type material came, and differences from this material in the present specimens are not sufficient to justify their specific separation.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2148 (S.12050-S.12075).

Geological Survey of Tanganyika Collection: Loc. WA.2148 /WA.2148(2), (4), (10) and (19)/.

Description.

The shell is moderately inflated, rather extended anteriorly and long and pointed posteriorly. The one complete (small) specimen is more pointed than any figured previously. The postero-dorsal margin is concave. The umbones, situated at about the anterior third of the shell, are moderately incurved. An obscure marginal carina near the umbo, develops rapidly into a fold. The narrow area has a median furrow, but is otherwise smooth except in the umbonal region where it is crossed by extensions of the flank costae. The long, lanceolate, smooth, impressed escutcheon is nearly as wide as the area. There is no inner carina. The flank ornament at the anterior end consists of oblique, relatively strong, widely spaced, slightly nodose costae, which are generally concave towards the antero-dorsal margin. The posterior part of the flank has sub-vertical, finer, close-spaced ribs. The two series of costae are sometimes clearly distinct, meeting at a well-defined angle, and sometimes curve into each other. The smooth postero-dorsal part of the flank is scarcely separated from the area. In almost every detail, where preservation allows comparison, the description given by Kitchin (1908, p.120) can be applied to the Tanganyika shells. An exception is specimen S.12052 (Pl.XXVI, fig.3), in which the anterior concentric series of costae do not pass normally to the anterior margin after about 3 mm. from the umbo, but are replaced by a slightly wider-spaced series continuing the same general course. This is probably an abnormality in a single shell.

Dimensions.

The only complete specimen is smaller than most. Dimensions are given for this (S. 12050) and for the largest (incomplete specimen (S.12051):

	S. 12050	S. 12051
Length	42.1 mm.	--
Height	23.5 mm.	33.2 mm.
Thickness (single valve)	8.5 mm.(ca.)	15.0 mm. (ca.)
Length of anterior end	12.3 mm.	18.0 mm.
Length of escutcheon	20.5 mm.	--

Comparison.

M. conocardiiformis was described first from the Uitenhage Beds (Neocomian) of South Africa and most later records are from the same series. Cox (1952a, p.121) remarked that the form described by Burckhardt as T. aff. conocardiiformis from South America is distinct in its zig-zag anterior flank ornament. Weaver (1931) likened T. picunensis to the south African form, but illustrated considerably different flank ornament in most cases. Lange (1914, p.235) described M. conocardiiformis from the Trigonia schwarzi Bed of southern Tanganyika. Rennie (1936, p.338) considered that Lange's specimens were not conspecific with M. conocardiiformis, though closely related both to this and to M. obesa van Hoepen from Zululand, but Cox (1952a, p.121) accepted Lange's determination. An occurrence of M. conocardiiformis in the Hauterivian/Aptian Trigonia schwarzi Bed would be somewhat younger than any other recorded, though of similar age to M. obesa.

Stoyanow (1949, pp.80-82) associated M. conocardiiformis with "T". cragini, "T". kitchini and "T". calderoni, which he regarded as belonging to the "Groups of T. v-scripta and T. vau" (= Iotrigonia). Stoyanow's species, however, clearly belong to Apiotrigonia. The reason advanced by Stoyanow for associating the forms in question in spite of different adult characters was that "in the young stage (Kitchin, 1903, Pl.7, figs.2a,b) this species (ie. M. conocardiiformis) is almost identical with T. cragini, a species in which V-shaped ornament is fully developed in later stages". Later opinion would not accept this line of argument. The specimen of M. aff. conocardiiformis recorded from the Umia Beds of Cutch is ill-preserved and much larger, but otherwise agrees well with selected individuals in the Tanganyika collection.

Apart from the specimen mentioned from Cutch, there has been no doubt of the Lower Cretaceous age of previously recorded material. Except for Lange's specimens, all other reliable records are from the Uitenhage Series (Lower Neocomian) of South Africa.

Associations and Age.

Actually associated with M. conocardiiformis at Locality WA.2148 are obscure gastropod casts and occasional oyster fragments, together with a specimen of (?) Thracia sp. and one of Indotrigonia cf. africana. Immediately above the stratum containing the Megatrigonia, however, is a shell-bed of Indotrigonia aff. africana and Indotrigonia aff. beyschlagi (Locality WA.2154, - p.71). From this shell-bed also came a small ?Myophorella (Myophorella) sp. and an unidentified ammonite acceptable as Tithonian though inconclusive (Dr. W.J. Arkell in litt. to W.G. Aitken, 2 Dec. 1954). There is nothing in this evidence to establish the age of the strata certainly as uppermost Jurassic or lowermost Cretaceous, but a Tithonian age is provisionally accepted.

Subgenus IOTRIGONIA van Hoepen, 1929.

Type species: Iotrigonia crassitesta van Hoepen, 1929. Lower Cretaceous, Zululand, Natal.

Van Hoepen (1929, p.6) established Iotrigonia as a new genus in a new subfamily, the Megatrigoniinae. Rennie (1936, p.338), Dietrich (1933, p.33) and Cox (1952a, p.116) regarded it as a subgenus of Trigonia, but Cox (1952b, p.58) considered it to be a subgenus of Megatrigonia. Kobayashi and Mori (1955, p.76) regarded it as a separate genus in the subfamily Megatrigoniinae Kobayashi, 1954, but Cox's (1952b) classification is followed. Iotrigonia is essentially Cretaceous, but I. cf. haughtoni Rennie (= "I. dubia" of Dietrich, 1933) and I. cf. vau (Sharpe) in the present collection are Upper Jurassic; I. dubia (Kitchin), I. v-scripta (Kitchin) and I. recurva (Kitchin) come from the ?Tithonian ?Neocomian Umia Beds in Cutch. Not reported since the holotype was described from Southern Tanganyika by Müller (1900, p.561), is I. kühni from the Upper Neocomian or Aptian.

1. Megatrigonia (Iotrigonia) cf. haughtoni (Rennie)
(Pl.XXVI, figs.5-9).

Trigonia (Iotrigonia) dubia W.O. Dietrich, 1933, p.33, Pl.II, figs.45, 46.

Trigonia (Indotrigonia) dietrichi W.O. Dietrich, 1933, Pl.II, fig.38.

Many specimens comparable to I. haughtoni (see Rennie, 1936, p.340, Pl.XLI, figs.1-4) from northern Zululand, though older, and apparently corresponding to poorly preserved material described by Dietrich (1933) as I. dubia (Kitchin), have been found at a single locality just above the "smeei" Oolite.

Locality and Material.

Hunterian Museum Collection: Loc. WA.801 (S.11393-S.11438).

Geological Survey of Tanganyika Collection: Loc. WA.801 [WA.801(47) - (61)].

(See Appendix II).

Some of these specimens exhibit more than one individual; other poor specimens occur along with (?)Pleurotrigonia sp. nov. on handspecimens from the same stratum, bearing the locality number WA.855.

Description and Discussion.

The shell is rather small and not massive, moderately inflated, fairly elongated and slightly lunate. The well incurved umbones are situated at about 1/3 of the length from the anterior end. The anterior margin is convex, its most forward point at or below the middle, and passes smoothly into the convex lower border of which the lowest point is behind the umbo. The postero-dorsal margin is concave, making a distinct angle with the oblique posterior margin, but curving into the lower margin.

The area is relatively narrow, steeply inclined to the flank near the umbo and separated from it by a marginal fold but not a carina. It is less steeply inclined to the flank posteriorly. There is a well marked median groove. The escutcheon is large and depressed, but its inner edge is elevated. The fairly wide ligament pit is about 1/3 the length of the escutcheon. No specimen showing the interior of the shell is available.

The ornament of the flank consists of strongly V-ed costae. The apices of the V's are initially anterior to the umbo, but the line of apices curves backwards later to meet the lower border at about its mid-point. No specimen displays the umbonal region undamaged, but within 3 mm. of the umbo, the costae are gently V-ed; smoothly convex costae cannot have been developed to so late a growth stage as in the typical I. haughtoni. The V-ing becomes gradually more acute as growth proceeds, not abruptly so, as in the type material. The anterior rib series is much weaker than the posterior and occupies more than half the ornamented portion of the flank. The anterior ribs may be concentric with the growth lines or somewhat oblique; they vary in strength and regularity, up to three matching each of the posterior series. Generally the anterior ribs are less evenly convex than in the type material and approach the anterior border less steeply. The strong and rather swollen posterior ribs are more or less vertical except for a few near the umbo and they only reach to the edge of the area in the upper part of the shell, leaving the postero-dorsal part of the flank smooth. The later ribs in the posterior series are not matched in the anterior series.

The flank ribs cross the marginal fold on to the area in the upper 6 - 7 mm.; they are sometimes more prominent on the upper half of the area than on the lower. Only at a very early stage do they cross to the escutcheon. At the junction of the area and the escutcheon, a tubercle forms on, or terminates, each rib that reaches so far, forming an inner carina in the first few millimetres of growth.

Dimensions.

Only one specimen, S.11393, which appears to be of average adult size, is complete enough for measurement.

Length	42.0 mm.
Height	29.0 mm.
Thickness (one valve)	11.0 mm.
Length of anterior end	12.5 mm.
Length of escutcheon	20.0 mm.

Comparison.

I. cf. haughtoni appears to correspond with the specimens figured by Dietrich (1933) as "I. dubia" (and one of his figures labelled "Indotrigonia dietrichi"). I. dubia (Kitchin) from Cutch is more elongated, the anterior rib series is stronger and more regular than in the Tanganyika material, and more evenly convex. A blunt marginal carina is present. Rennie (1936, p.345) also concluded that the shells described by Dietrich as "I. dubia" are distinct from this.

I. cf. haughtoni (and the type material) is smaller than I. v-scripta of Cutch and shells of the group of I. vau of South Africa and Tanganyika, and does not develop such coarse ornament. I. v-scripta and I. stowi are also distinguished by their elongate shape and long pointed anterior end. I. vau, while nearer in outline, has shallower V-ing of the costae and the apices of the V's lie along a more oblique line. Also, the anterior and posterior series nearly match in numbers and strength, an unusual occurrence in I. cf. haughtoni. Rennie (1936, p.344) considered that I. haughtoni has closer relationships with I. v-scripta than with the group of I. vau. The variable I. recurva Kitchin of Cutch differs particularly from I. cf. haughtoni in having a longer anterior end, a blunt marginal carina instead of a marginal fold, and a wide, smooth, ante-carinal space. I. kühni (Müller), which is founded on imperfect material, differs from I. cf. haughtoni in being shorter, in the apices of the V's of the costae being less acute and in having the two rib series matching in number.

Associations and Age.

The shells of I. cf. haughtoni came from a locality close to the top of the "smeei" Oolite, and are regarded as Tithonian in age. Rennie (1936, p.301) dated I. haughtoni from Zululand as Neocomian, though Haughton (in Rennie, 1936, p.295) on a preliminary analysis of ammonite faunas, thought the strata from which the species came to be Aptian. The specimens from Tanganyika are crowded in a band of fine, calcareous, shelly sandstone. Apart from the numerous accompanying specimens of Pleurotrigonia sp. nov., only a few fragmentary lamellibranch remains and gastropod casts were found in association.

2. Megatrigonia (Iotrigonia) cf. vau (Sharpe)
(Pl.XXVII, figs.1-4).

The following are references to typical material:

Trigonia vau D. Sharpe, 1856, p.194, Pl.XXII, fig.5.

(?) Trigonia vau R. Tate, 1867, Pl.VII, fig.8.

Trigonia vau F.L. Kitchin, 1908, p.110, Pl.VI, figs.1-3.

The collection includes 4 incomplete specimens comparable to M. (Iotrigonia) vau (Sharpe), which differ among themselves and in varying degree from the type material.

Localities and Material.

Hunterian Museum Collection: Locs. WA.2267 (S.12048); WA.2312 (S.12046); WA.2315 (S.12047); WA.2316 (S.12049).

(See Appendix II).

Comparison with Type Material.

The group of shells resembles I. vau s. str. in size but they appear to be slightly more massive, and in all except S.12049 (Pl.XXVII, figs.1a-c) the anterior end is shorter and blunter than in typical material. In S.12049 which, of the Tanganyika shells, most resembles I. vau s. str., the anterior end is longer and more tapered even than in I. vau, tending to the shape in I. stowi (Kitchin). This is the only shell in the present collection complete enough to show the similarity to I. vau in the form of the posterior end and the lower part of the shell.

The outstanding point of similarity to I. vau s. str., apart from the general outline, is the ornament of strong V-ed costae on the flank. In the form of the costae and the relative strength of the anterior and posterior series, the broken shell S.12048 (Pl.XXVII, figs.4a-b) most resembles I. vau s. str., but the posterior series is more widely spaced and is slightly nodose. In the posterior series of ribs the shells from Tanganyika vary less among themselves and from typical material, than in the anterior series. In S.12049 it is a point of difference from the type material that the anterior series of ribs is more robust, being almost as strong as the posterior series. In all the Tanganyika shells the rib series meet in a more acute angle than in I. vau s. str. and the line of the apices never runs so obliquely backwards from the umbo. S.12046 (Pl.XXVII, figs.2a-d) is unique in having the line of apices running forward and downward from the umbo. In all the shells except S.12049 the anterior series of ribs is more numerous than the posterior, finer and rather irregular. In S.12047 (Pl.XXVII, figs.3a-d) the lower anterior ribs become very irregular and wavy, and approach the horizontal so that the shell has something of the appearance of Apiotrigonia. On the extreme anterior part of this shell, however, definite strong ribs again appear running at right angles to the commissure between the valves. In none of the shells in the present collection is the umbonal apex completely preserved, but in no case can concentric ribbing have persisted to such a late stage of growth as in I. vau s. str., before onset of V-ed ribbing.

In S.12046 and to a less extent in S.12048 a frontal band is developed, in both cases the ribs of the anterior series thickening at the angulation of the shell and down-warping to the horizontal. In the other two specimens the shell surface curves abruptly at the anterior end but there is no distinct frontal band, though in S.12049 there is some strengthening of the ribs near the anterior margin. In all the shells, most of the anterior ribs fail to reach the anterior commissure, near which growth rugae appear. Only S.12049 is complete enough to show the similarity to I. vau s. str. in the development of an unornamented band immediate-ly adjacent to the lower border.

In all the shells the area is smooth and separated from the flank only by a marginal fold. No concentric ribs are seen proximally passing from the flank on to the area, as in I. vau s. str., but this may be due in part to chance of preservation. In S.12046 (Pl.XXVII, fig.2d), from 2 mm. to 10 mm. from the umbo, a fine inner carina is marked by a line of delicate, transversely elongated tubercles, possibly relicts of ribs such as cross to the area from the flank in the type material. A similar feature is illustrated by Kitchin (1908, Pl.VI, fig.4b) in I. stowi (Kitchin).

The escutcheon is not visible in S.12048, but in the other shells is more elongated and depressed than in I. vau s. str., and is well marked-off from the area throughout growth, not tending to merge with it in later growth stages as in the type material.

The ligament pit in the three specimens in which it is seen is longer and narrower than in I. vau s. str.. Where seen, the hinge is similar to that of the South African material, typically megatrigoniid, but with slightly less divergent elements in S.12047 due to the slightly narrower umbonal region. In S.12046 the posterior tooth 4b is not preserved and a broken portion of tooth 3a of the right valve lies in the socket between 2b and 4a and conceals some of the detail.

Kitchin (1908) was quite clear as to the distinction between the related species I. vau (Sharpe) and I. stowi (Kitchin), both of which occur in the Uitenhage Beds of South Africa. It is reported, however, (fide Dr. S.H. Haughton) that in large communities that have been studied, every gradation between the two occurs. Kitchin (1903, p.74; 1908, p.118) gave quite adequate grounds for specific distinction between I. vau and I. stowi, but Dr. Haughton's information makes it clear that they are morphological species only. Kitchin's own remarks (1908, pp.117-118) in connection with I. stowi, that cases occur in which the anterior end is shorter than in the examples he illustrates, that the anterior down-warping of the ribs is a variable feature, and that in the antero-ventral part of the shell the ribs may be broken up into nodes, may be noted. They suggest a wide range of variation in I. stowi, in some respects towards I. vau. Also this variation is apparently no less than between the four Tanganyika specimens, which are all compared to the one species although there are distinct superficial differences from I. vau. In the elongation of the anterior end of S.12049, for example (Pl.XXVII, fig.1a), and the down-warping of the anterior ends of the ribs of the anterior series in all the specimens, characters tending towards I. stowi are apparent.

Dimensions.

	S.12046	S.12047	S.12049
Length	-	-	73.0*
Height	50.5*	48.5	45.0
Thickness	19.0	13.6	14.3
Length of anterior end	21.0	16.5	23.6
Length of escutcheon	-	-	33.6

*Estimated.

Comparison.

Kitchin (1903, 1908) has discussed the relations of I. vau to the I. v-scripta Group of Cutch and to I. kühni of southern Tanganyika. The closest relationship, he suggested, was with I. dubia of the Umia Beds of Cutch. In view of the remarks above however, quoted from S.H. Haughton on the relationship between I. vau and I. stowi, it is interesting to note Kitchin's comment (1908, p.119) that "When studied in connection with the shells of the group of Trigonia v-scripta from the Oomia Beds of Cutch, T. stowi can only be closely compared with T. v-scripta itself". Stoyanow (1949, p.79) also commented on the relations of the South African and Cutch groups, and related the American "T". cragini, "T". kitchini and "T". calderoni, and the South African "T". conocardiiformis to the group of "T". vau. The American forms however, would now be placed in the sub-genus Apiotrigonia, and "T". conocardiiformis is a Megatrigonia s. str.

The only other species to which I. vau or the Tanganyika shells that are compared to it, show considerable similarity, is I. haughtoni of the Lower Cretaceous of Zululand (and I. cf. haughtoni (q.v.) of the Tithonian of southern Tanganyika). I. haughtoni is of smaller growth, however, and is immediately distinguished by the fine anterior rib series, sub-parallel to the growth lines, and 2-3 times more numerous than the strong sub-vertical ribs of the posterior series.

Associations and Age.

Other Trigoniids associated with I. cf. vau in the Mandawa - Mahokondo area are: Indotrigonia aff. robusta sp. nov. and Opisthotrigonia curvata sp. nov. (Loc. WA.2267); Indotrigonia aff. africana sp. nov. (Locs. WA.2312, 2315); and a large Trigoniid, gen. et sp. indet. (Loc. WA.2316). Also associated are Astartids (including Seebachia janenschi at Loc. WA.2267), Gervillella, Pecten, etc. The specimens of I. cf. vau appear to be Tithonian, and older therefore than the I. vau of South Africa and the majority of species of the sub-genus.

Subgenus RUTITRIGONIA van Hoepen, 1929.

Type species: *Rutitrigonia peregrina* van Hoepen, 1929. Cretaceous, Zululand, Natal.

Van Hoepen (1929, p.31) established *Rutitrigonia* as a new genus in a new subfamily, the Rutitrigoniinae. Rennie (1936, p.355), however, regarded it as a subgenus of *Trigonia*, and Cox (1952b, p.59) considered it to be a subgenus of *Megatrigonia*. Cox stated that *Rutitrigonia* is a Cretaceous subgenus, but included in it *R. dietrichi* (Lange), which is an Upper Jurassic form.

The following are distinguished in the present collection, the first-named from the Upper Kimmeridgian, the remainder from Neocomian - Lower Aptian Beds (the *Trigonia schwarzi* Bed of the Tendaguru Series):- *R. dietrichi* (Lange), *R. bornhardti* Müller, *R. turikirae* sp. nov., *Rutitrigonia* sp., *R. schwarzi* (Müller), *R. nossae* sp. nov., *R. nyangensis* sp. nov., *R.* aff. *nyangensis*, *Rutitrigonia* spp. juv. indet., *R. krenkeli* (Lange), *R. kigombona* sp. nov.. Except for *R. schwarzi* and *R. krenkeli* described from Mozambique, these species have not been recorded outside Tanganyika.

Other species that have been described from southern Tanganyika are *R. niongalensis* (Lange) and *R. janenschi* (Lange), the status of which as separate species has been questioned (Dietrich, 1933; Hennig, 1937), and is discussed below.

1. _Megatrigonia (Rutitrigonia) dietrichi_ (Lange)
(Pl.XXVIII, figs.1-5)

Trigonia dietrichi E. Lange, 1914, p.223, Pl.XX, fig.7.

Dietrich (1933, p.32, Pl.II, figs.38-41) described shells he believed to belong to this species. He noted radial ornament on the area, observed that in the earlier stages his specimens could not be distinguished from _Trigonia (Indotrigonia) smeei_, and placed the species in the sub-genus _Indotrigonia_. Rennie (1936, p.356) regarded this assignment as justified on the basis of the early costate character. Radial ornament of the area is not described in the holotype however. Hennig (1937, p.172) accepted the assignment of the species to _Indotrigonia_, but could not accept Dietrich's figured specimens as conspecific with the holotype. He mentioned specimens in his own collection separated stratigraphically by only a few metres at the same locality, which corresponded to the forms figured respectively by Lange and by Dietrich. Cox (1952b, p.59) assigned the species to _Rutitrigonia_ which is fairly acceptable on the basis of the original description. The absence of concentric costae passing on to the area from the flank near the umbo, the marked development of the marginal angulation and the passage of the costae right across the flank throughout growth, are, however, unusual features for the subgenus, and the ornament is between that of _Pleurotrigonia_ and _Rutitrigonia_ (see also p.8). The specimens described by Dietrich could not be assigned to this subgenus on account of the radial ornament on the proximal portion of the area. One of his shells, illustrated in his Pl.II, fig.38, clearly belongs to Iotrigonia and is probably the same species as Iotrigonia dubia of his Pl.II, figs.45, 46 (see above under Iotrigonia cf. haughtoni). The taxonomic position of Dietrich's other figured specimens is questionable.

Localities and Material.

Hunterian Museum Collection: Locs. WA.1628 (S.12078-S.12082); WA.1656 (S.12077); WA.2311 (S.12076).

S.11482 (Loc. WA.1628) and S.12113 (Loc. WA.1310) are designated R. cf. dietrichi.

Geological Survey of Tanganyika Collection: Loc. WA.1628 [WA.1628(D)].

(See Appendix II).

Description.

R. dietrichi is smaller than other species of Rutitrigonia from Tanganyika, except "R. niongalensis". The shell is trigonally ovate to lunate, with umbones situated at about 1/3 of the length from the anterior end. The inflation is moderate and greatest below or just posterior to the umbones. The anterior end is strongly convex and passes smoothly into the convex lower border. The most forward point of the shell is at the middle of the anterior margin or below and the lowest point rather posterior to the umbones. The postero-dorsal margin is concave and the posterior end rounded.

The ornament of the flank is of rather narrow, approximately concentric costae with crests 2 - 3 mm. apart, varying slightly in their direction as compared with the growth lines. They are flexed down to meet the anterior margin at about right angles and extend across the whole flank to the edge of the area. The area is separated from the flank by an angulation or strong fold, dying out posteriorly, and not by an upstanding marginal carina. The area is narrow, convex and smooth and unlike other species of the subgenus, R. dietrichi shows no passage of costae proximally from flank to area. The smooth escutcheon is not separated from the area except by its relative depression. The interior is not accessible in any available specimen.

The present material corresponds fairly closely with the description and figure of the holotype, but some of the specimens are somewhat larger. Greater downward convexity or more marked undulation of costae than in the holotype is sometimes noticeable. The original diagnosis of the species states that the marginal carina is sharp and extends to the postero-ventral extremity, but the figure of the holotype suggests that the "carina" is an angulation, somewhat rounded-off after mid-growth, as in the present specimens.

Dimensions.

	L	H	T	A	E
S.12076	-	29.2	9.5	13.0	-
S.12077	42.0*	30.0*	11.0*	13.5*	-
S.12078	-	29.5	11.5	11.8	-
S.12079	41.0	29.3	9.5	12.0	17.0*
S.12080	33.8	25.3	9.5	11.1	16.0
WA.1628(D)	35.0*	28.0*	9.0	12.0	-

*Estimated.

L Length
H Height
T Thickness (one valve)
A Length of anterior end
E Length of escutcheon.

Comparison.

R. dietrichi is smaller than adults of other species of Rutitrigonia in Tanganyika. It resembles "R. niongalensis", which (see p.198) is now believed to represent the juvenile stage of R. nyangensis sp. nov. or R. nossae sp. nov. or of both of these species. In "R. niongalensis", however, the costae retreat at an early stage towards the anterior end, leaving the posterior part of the flank smooth; in the umbonal region the costae cross to the area which is not distinctly marked-off from the flank by an angulation. The same differences seem to appear in ?R. stephaninii (Venzo) from Somalia[1], which also has a less lunate shape. One

[1] According to B.H. Baker, Department of Mines and Geology, Kenya (personal communication), this form is not older than Kimmeridgian. Venzo (1949) regarded it as Bathonian.

shell (WA.1628(D) - Pl.XXVIII, fig.2), with a strong angulation between flank and area and a slight sulcus immediately in front of this angulation, is not unlike selected specimens of Laevitrigonia curta sp. nov. in lateral view, except for its much greater elongation. As Hennig (1937, p.172) pointed out, the shells figured by Dietrich (1933, Pl.II, figs.38-41) as Trigonia (Indotrigonia) dietrichi do not belong to this species. Figure 38 illustrates an Iotrigonia.

Associations and Age.

R. dietrichi was described by Lange (1914) from the "Trigonia smeei" Bed of the Jurassic portion of the Tendaguru Series. Kitchin (1929, p.210) concluded that it occurs also in the Trigonia schwarzi Bed (Cretaceous), but the view of Lange, who had access to the collections of the German Tendaguru Expedition, that it is wholly Jurassic is more acceptable. Dietrich (1933, p.32) regarded it as being characteristic of the Nerinea Bed (or the lower part of his "smeei Stage"), his highest record being from immediately above the Middle Saurian Bed. As noted above, however, Dietrich was not dealing in all cases at least, with shells of this species. Hennig's (1937) records of the species are in the Nerinea Bed and the "Trigonia smeei" Bed. All the specimens in the present collection came from above the "smeei" Oolite of the Mandawa - Mahokondo area, from Upper Kimmeridgian - Tithonian strata of about the age of the "Trigonia smeei" Bed of Tendaguru. It cannot be upheld therefore, that it is characteristic of the lowermost part of the marine strata of the Tendaguru Series.

R. dietrichi has been noted in association with shells of the Indotrigonia africana species group (Locs. WA.1628 and WA.1656); I. v-striata (Loc. WA.1628); Opisthotrigonia curvata (Loc. WA.1628); and Laevitrigonia curta (Loc. WA.1656). (See Appendix I for localities). Also observed in association have been species of Anomia, Astarte, Cucullaea, Exogyra, Lima, Modiolus, Ostrea, Pecten and Seebachia.

2. Megatrigonia (Rutitrigonia) bornhardti Müller
(Pl.XXIX, figs.1-4; Pl.XXX, figs.1-5)

Trigonia bornhardti G. Müller, 1900, p.552, Pl.XXII, figs.1-3.

Trigonia bornhardti E. Krenkel, 1910, p.210, Pl.XX, fig.9, non fig.3, (?)non fig.7.

Trigonia (Laevitrigonia) bornhardti E. Hennig, 1937, p.176, Pl.XIV, figs.1a, b.

R. bornhardti was first described from Ntandi in the south of the Mbemkuru River depression (outside the area depicted in Plate II of Part I). Dietrich (1933, p.29) pointed out that the labelling of figures by Krenkel (1910, Pl.XX) is in error: among other mistakes, Fig.9 is wrongly labelled Trigonia beyschlagi instead of Trigonia bornhardti; Fig.3 labelled T. bornhardti, was thought by Dietrich possibly to be T. schwarzi, but is now considered to represent a specimen of R. nyangensis sp. nov.; Fig.7 is not clear enough for identification, but is probably not R. bornhardti. Dietrich believed that the locality marking of the specimens in Krenkel's figure are also wrong, and stated that Niongala (the locality given for Krenkel's figured R. bornhardti) does not yield this form. Lange (1914) in his survey of Trigonia in southern Tanganyika, only mentioned R. bornhardti in reference to a first description of the related R. janenschi. Dietrich (1933, p.36) assigned the species to Laevitrigonia and this was accepted by Hennig (1937). Hennig cast doubts on the specific separation of R. janenschi and R. bornhardti and thought that R. niongalensis (Lange) represents young specimens of R. bornhardti rather than of R. schwarzi as contended by Dietrich (see also p.197). Rennie (1936, p.358) and Cox (1952b, p.59) placed the species in the subgenus Rutitrigonia.

Localities and Material.

Assigned to R. bornhardti are specimens from the following localities:-

Hunterian Museum Collection: Locs. WA.755 (S.11367 - S.11373); WA.756 (S.11374 - S.11379); WA.1653 (S.11382 - S.11392); WA.1764 (S.11465 - S.11466).

Geological Survey of Tanganyika Collection: Locs. WA.755 [WA.755(6), (9)-(26)]; WA.756 [WA.756(6), (8)-(23)]; WA.758 [WA.758(1)-(3)]; WA.1653 [WA.1653(1), (5)]; WA.2541 [WA.2541(1)].

From the following, shells of R. cf. bornhardti have been obtained:

Hunterian Museum Collection: WA.1757 (S.11467 - S.11475); WA.1762 (S.11464).

Geological Survey of Tanganyika Collection: Locs. WA.2494 /WA.2494(1)/; WA.2535 /WA.2535(1)/; WA.2539 /WA.2539(A), (B)/.

(See Appendix II).

Description.

The following description is based on specimens in the present collection, which are seldom complete, and on previous descriptions and figures.

R. bornhardti is large for the subgenus, massive, elongate, ovate to pyriform, with moderate inflation, greatest approximately below the umbones, which are usually about 1/3 of the length from the anterior end, sometimes more. The anterior end is convex, the most forward point situated below the middle of the anterior margin. The lowest point on the lower margin occurs below the umbones, and the lower margin rises gently with little curvature to the postero-ventral extremity. The postero-dorsal margin is concave, falling fairly steeply from the umbo, the short, oblique posterior margin curving into the upper and lower margins.

The flank ornament consists of fairly strong, more or less concentric, rounded costae with shallow interspaces about equal in width to the costae. The costae are parallel to the growth lines near the umbo, but in later growth are gently downwarped to a greater or less extent anteriorly. Sometimes they cross the shell obliquely forwards and downwards throughout much of its growth, but usually approach the anterior margin at about right angles. There is often some irregularity, reduction in strength and occasional intercalation or bifurcation of costae in the lower part of the flank. Adjacent to the pallial border in most well-grown shells is a band up to 15 mm. wide, smooth except for growth lines or growth rugae, which truncates the downwarped flank costae anteriorly. Near the umbo the costae pass over on to the area, but throughout most of the growth they fade out at about 2/3 to ¾ of the distance across the flank from the anterior. Müller described a furrow running down the line of termination of the costae, which has not been noted by later authors or in any specimen recently collected.

There is no marginal carina and the shell surface curves sharply into the narrow area. The angle between flank and area decreases towards the posterior where the area widens slightly. Apart from 6-8 costae close to the umbo (which are warped rearwards on crossing from the flank) the area is smooth. There is no inner carina, and the escutcheon is smooth except for 3-4 concentric ribs which encroach upon it from the area near the umbo. The escutcheon is long, rather wide, lanceolate and slightly depressed. No specimen in the present collection shows detail of the hinge and the anterior. The illustration of the holotype shows the hinge to be very massive and typically trigoniid.

Dimensions.

The following table gives the dimensions of two complete shells in the present collection, and of two figured specimens. The dimensions of a specimen of R. janenschi Lange are also given:-

	------------ R. bornhardti	----------------			R. janenschi
	Müller (1900)[1]	Hennig (1937)[2]	WA.758(1)	WA.758(2)	Lange (1914)[3]
L	110.0 mm.	108.0 mm.	102.5 mm.	98.0 mm.	110.0 mm.
H	77.0	69.0	67.0	65.5	72.0
T	21.5	32.5	23.5	23.8	24.0
A	36.0	41.0	31.0	27.7	41.0
E	--	--	41.0	41.0	40.0
H/L	70.0%	63.9%	65.4%	66.8%	65.5%
T/L	19.5%	30.1%	22.9%	24.3%	21.8%
A/L	32.7%	38.0%	30.2%	28.3%	37.3%

L Length
H Height
T Thickness (single valve)
A Length of anterior end
E Length of escutcheon.

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1. Müller, 1900, Pl.XXII, fig.1.
2. Hennig, 1937, Pl.XIV, fig.1a.
3. Lange, 1914, Pl.XIX, fig.6a.

Remarks.

Krenkel (1910, p.210) mentioned that the right valve is higher than the left, but this cannot be confirmed in the case of a double-valved specimen in the present collection [WA.758(3)], and is not apparent in the specimen figured by Hennig (1937).

There is no specimen in the present collection corresponding to R. janenschi (Lange), which is said to differ from the typical R. bornhardti in having flank costae more or less parallel to the growth lines, turning up towards the anterior margin and stopping abruptly posteriorly. The umbo is stated to be nearer the mid-point of the shell than in R. bornhardti and there is no smooth band near the lower border. Hennig (1937, pp.176, 177), however, stated that his collection from a R. bornhardti community at or near the type locality, includes specimens with various combinations of the supposedly discriminative biocharacters. Examples conforming to the holotype are stated to be most common. Hennig's figure of R. bornhardti, an outside variant, is similar to R. turikirae sp. nov., from which it differs, however, in the absence of hollowing on the less extensive smooth posterior part of the flank and in the absence of accretionary shell material near the anterior extremity. R. bornhardti and R. turikirae are thought to represent different levels in an evolving stock, and the name R. janenschi may be retained meanwhile as possibly representing another such level.

Comparison.

Certain shells from Locality WA.1653 show details of the umbonal region not previously figured, and are mentioned below (p.198) in comparison with the young stages of other species of Rutitrigonia. The good preservation of some of the shells from this locality emphasises the similarity of R. bornhardti to such examples of R. agrioensis Weaver from Argentina as have no anterior development of unribbed shell material. The similarity to R. longa (Agassiz) has been discussed by earlier authors, and Hennig (1937, p.177) has remarked on a variant corresponding to R. laevisulcata (Lycett). The differences between R. bornhardti and R. turikirae are discussed in dealing with the latter species (p. 176).

Associations and Age.

Localities WA.755 and WA.756 are on a main native track near the village of Ntandi (outside the area depicted in Plate II of Part I) in adjacent gullies apparently exposing the same stratum. This is probably the place from which Bornhardt (1900) collected the original Neocomian "Ntandi fauna" described by Müller (1900), elements of which have been discussed by Krenkel (1910), Lange (1914), Dietrich (1933) and Hennig (1937) with some nomenclatural revisions. The "Ntandi fauna" was listed by Quennell, McKinlay and Aitken (1956) under the term "Ntandi Beds". The other bornhardti localities listed contain similar but less abundant material, usually in poor preservation. Locality WA.1653 in the Runyu

Inlier to the east of the Mandawa - Mahokondo area has yielded Astarte stuhlmanni Müller, Hinnites (Prohinnites) cf. fraasi (Krenkel) and Gervilleia alaeformis (Sowerby) var. percrassa Müller of the "Ntandi fauna" to substantiate the age of the strata there.

R. bornhardti occurs in the Neocomian - Lower Aptian Trigonia schwarzi Bed, but not in association with the name form. The relation between the bornhardti and schwarzi horizons is discussed elsewhere (Part I, p.148). R. bornhardti appears to be most common in the earlier part of the Trigonia schwarzi Bed sequence, but to persist into the later part as at Locality WA.2494, where R. cf. bornhardti is associated with a fauna reminiscent of that of the Niongala area which is probably Lower Aptian (see pp.187-189).

3. Megatrigonia (Rutitrigonia) turikirae sp. nov.
(Pl.XXXI, figs.1-2; Pl.XXXII, figs.1-3; Pl.XXXIII,figs.1-4)

R. turikirae sp. nov. is closely related to R. bornhardti (and to R. janenschi if this is to be regarded as distinct) previously described from the Mbemkuru River depression. The new species is erected on the basis of two communities of shells from the Mbemkuru area.

Localities and Material.

Hunterian Museum Collection: Loc. WA.2492 (S.12138 - S.12167).

Geological Survey of Tanganyika Collection: Locs. WA.2492 [WA.2492(2), (16), (17), (24), and (34)-(62)]; WA.2565 [WA.2565(1)-(17)].

(See Appendix II).

Specimen S.12138 is designated holotype.

Diagnosis.

Shell large, massive, elongated, ovate to pyriform, moderately inflated, with greatest inflation below or posterior to the umbones. Umbones between 1/3 and ½ of the length from the anterior end, somewhat incurved, not very high. Anterior end long and rather pointed, the lower part of the anterior margin passing smoothly into the gently convex lower border, of which the lowest point lies posterior to the umbones. Antero-dorsal margin straight, sloping equally from the umbo with the proximal half of the postero-dorsal margin, which, however, becomes almost horizontal in later growth. Posterior end narrowly convex or obliquely truncated.

Flank ornamented by strong rounded costae, with inter-spaces equal to width of costae or wider. Costae concentric in earlier growth and approaching the anterior border at about right angles; in later growth almost straight, crossing the flank obliquely forwards and downwards and often angularly downwarped immediately anterior to the line of greatest convexity. There is some undulation and irregularity in later growth stages and in the final stages of old individuals costae disappear. Flank costae encroach on the area near the umbonal apex, but later terminate, sometimes rather abruptly, along an oblique line running downwards and backwards from the umbonal region, leaving about ½ of the flank smooth. The smooth part of the flank is generally slightly hollowed. Shell material at anterior end thickened, and at the anterior extremity unornamented, rugose, accretionary shell material is developed to a greater or less extent.

Area narrow, convex, smooth (except immediately below the umbo where flank ribs encroach), separated from the flank only by a fold in the shell surface, which becomes less distinct in later growth. Escutcheon large, lanceolate, nearly as wide as the area, slightly depressed; ornamented by growth lines and fine growth rugae only. Ligament pit narrow lanceolate, about 1/3 of the length of the escutcheon. Dentition massive, trigoniid, with very divergent outer cardinal teeth.

<u>Dimensions.</u>

	S.12148	S.12154	WA.2492(16)	WA.2492(24)	WA.2565(16)
Length (L)	109.0	122.0	116.0*	101.5*	119.5
Height (H)	74.5	78.0	72.5	69.0	70.5
Thickness (single valve)(T)	25.0	27.5	23.0*	23.0	27.0
Length of escutcheon (E)	46.5	56.0*	51.0*	40.0	50.0
Length of anterior end (A)	41.0	46.0	43.0	39.0	48.0
H/L	68.3%	63.9%	62.5%	68.0%	59.0%
T/L	22.9%	22.5%	19.8%	22.6%	22.6%
A/L	37.6%	37.7%	37.1%	38.4%	40.1%

*Estimated

Comparison.

The holotype of R. bornhardti differs from R. turikirae as follows:-

(a) The umbones are closer to the anterior end, which is not pointed,

(b) the posterior end is more attenuated,

(c) the flank costae are more closely spaced, essentially concentric and parallel to the lower border, and are rather less extensive posteriorly,

(d) the area is narrower towards the posterior end,

(e) there is no development of accretionary shell material near the anterior extremity,

(f) the hinge teeth are less divergent.

R. janenschi (Lange) differs in being slightly less elongate, having a rather narrower area posteriorly and in having concentric costae throughout growth, sub-parallel to the lower border, upturned at the anterior end and terminating more abruptly posteriorly. This species also lacks any development of accretionary shell material at the anterior end.

Hennig (1937, Pl.XIV, fig.1) figured as R. bornhardti a specimen very similar to R. turikirae except in the absence of hollowing of the smooth part of the flank and of accretionary shell material near the anterior extremity. The bulk of his material, however, was stated to be closer to the holotype of R. bornhardti. The few specimens of R. turikirae with relatively short anterior end and small development of accretionary shell material approach very closely to a condition which is common in R. bornhardti. Young individuals of R. turikirae and R. bornhardti would not be distinguishable (see also pp. 197-200).

As has been suggested in the case of species of Indotrigonia from lower in the Tendaguru Series, the morphological divergences in the two species (and perhaps R. janenschi) are probably due to modal shift in certain biocharacters within the same stock, presumably related to some difference in age between the species.

There appear to be no Indian, South American or South African species comparable in adult characters to R. turikirae, and the European R. laeviuscula for example, differs more from it than from R. bornhardti.

Associations and Age.

The fauna associated with R. turikirae includes:- Astarte sp. (WA.2492), A. stuhlmanni Müller (WA.2565), Gervillella sp. (WA.2492), Ptychomya sp. (WA.2492), P. robinaldina d'Orbigny var. hauchecornei (Müller) (WA.2565), Yaadia hennigi (Lange) (WA.2565).

R. turikirae occurs in the Neocomian - Lower Aptian sequence of the Tendaguru Beds, apparently low in the sequence.

4. Megatrigonia (Rutitrigonia) sp.
(Pl.XXVIII, figs.6-7).

From locality WA.2185 (S.11380 - S.11381 - see Appendix II) came two small, poorly preserved, probably immature specimens of Rutitrigonia. They are incomplete posteriorly, with flank ornament partly eroded and with little detail visible of the area and escutcheon. The general appearance is that of young specimens of R. bornhardti. To some extent they resemble ?R. stefaninii (Venzo) var. transversa from Somalia (Venzo, 1949, Pl.XV, figs.41-44), but the costae are stronger and more regularly concentric, and do not extend so far across the flank as in many examples of this species. The shell was probably more pointed posteriorly than in ?R. stefaninii. From R. dietrichi the shells differ in having less prominent umbones and in the extension of the flank costae on to the area in the umbonal region and only over the anterior two-thirds of the flank for most of the shell's growth.

The locality lies stratigraphically above beds containing Indotrigonia beyschlagi (Locality WA.2176) in the same stream section. There is no local evidence of unconformity, but there may be a disconformity below a limestone member taken as the local base of the Cretaceous (see Part I, p.91) between the Localities WA.2176 and WA.2185. The Cretaceous strata here are Neocomian or Lower Aptian, probably the former.

5. Megatrigonia (Rutitrigonia) schwarzi (Müller)
(Pl.XXXIV, figs.1-6).

Trigonia schwarzi G. Müller, 1900, p.562, Pl.XXV, figs.13,14.

Trigonia schwarzi E. Krenkel, 1910, p.211, Pl.XX, fig.10, non fig.3.

Trigonia schwarzi E. Lange, 1914, p.231, Pl.XIX, figs.4,5.

R. schwarzi was first described from the Tschikotsha Stream (a northern tributary of the Namgaru), to the west of the Litshihu Plateau in the southern coastal area of Tanganyika, but not adequately figured. (See Pl.XXXIV, fig.6 which is from Müller's (1900) Pl.XXV, fig.14. Müller's Pl.XXV, fig.13 is not recognisable as a Trigoniid.) The specimen figured in anterior view by Krenkel (1910, Pl.XX, fig.3), mistakenly labelled as Trigonia bornhardti, and thought by Dietrich (1933, p.29) possibly to be R. schwarzi, is considered more likely to be an example of R. nyangensis sp. nov.. Lange (1914) placed R. longa Agassis var. undulatostriata Paulke from South America in the synonymy of R. schwarzi, but this was not accepted by later authors (see also p.193). Dietrich (1933, pp.35, 36) assigned the species to the subgenus Laevitrigonia. He rejected Lange's distinction of R. niongalensis from it, considering this species to be based on immature specimens of R. schwarzi (but see p. 197). Dietrich's figured specimens are not accepted as R. schwarzi (see below). Hennig (1937, p.178) accepted the assignment of the species to Laevitrigonia, but believed that R. niongalensis probably represents the young stage of R. bornhardti, not of R. schwarzi. He reported R. schwarzi from near Port Amelia in Mozambique, the only recorded occurrence (apart from Lange's discounted report) outside Southern Tanganyika. Rennie (1936, p.358) and Cox (1952b, p.59) placed the species in Rutitrigonia.

"R. schwarzi" has been described by Müller (1900), Krenkel (1910), Lange (1914), Dietrich (1933) and Hennig (1937), but some at least of these authors included specimens that would now be assigned to R. nyangensis sp. nov. and R. nossae sp. nov.. The large size and the narrowness of the high umbonal region of the shells figured in interior view by Dietrich (1933, Pl.III, figs.52, 53) from Niongala, suggest that they belong to R. nossae. In the author's collection from Niongala at probably the same locality from which the figured specimens came, no examples of R. schwarzi occur, but there are specimens of R. nossae. As observed above, a specimen from this locality figured by Krenkel (1910) is probably R. nyangensis. R. nyangensis and R. nossae are associated in recent collections from the neighbourhood of the German Tendaguru Expedition locality Kigombo, from where Lange (1914) recorded R. schwarzi, which the recent collections from there do not contain. That Lange (1914) placed R. longa var. undulatostriata in the synonymy of R. schwarzi suggests that R. nyangensis had been included in R. schwarzi, since the latter has marked differences from the South American form, but R. nyangensis is very similar.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2415 (S.11348 - S.11366.

Geological Survey of Tanganyika Collection: Loc. WA.2415 /WA.2415(4), (7), (13), (17), (23)-(40).

(See Appendix II).

Description and Discussion.

Although several authors have described R. schwarzi, a further account is desirable in view of the probable inclusion of more than one species in earlier accounts.

R. schwarzi is of medium size for the subgenus, elongate, ovate to pyriform, inequilateral. It is rather inflated with maximum inflation approximately below the umbones. The umbones are fairly high, incurved, opisthogyral and placed ¼ to 1/3 of the length from the anterior end. The anterior end is strongly convex, passing smoothly into the gently convex lower border of which the lowest point is posterior to the umbo. The postero-dorsal margin is rather short and slopes gently back from the umbo and there is sometimes slight flanging of the antero-dorsal margin of the shell. The posterior margin is convex in younger growth, but later tends to be straight, rather long and oblique, the postero-ventral angle being about 90°. In anterior view, a complete specimen would have an approximately heart-shaped section. Viewed from above, the shell narrows sharply from the point of greatest convexity opposite the umbones, and the posterior part of the flank may appear slightly concave.

In early growth stages the ornament consists of fine, evenly spaced, concentric costae. The first three or four cross the area on to the escutcheon, a further six or seven cross on to the area but not on to the escutcheon, and two or three thereafter reach the marginal fold but do not encroach on the area. The remainder are confined to the anterior part of the flank, and most do not extend behind the line of greatest inflation below the umbo. The costae do not become noticeably coarser with growth, but rapidly become widely spaced, with crests about 4 mm. apart and smooth shallow interspaces. They are slightly undulating and downwarped towards the anterior end, sometimes sharply, with consequent decrease in spacing. In larger shells a small unribbed area immediately anterior to the umbo may develop. The posterior part of the flank is unornamented except for growth lines.

The area lies at a progressively greater angle to the flank with growth, and is not sharply distinguished from it, there being no marginal carina or angulation. Except in the umbonal region, it is smooth. The few costae which cross from the flank to the area are flexed backwards at the junction. The escutcheon is often very poorly demarcated from the area, but sometimes is excavated. It is smooth except in the uppermost part, where concentric costae encroach upon it from the area.

The interior of the shell has not been fully exposed in any specimen available to the writer. The hinge of one specimen in which it is partly exposed does not appear to differ significantly from that described and figured by Dietrich (1933, Pl. III, figs. 52, 53) of what is now believed to be R. nossae sp. nov., except in being less massive and less "compressed" laterally.

The immature specimens in the community of R. schwarzi from Loc. WA.2415 confirm that R. niongalensis does not represent the young R. schwarzi, which is shorter and more ovate (see also p. 197).

Dimensions.

Dimensions of typical adult specimens are:-

	S.11348	Lange, 1914, Pl. XIX, fig. 4
Length (L)	74.3 mm.	84.5 mm.
Height (H)	55.0	60.5
Thickness (1 valve) (T)	20.0	-
Length of anterior end (A)	22.4	22.5
Length of escutcheon	22.5	-
H/L	74.0%	71.6%
T/L	26.9%	-
A/L	30.1%	26.6%

Comparison.

A comparison of R. schwarzi with R. nyangensis sp. nov. and R. nossae sp. nov. is given in the accounts of these species. Confusion with adult shells of other species is unlikely to arise.

Associations and Age.

R. schwarzi is the name fossil of the Trigonia schwarzi Bed from which a very extensive fauna has been reported, which has been monographed by Lange (1914) and further described by the authors dealing with R. schwarzi itself, and by Zwierczky (1914) [see Quennell, McKinlay and Aitken (1956)]. Spath (1930, p.135; 1939, p.140) has shown that the Trigonia schwarzi Bed ranges from Hauterivian to Aptian. Much of the fauna has been described from localities from which the name fossil has not been recorded. The case for subdivision of the Trigonia schwarzi Bed is briefly presented elsewhere (Part I, p. 148) and Hennig's (1937, p.117) conclusion that R. schwarzi is (in the main) younger than R. bornhardti is supported.

The fauna found in association with R. schwarzi during recent collecting was small, consisting of Ptychomya praelonga Hennig, (?)Bakevillia sp. and Parallelodon sp., together with small gastropods. A community of Rutitrigonia krenkeli (Lange) was noted about 30 feet above that of R. schwarzi in the same section.

6. <u>Megatrigonia (Rutitrigonia) nossae</u> sp. nov.
(Pl.XXXV, figs.1-3).

(?) <u>Trigonia schwarzi</u> W.O. Dietrich, 1933, Pl.III, figs.52,53.

<u>R. nossae</u> sp. nov. is closely allied to <u>R. schwarzi</u> Müller, but is significantly different in a number of features, and is not associated with typical examples of <u>R. schwarzi</u>.

<u>Localities and Material</u>.

Hunterian Museum Collection: Locs. WA.2459 (S.11343 - S.11344); WA.2460 (S.11345); WA.2461 (S.11346 - S.11347); WA.2494 (S.11340 - S.11342).

Geological Survey of Tanganyika Collection: Loc. WA.779 /WA.779(1-5)/.

(See Appendix II).

Specimen S.11340 has been selected as holotype.

The localities represented in the Hunterian Museum Collection are all in the neighbourhood of the locality Kigombo of the German Tendaguru Expedition. Loc. WA.779 is at or near the locality Niongala of that Expedition and of the British Museum Tendaguru Expedition.

<u>Diagnosis</u>.

Shell large for the subgenus, robust, pyriform, inequilateral, well-inflated with the maximum inflation anterior to the umbones. Umbones high, between ¼ and 1/3 of the length from the anterior end, incurved, opisthogyral. Anterior end strongly convex and passing smoothly into the rather convex lower border, of which the lowest point is well posterior to the umbo. Postero-dorsal margin rather short and sometimes fairly steep. Posterior end rounded. Complete shell heart-shaped in section as viewed from the anterior end.

Ornament of rather close-spaced and not very robust concentric costae, of which the upper side is steep and the lower slopes evenly to the base of the next lower rib, giving an appearance of imbrication. Crests of costae about 4 mm. apart in adult. Ornament retreats at an early stage towards the anterior end, and for the greater part of growth is confined to that part of the flank anterior to the line of greatest convexity. Ribs sometimes down-warped sharply at the anterior, and sometimes only the short down-sloping portion remains. No marginal carina. Area set at a rather small angle to the flank throughout growth, smooth except in the region of the umbo. A median groove is sometimes visible. Escutcheon ill-defined, smooth.

Dimensions.

Dimensions of the holotype are:-

	S.11340
Length (L)	89.0 mm.
Height (H)	79.0
Thickness of a single valve (T)	30.0
Length of anterior end (A)	27.0
Length of escutcheon	31.0
H/L	88.8%
T/L	33.7%
A/L	30.3%

Comparison.

R. nossae is larger and proportionately higher than R. schwarzi, to which it has obvious similarities. The lower border is more convex; the form of the costae is different and they are closer spaced and occupy a smaller portion of the flank. The angle between the flank and the area is less than in R. schwarzi, which has no median groove. None of the available specimens is sufficiently well preserved to show detail of youthful sculpture near the umbonal apex, nor are the interior and hinge line accessible in any specimen. The large size and high, relatively narrow umbonal area of the specimens figured by Dietrich (1933, Pl.III, figs.52, 53) as R. schwarzi suggest that they belong to R. nossae. It does not seem practicable to distinguish between what may be youthful specimens of R. nossae and R. nyangensis, though the adult characters of these species are very different. It is thought that R. niongalensis (Lange) represents the young stage of one or both of these species.

Associations and Age.

The following Trigoniids have been noted in association with R. nossae:-

Rutitrigonia cf. bornhardti (Müller) (Loc. WA.2494)

R. nyangensis sp. nov. (Locs. WA.2461, WA.2462, WA.2494)

Rutitrigonia sp. juv. indet [?niongalensis (Lange)] (Locs. WA.2459, WA.2460, WA.2462)

R. kigombona sp. nov. (Locs. WA.2460, WA.2462)

Yaadia hennigi (Lange) (Loc. WA.2494).

The localities at which R. nossae has been found are in three areas, the Nossa Stream (near Kigombo), west of Mto Nyangi, and Niongala. At the last two named, collecting has been done at several neighbouring localities at or near the same horizon, and though R. nossae may not have been found at each, the fauna from them all is listed as each group of localities is regarded as virtually one. This is done to indicate the overall similarity of the faunas from the Nossa Stream and west of Mto Nyangi to that from Niongala. Fraas (1908) termed the strata there the "Niongala Beds", since included by Hennig (1914) in the Trigonia schwarzi Bed. To the list given below, therefore, may also be added the considerable fauna from the "Niongala Beds" quoted by Quennell, McKinlay and Aitken (1956) (whose lists do not take into account the nomenclatural revisions of Trigoniids made in this paper).

	Niongala	West of Mto Nyangi	Nossa Stream
Nautilus cf. mikado Krenkel	-		
N. cf. pseudoelegans Krenkel	-		
Ancyloceras sp.	-		
Astarte sp.	-	-	-
A. brancai Dietrich		-	-
Cardium (Tendagurium) rothpletzi (Krenkel)	-	-	
Corbis (Sphaera) corrugata Sowerby	-	-	-
C. (Sphaera) sp.	-		
Exogyra cf. couloni (Defrance)	-		-

	Niongala	West of Mto Nyangi	Nossa Stream
Gervillea alaeformis Sowerby var. percrassa Müller			-
Lima (Plagiostoma) euploca (Lange)		-	
Hinnites sp.	-		
Lima sp.		-	
Lopha sp.		-	
Modiolus sp.		-	
Monopleura sp.		-	
Ostrea (s. lato) sp.		-	-
Pecten (Neithea) lindiensis (Krenkel)	-		
Pholadomya gigantea (Sowerby)	-		
Pinna (Stegoconcha) sp.	-		
Ptychomya sp.	-	-	

On the basis of Ancyloceras found there, Spath (1930, p.135) gave a Lower Aptian age for the beds at Niongala, which is probably acceptable also for the strata at the other localities.

7. Megatrigonia (Rutitrigonia) nyangensis sp. nov. (Pl.XXXVI, figs.1-5).

(?) Trigonia bornhardti E. Krenkel, 1910, Pl.XX, fig.3.

Rutitrigonia nyangensis sp. nov. is in some respects similar to R. schwarzi (Müller) with which previous authors may have grouped specimens that would be assigned by the writer to R. nyangensis.

Localities and Material.

Hunterian Museum Collection: Locs. WA.778 (S.11486); WA.2461 (S.11453 - S.11454); WA.2462 (S.11456 - S.11463); WA.2463 (S.11455); WA.2493 (S.11449 - S.11451); WA.2494 (S.11452).

Geological Survey of Tanganyika Collection: Loc. WA.2462 [WA.2462(2), (3)].

(See Appendix II).

Specimen S.11453 is selected as holotype.

Diagnosis.

Shell of medium size for the genus, massive, pyriform, elongate, inequilateral, very inflated, with maximum inflation below the umbones, which are prominent, strongly incurved and situated at about 1/3 or less of the length of the shell from the anterior end. Postero-dorsal margin straight, horizontal from close behind the umbones. Antero-dorsal margin immediately in front of the umbones short, straight and horizontal, passing sharply into the bluntly convex anterior margin, which is sometimes cut away below. Anterior margin passing smoothly into the convex lower margin which rises steeply to the postero-ventral extremity. Siphonal margin very short and oblique, or the shell may be pointed posteriorly. Posterior end gaping in adult shells.

Flank occupying about 5/6 of shell's surface, flanged at the antero-dorsal edge in the adult. Flank ornament in early growth stages of fine, concentric, evenly spaced costae parallel to the growth lines which pass on to the area to about 8-10 mm. from the umbo. After this stage, the costae retreat to leave the posterior third of the flank smooth until the shell's height is about 20 mm., coarsening rapidly thereafter and retreating in front of the line of greatest inflation and disappearing altogether by mid-growth of the adult. In the adult, they are placed about 4 mm. apart, and cross the anterior end forwards and downwards from the area of greatest convexity of the surface, but are approximately horizontal over the antero-dorsal, flanged portion of the shell. They largely disappear after mid-growth of the shell, when ornament takes the form of sub-concentric folds extending to about mid-flank, or strong concentric growth rugae extending over the whole width of the flank, though more prominent anteriorly. The sub-concentric folds may be downwarped anteriorly into conformity with the direction of the costae.

Area very narrow, curving sharply into the flank, gently concave and smooth after about 8-10 mm. from the umbo except for growth lines. Flank ribs in early growth are deflected backwards on crossing to the area, but swing sharply forward at its mid-line. Escutcheon well defined in young individuals; long lanceolate, smooth, depressed, as wide as the area; partly obscured by thickening of marginal shell material in later stages. Ligament groove lanceolate, rather wide, with strong nymphal plates; about half the width of the escutcheon. Hinge teeth rather large, strongly divergent, trigoniid, tooth 3b curving almost to the horizontal below the postero-dorsal margin.

Dimensions.

	S.11453	S.11457
Length (L)	81.0	75.0
Height (H)	59.0	57.8
Thickness (1 valve) (T)	26.0	25.0
Length of anterior end (A)	26.0	30.4
Length of escutcheon (E)	30.0*	23.5*
H/L	72.8%	77.0%
T/L	32.1%	33.3%
A/L	32.1%	40.5%

*Estimated.

Comparison.

R. nyangensis bears some resemblance to R. schwarzi. It is similar in adult size, but has a narrower area placed more nearly at right angles to the flank; the shell is more pointed posteriorly, and the lower margin rises more steeply to the rear; the vertical transverse section of the shell is more evenly convex; the anterior, horizontal extension to the straight hinge margin and the antero-dorsal flanging of the shell surface are more prominent. The figure given by Krenkel (1910, Pl.XX, fig.3), mistakenly labelled Trigonia bornhardti and thought by Dietrich (1933, p.29) possibly to represent R. schwarzi, is probably R. nyangensis.

More striking than the resemblance to R. schwarzi is the likeness of R. nyangensis to the shell described from South America by Paulke (1903, p.291, Pl.XVII, fig.1) as Trigonia longa Agassiz var. undulatostriata. This was placed by Lange (1914, p.231) in the synonymy of R. schwarzi, a grouping that is not accepted by the writer. In suggesting the synonymy, Lange obviously had in mind specimens which would now be assigned to R. nyangensis, but Paulke's figure suggests that even specimens of R. nyangensis which do not show strong antero-dorsal flanging of the surface, could be distinguished by the horizontal extension of the hinge margin anteriorly. Moreover, although Paulke's specimen is probably not fully mature, the absence of growth rugae on the lower flank suggests a difference from R. nyangensis.

R. nyangensis also resembles R. agrioensis (Weaver) from Argentina (Weaver, 1931, p.226, Pl.27, figs.142-146). In this species, however, the flanged anterior part of the flank is unribbed, being marked only by growth rugae; the flank costae extend further to the rear and do not have the downward and forward sweep of those in R. nyangensis. The South American species has a more obvious marginal angulation, and the ligament groove is smaller than in R. nyangensis.

There appears to be no means of distinguishing youthful specimens of R. nyangensis and R. nossae, and "R. niongalensis" probably represents the youthful stage of one or both of these.

Associations and Age.

The associations and age of R. nyangensis are as described for R. nossae sp. nov. with which it is generally associated.

8. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov. (Pl.XXXVII, figs.1-5).

A community of youthful specimens together with fragments of adults from a large boulder apparently from strata at about the local base of the Cretaceous, are related to R. nyangensis.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2499 (S.11439 - S.11448).

Geological Survey of Tanganyika Collection: Loc. WA.2499 [WA.2499(4), (9), (13)-(18)].

(See Appendix II).

Description and Discussion.

The almost complete specimens are small, pyriform, well inflated but apparently immature. The detail of form and ornament is much as in young specimens of R. nyangensis s. str., but differences are:- the sub-rostrate posterior end; the well developed marginal fold extending to the postero-dorsal extremity; the smaller inclination of the area to the flank towards the posterior end; the hollowing of the smooth posterior part of the flank. No almost complete specimen is as large as any example of R. nyangensis s. str. showing growth rugae on the flank. Fragmentary portions of larger specimens show something of this character, however (Pl.XXXVII, figs.3 & 4).

Cox (1952b, p.58) observed that there is a considerable similarity between the Triassic genus Prorotrigonia and certain species of Rutitrigonia. This community of small immature shells here assigned to R. aff. nyangensis emphasises this superficial likeness. The few fragments of larger specimens showing adult features like R. nyangensis s. str., as well as the well-preserved detail of concentric costae near the umbonal apex, and the broad depressed escutcheon, serve to distinguish the community as belonging to Rutitrigonia.

Dimensions.

	S.11439	S.11440
Length (L)	31.5 mm.	36.0 mm.*
Height (H)	23.0	26.0
Thickness (1 valve) (T)	9.5*	10.0
Length of anterior end (A)	11.5*	11.5
Length of escutcheon (E)	13.8	14.7
H/L	73.0%	72.2%
T/L	30.2%	27.8%
A/L	36.5%	31.9%

*Estimated.

Associations and Age.

The only associated lamellibranch species to have been noted are Rutitrigonia cf. krenkeli and Astarte stuhlmanni, both forms which occur in the Neocomian - Lower Aptian succession of the area. Gastropod fragments are also present. The shells were found in a large boulder presumably derived from an outlier of Lower Cretaceous strata that would be presumed to belong to the lower part of the Neocomian - Lower Aptian sequence.

9. Megatrigonia (Rutitrigonia) spp. juv. indet.
(Pl.XXXVII, figs.6-12).

A number of immature specimens of Rutitrigonia from the following localities cannot be specifically identified:-

Hunterian Museum Collection: Locs. WA.2459 (S.12168 - S.12173); WA.2460 (S.12174 - S.12176); WA.2462 (S.12177 - S.12179).

Geological Survey of Tanganyika Collection: Locs. WA.779 [WA.779(6)]; WA.2459 [WA.2459(4), (10)-(28)]; WA.2460 [WA.2460(3), (6)-(9)]; WA.2462 [WA.2462(9) - (13)].

(See Appendix II).

With the possible exception of WA.779 the localities are all at much the same horizon. R. nossae is present at all except WA.2462, where R. nyangensis occurs. The specimens are assumed to belong to one or other of these species, which although there are strong divergencies in later growth, appear to be indistigηuishable in the young stages.

The specimens cannot be distinguished from "R. niongalensis (Lange)" which is discussed below.

The Status of "Rutitrigonia niongalensis (Lange)" and the Discrimination of Immature Specimens of Megatrigonia.

Lange (1914, p.232) described "R. niongalensis" as a distinct species of small growth, comparable in size to R. dietrichi. Dietrich (1933, p.35) considered that it represents the young stage of R. schwarzi, but Hennig (1937, p.179) thought it more likely to be the young stage of R. bornhardti.

The R. schwarzi community from Locality WA.2415 contains both young and mature specimens, and confirms that the young R. schwarzi differs from "R. niongalensis" (see Pl. XXXV, figs.4-5). The young R. schwarzi is less pointed posteriorly, shorter and less inflated than "R. niongalensis", and the lower border does not rise abruptly towards the posterior end as in this form. The area is wider and less steeply inclined to the flank; the escutcheon in the young R. schwarzi is often barely distinguishable, not wide and impressed as in the other form. When the shell is about 15 mm. high the flank costae have become noticeably wider spaced than in "R. niongalensis", and have retreated to the anterior part of the flank. In "R. niongalensis" they cross the zone of greatest inflation below the umbones to a later stage of growth.

No specimen of R. bornhardti as small as R. niongalensis is available or figured, but specimen S.11383 (Pl.XXX, figs. 5a-c) from Loc. WA.1653 is not much larger and though incomplete, allows comparison. The umbones of the young R. bornhardti are less prominent, the flank costae slightly wider apart at the equivalent stage and the inflation of the shell is less. In horizontal section (ie. viewed from above) R. bornhardti is smoothly curved on the flanks, while in "R. niongalensis" there is strong inflation opposite the position of the umbones, and posteriorly the section narrows sharply, the flanks becoming concave (see Lange, 1914, Pl.XX, fig.6). The same comments apply in comparing M. (Rutitrigonia) sp. (p.178, Pl.XXVIII, figs.6-7) with "R. niongalensis". "R. niongalensis" occurs typically at the German Tendaguru Locality at Niongala from which R. bornhardti is not reliably reported.

Some of the specimens described above (p.196) as Rutitrigonia spp. juv. indet., which are considered to be young examples of R. nyangensis or R. nossae or of both are indistinguishable from "R. niongalensis". Since adult shells of these two species have been described from the Niongala area (though previously assigned to R. schwarzi), it is probable that the original "R. niongalensis" represents the young stage of one or both of them.

In the earliest stages of growth, it is not possible to distinguish definitely between different species of Rutitrigonia, and distinction is not practicable even between the young of different subgenera of Megatrigonia. For example, Stoyanow (1949, pp.80-82) has observed that the young stages of M. (Megatrigonia) conocardiiformis and M. (Apiotrigonia) cragini are identical (see p.147). Observation of specimens in the present collection of M. (Megatrigonia) conocardiiformis (Pl.XXVI, figs.3b, 4b; see also Kitchin, 1903, Pl.VII, fig.2), M. (Iotrigonia) cf. vau (Pl.XXVI, fig.5b) and M. (Rutitrigonia) nyangensis (Pl.XXXVI, fig.4b), in none of which the concentric costae of the umbonal region cross from the area on to the escutcheon, suggests that they would be indistinguishable in their youngest stages.

In the great majority of cases ornament in the neanic stage of species of Megatrigonia (s. lato) consists of concentric costae crossing from the flank with slight backward flexure on to the area, and thence to the escutcheon. The costae crossing the escutcheon are fewer than those crossing the area. In fairly early growth, the costae usually terminate even before crossing the whole width of the flank in Rutitrigonia. The numbers of costae on each section of the shell vary, and exceptionally (as apparently in R. dietrichi), no costae cross from the flank to the area in the umbonal region. Costae have not been noted on the escutcheon in R. dietrichi, R. nyangensis, R. nossae, and R. turikirae, but are present in R. bornhardti, R. schwarzi and R. krenkeli (see below). In the other subgenera of Megatrigonia the stage at which the flank ornament changes from concentric costae to the form characteristic of the adult, is different in different species.

10. Megatrigonia (Rutitrigonia) krenkeli (Lange)
(Pl. XXXVIII, figs. 1-4).

Trigonia krenkeli E. Lange, 1914, p.231, Pl. XX, fig. 2.

Trigonia (Rutitrigonia) pongolensis J.V.L. Rennie, 1936, p.359, Pl. XLI, figs. 5, 6; Pl. XLII, figs. 5-7.

The holotype, a lone, ill-preserved specimen, was described as probably derived from the Trigonia schwarzi Bed of the Mbemkuru Valley area in Southern Tanganyika. Dietrich (1933, p.31) described the species from two further localities (without illustration), one in the Mbemkuru Valley area and one in the Namgaru Valley not far to the south; none of the specimens described was complete.

Dietrich (1933) placed the species in the subgenus Indotrigonia, regarding it as "a morphological continuation of the evolution of Trigonia smeei - in simplification of the sculpture, reduction and coarsening of the ribs".[1] This

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[1] Author's translation.

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concept was held to support his opinion that "T. (Indotrigonia) smeei" is confined to the Upper Jurassic; he had already cast doubts on previous reports of its occurrence in the

Trigonia schwarzi Bed of the Tendaguru Series.

Rennie (1936, p.358) considered that the concentric ribbing in the neanic stages is of such a character in both pongolensis and krenkeli as to exclude them from Indotrigonia in spite of adult similarities and stated that the early loss of concentric ribbing in the area "would point to a remoteness in the supposed relationship between this species and T. smeei which is difficult to reconcile with the fact that T. smeei is known to persist into the zone of T. schwarzi". Accepting the late occurrence of "Indotrigonia smeei" at the same stratigraphical level as R. krenkeli reported by Lange, he argued that this could not therefore be derived from "Indotrigonia smeei". This interpretation obviously conflicts with Dietrich's.

In support of the assignment of krenkeli and pongolensis (which are not now considered distinct - see below) to Rutitrigonia, Rennie observed that "The association .... with Rutitrigonia seems justified for the following reasons: the anteriorly rounded and posteriorly produced form; the concentric, smooth costae confined in the adult to the flank; the smooth, moderately wide area without carinae; the narrow escutcheon; the neanic ornament of concentric ribs which pass on to the area".

Cox (1952b, p.59) accepted the association of pongolensis and hence presumably also of krenkeli with Rutitrigonia, and this is followed here. However, the justification of

Rennie's doubts of the correctness of the assignment is also recognised; the shape, nature of the flank ornament and the development of a frontal face are not characteristic of this subgenus. At a later stage it may be desirable to consider erection of a new subgenus to accommodate such forms as R. krenkeli and possibly the somewhat similar R. picteti Coquand of the Upper Aptian of Spain and (?)Aptian of Somaliland. The relation of such species to the subgenus Jaworskiella Leanza, which Cox (1952b, p.57) placed in the genus Myophorella Bayle, will require consideration.

The Zululand species R. pongolensis Rennie was founded on only two specimens, not well preserved, and the figured specimens can be matched in the only large community known from Tanganyika. The differences Rennie cites between the holotypes of R. pongolensis and R. krenkeli (the former having the ventral and dorsal margins more nearly parallel and the latter with a more steeply inclined area) are very slight, and in view of the overlap now demonstrated between them, there seems no reason to retain both. It cannot be shown whether the Tanganyika and Zululand forms differ markedly in age.

Localities and Material.

Hunterian Museum Collection: Loc. WA.2416 (S.12025 - S.12035).

Specimens S.12044 (Loc. WA.2466) and S.12045 (Loc. WA.2499) are designated R. cf. krenkeli.

Geological Survey of Tanganyika Collection: Loc. WA.2416 [WA.2416(2), (6), (14)-(31)].

(See Appendix II).

Description.

Only damaged and fragmentary specimens of R. krenkeli have been described before, and a further account of almost complete shells now available seems justified.

The shell is of medium size for the subgenus, massive, quadrangular, strongly inequilateral and moderately inflated, with prominent, high umbones placed at about $\frac{1}{4}$ of the length from the anterior end. The anterior border is strongly convex, and passes smoothly into the less strongly convex lower border, of which the lowest point is posterior to the umbo. The postero-dorsal margin slopes back at a moderate angle from the umbo and forms an obtuse but distinct angle with the long oblique posterior margin, which joins the lower border in a sharp curve. The area lies at right angles to the flank near the umbo, and remains rather steeply inclined to it until later growth. The escutcheon is about half the width of the area and is long and lanceolate in shape. No marginal carina is present, but a form of inner carina is made by thickening at the edge of the escutcheon of transverse ribs which near the umbo cross from the flank to the area and then to the escutcheon.

The flank comprises between 2/3 and $\frac{5}{6}$ of the surface of the shell and is ornamented by very coarse, widely spaced, smooth, more or less concentric costae. These are not parallel to the growth lines, rising steeply towards the posterior end except in the later growth stages when they approach the direction of the growth lines. Distally, too, they become less regular and less robust especially towards the posterior. The flank ribs do not usually quite reach the anterior margin except in late stages of growth. A narrow, flattened frontal face is developed. In early growth stages the flank costae pass over the sharp angulation of the shell surface on to the area. About 8-10 ribs usually do so, but the inner portion of the area may have traces of more than this number, not distinguishable immediately adjacent to the flank. A median furrow is present in the upper part of the area, effecting a shallow V-ing of the ribs of the area with apex towards the umbo. The furrow lies dorsally to the centre of the area, and dies out on the almost smooth later part, where it can be traced only as a slight hollow. Only traces of growth lines mark this portion of the area. The escutcheon is long, slightly concave, and is smooth for the most part, except that the first 3-4 concentric costae pass across the area on to it, to reach the postero-dorsal margin. The hinge and the interior of the shell are not exposed in any available specimen.

Dimensions.

Dimensions of typical specimens are:-

	S.12025	S.12027
Length (L)	73.4 mm.	55.4 mm.
Height (H)	57.0	40.0
Thickness (T)	19.0	15.2
Length of anterior end (A)	19.8	10.7
Length of escutcheon	31.5	21.3
H/L	77.7%	72.2%
T/L	25.9%	27.4%
A/L	27.0%	19.3%

Comparison.

The only species likely to be confused with R. krenkeli is R. kigombona sp. nov. (see p.206) which differs only in its greater elongation, with resultant parallelism of the ventral and postero-dorsal margins, and the presence of an almost unornamented portion at the posterior end of the flank. Both would seem certainly to belong to the same stock. Otherwise, the nearest species to R. krenkeli is R. picteti Coquand from the Upper Aptian of Spain and (?)Aptian of Somaliland, in which the flank costae are of the same pattern, but finer.

Age and Associations.

Locality WA.2416 lies about 30 feet above an horizon yielding R. schwarzi. It is not far below Makonde Beds, which may, however, rest unconformably on the marine strata.

Locality WA.2466 is in the same neighbourhood and slightly higher. Specimen S.12045 (R. cf. krenkeli) was derived from a loose boulder, along with shells of R. aff. nyangensis sp. nov.. Associated lamellibranchs at Locality WA.2416 include Astarte sp. and Ptychomya praelonga Hennig. The occurrence is in the upper part of the marine Lower Cretaceous sequence of the area (the Trigonia schwarzi Bed) and is probably Lower Aptian.

10. Megatrigonia (Rutitrigonia) kigombona sp. nov.
(Pl.XXXVIII, figs.5a-c).

From two adjacent localities in the Kigombo area shells close to, but not conspecific with R. krenkeli (Lange) have been collected, which have been named R. kigombona sp. nov.

Localities and Material.

Hunterian Museum Collection: Locs. WA.2460 (S.12036); WA.2462 (S.12037 - S.12043).

(See Appendix II).

Description.

The shell is identical with that of R. krenkeli (see p.200) except for its greater elongation and the presence of an almost unornamented portion at the posterior end of the flank. The more elongated shape gives rise to a greater parallelism of the ventral and postero-dorsal margins than in R. krenkeli, since the length and attitude of the posterior margin is much the same in both species.

Dimensions.

	S.12037	S.12039	S.12042
Length (L)	88.7 mm.	90.8 mm.	87.7 mm.
Height (H)	60.5	61.7	58.9
Thickness (one valve)(T)	20.0	23.0	20.0
Length of anterior end (A)	20.5	20.5	18.8
Length of escutcheon	30.8	34.0	32.0
H/L	68.2%	67.9%	67.2%
T/L	22.6%	25.3%	22.8%
A/L	23.1%	22.6%	21.4%

Associations and Age.

Trigoniids noted actually in association with R. kigombona, which is known only from two adjacent localities, are R. nyangensis sp. nov., R. nossae sp. nov. and Rutitrigonia sp. juv. indet. (= "R. niongalensis"); and Lima (Plagiostoma) euploca (Lange), Astarte sp., Monopleura sp. and belemnites also occur. The strata are those discussed in connection with the other species of Rutitrigonia mentioned (see especially pp.187-189) and the stratigraphical significance of the group of Trigoniids as a possible means of subdividing the Neocomian/Lower Aptian strata of the area is discussed elsewhere (Pt.I, p.148 et seq.). It is thought they belong to a fairly high horizon in the strata, probably in the Aptian.

6. Genus LINOTRIGONIA van Hoepen, 1929.

Type species: Linotrigonia linifera van Hoepen, 1929. Lower Cretaceous, Zululand, Natal.

Van Hoepen (1929, p.15) described Linotrigonia as a genus of a new sub-family the Pterotrigoniinae, which comprises most of the Scabrae. Rennie (1936) did not accept van Hoepen's new subfamily and thought the distinctions made between some of the included genera are of little significance. Cox (1952b, p.60) retained Linotrigonia as a separate genus representing the shorter and more compressed forms once included in the Scabrae, but combined all the other genera of the "Pterotrigoniinae" in the genus Pterotrigonia. He distinguished the sub-genera Linotrigonia s. str. and Oistotrigonia Cox. The present collection contains only the former. Kobayashi and Tamura (1955, p.89) assigned Linotrigonia to the Clavellatae Section of the Myophorellinae, along with Yaadia Crickmay non Cox and Myophorella. Kobayashi (1956, p.5) described Linotrigonia as "a Myophorella having diagonal costellae on the area". As elsewhere in this paper, Cox's classification has been retained. No specimen that would now be assigned to Linotrigonia has hitherto been described from East Africa.

Linotrigonia (Linotrigonia) sp.
(Pl.XXV, figs.4,5).

Linotrigonia is represented in the collection by only two specimens from a single locality.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2498 (S.11480 - S.11481).

(See Appendix II).

Description and Discussion.

Both specimens are small and incomplete. The elevation of the umbo, the narrowness of the area and the apparent narrowness of the posterior end distinguish the specimens from Oistotrigonia, though the oblique costellae of the area in chevron arrangement with the flank costae are present over all the visible extent of the area. The full shape and dimensions of the specimens cannot be estimated. S.11481 appears to have been only about 11.5 mm. in height, but may not have been mature. The specimens differ from any of the Zululand forms described by van Hoepen (1929) in their smaller size, greater prominence and extent of the oblique costellae of the area and greater downward convexity of the flank costae, which are more concentric in the upper part of the shell. They appear to differ little from L. forbesii (Lycett) from India except in the greater downward convexity and less regular tuberculation of the flank costae, and again probably, in smaller size.

The specimens are associated with Rutitrigonia nyangensis in the Neocomian - Lower Aptian sequence of the area.

7. Genus LAEVITRIGONIA Lebkücher, 1932.

Type species: Trigonia gibbosa J. Sowerby, 1819, Portlandian, England.

Cox (1952b, p.62) gave Laevitrigonia generic status, while previous authors had regarded it as a subgenus of Trigonia. Venzo (1942, p.17) discussed the stratigraphical and geographical distribution of Laevitrigonia and listed the species to be assigned to it. From Tanganyika, following Dietrich (1933) and Hennig (1937), he included the species schwarzi Müller, bornhardti Müller and janenschi Lange, which have since been shown by Rennie (1936, p.358) and Cox (1952b, p.59) to belong to Rutitrigonia. The species stefaninii Venzo from Somalia [Kimmeridgian or later fide B.H. Baker, Department of Mines and Geology, Kenya, not Bathonian as stated by Venzo (1949)], the only other species hitherto assigned to Laevitrigonia from the East African area, appears also to be a Rutitrigonia. Venzo also placed spissicostata Kitchin from the Umia Beds of Cutch in Laevitrigonia, and it is to this form that the species L. curta sp. nov. described from Tanganyika is most comparable. Cox (1952a, p.116; 1952b, p.62) also assigned the Cutch species cardiniiformis Kitchin and trapeziformis Kitchin to the genus as well as meridiana Woods from New Zealand. Kobayashi and Mori (1954, p.162) placed Laevitrigonia along with Psilotrigonia and Liotrigonia in the Laevitrigonia Section of the subfamily

Trigoniinae of Kobayashi (1954). However, they regarded the species from the Indo-Pacific area placed by Cox in the genus, as belonging to a new genus Eselaevitrigonia of the Indotrigonia Section of the sub-family. As elsewhere in this paper, Cox's (1952b) classification is followed.

1. Laevitrigonia curta sp. nov.
(Pl.XXXIX, figs.1-5).

Laevitrigonia curta sp. nov. belongs to the Indo-Pacific group of species, which differs in some respects from European species.

Localities and Material.

Hunterian Museum Collection: Locs. WA.1477 (S.12021); WA.1656 (S.12022 - S.12023); WA.1779 (S.12024).

Geological Survey of Tanganyika Collection: Loc. WA.1779 [WA.1779(1)].

(See Appendix II).

Hunterian Museum specimen S.12023 (Pl.XXXIX, figs. la-c) is designated holotype.

Diagnosis.

Shell trigonally ovate, moderately inflated, with somewhat concave, steeply sloping postero-dorsal margin; inequilateral, with well elevated and incurved, slightly opisthogyral umbones placed about 1/3 of the length of the shell from the anterior end. Posterior margin short, oblique.

Marginal angulation well defined throughout growth, slightly sigmoidal. No upstanding marginal carina, nor inner carina.

Area narrow, sometimes slightly convex and set at right angles to the flank to rather less than mid-growth stage; there is then a sudden and progressive increase in the angle, though it never becomes very obtuse. A faint median groove and radial striation are sometimes present on the area. Escutcheon of moderate length and usually well impressed, with well marked, curved, radial grooving usually present. Flank displays a flat, generally smooth, somewhat depressed ante-carinal space, to which there corresponds a sulcus in the pallial border. Ante-carinal space delimited anteriorly on a slightly curving line downwards from the umbo, defined by local upward inflection and swelling of the posterior ends of the costae. In the adult shell this line cuts the pallial border between one quarter and one third of the length from the postero-ventral angle. In later growth some encroachment of the costae may occur on to the ante-carinal space. Anterior portion of the flank decorated with generally concentric but slightly irregular and sometimes undulating, rounded costae, which curve upwards and thicken near the ante-carinal space. Inter-costal spaces less than width of costae. Occasionally a slightly developed frontal face is present, never well defined.

Hinge (left valve only seen) typically trigoniid, resembling that of Trigonia s. str., with dominant massive bifid central cardinal tooth 2, strong cardinal 4a and weak cardinal 4b.

Dimensions.

	L mm.	H mm.	T mm.	A mm.	E mm.	H/L	A/L	T/L	No. of ribs in 25 mm. below umbo.
S.12023	31.5	29.5	10.5	13.5	15.0	93.7%	42.9%	33.3%	14
S.12021	31.0	28.0	11.0	11.4	14.5*	90.3%	36.8%	35.5%	17
S.12022	-	30.0	8.8	10.3	14.5*	-	-	-	15
S.12024	29.3	25.0	9.0	10.0	15.5	85.0%	34.1%	30.7%	15

L - Length
H - Height
T - Thickness (one valve)
A - Length of anterior end
E - Length of escutcheon.

* Estimated.

Further Description and Discussion.

L. curta is unlike the usual *Laevitrigonia* in possessing curved radial striae on the escutcheon, which is normally smooth in this genus. The same feature appears to a less extent in *Opisthotrigonia curvata* sp. nov.. In specimens where the costae are more regular the resemblance of *L. curta* to the new *Opisthotrigonia* is striking except in respect of the shorter figure and the rather less opisthogyral growth. According to Cox's (1952b) classification *curta* is to be assigned to *Laevitrigonia*, but it forms a link between this genus and *Opisthotrigonia* making their separation a matter of some doubt.

Kobayashi and Mori (1954, p.161) suggested that the Indo-Pacific species of "Laevitrigonia" developed independently from the European stock and that spissicostata, the form to which curta bears most resemblance, is in fact closer to Opisthotrigonia than to Laevitrigonia. With T. meridiana Woods as genotype and including spissicostata, they erected the genus Eselaevitrigonia which differs from Laevitrigonia in the continuation of the irregular concentric costae across the ante-carinal depression. Kobayashi and Mori have therefore reached a somewhat similar conclusion to that arrived at above concerning the relationship of shells of the same type as L. curta to Opisthotrigonia, but as usual, Cox's classification is followed.

Comparison.

L. curta most resembles L. spissicostata (Kitchin), but it is smaller, the area is more steeply inclined to the flank proximally, the ante-carinal space is less concave and the costae more regular. L. spissicostata does not have the radial striae on the escutcheon as in L. curta, or the traces of radial ornament on the area in addition to the median groove.

Associations and Age.

L. curta occurs in Tithonian strata above the "smeei" Oolite in the Mandawa - Mahokondo area, and has been found in association with shells of the I. africana species group and with Megatrigonia (Rutitrigonia) dietrichi. Other associated lamellibranchs include species of _Astarte_, _Corbis_, _Modiolus_ and _Pecten_.

8. Genus OPISTHOTRIGONIA Cox, 1952.

Type species: Trigonia retrorsa Kitchin, 1903. Tithonian, Cutch, India.

Cox (1952b, p.62) described Opisthotrigonia as a monotypic genus resembling Laevitrigonia, but with a distinct sickle shape. Earlier (Cox, 1952a, p.116) he had assigned the type species to Laevitrigonia (regarded as a subgenus of Trigonia). Kobayashi and Mori (1954, p.162) placed Opisthotrigonia in the Indotrigonia Section of the sub-family Trigoniinae of Kobayashi (1954), but as elsewhere in this paper, Cox's classification is followed. A new species O. curvata is now described from southern Tanganyika. A photograph of a specimen of O. retrorsa (Kitchin) from the Blake Collection in the British Museum (Natural History) is given for reference and comparison (see Pl.XXXIX, figs.6a,b).

1. Opisthotrigonia curvata sp. nov.
(Pl.XL, figs.1-7).

Except for a marked difference in adult size, O. curvata differs from the type species only in rather minor features.

Diagnosis.

Shell trigonal, moderately inflated, very inequilateral, and somewhat sickle-shaped, with strongly concave posterodorsal margin, and the posterior end drawn out and very obliquely truncated. Umbones high, well incurved and moderately or strongly opisthogyral, usually placed about ¼ of the length from the anterior end, but sometimes at over 1/3. Marginal carina well defined in earlier growth, but becoming rounded later; escutcheon carina of variable prominence; both carinae smooth and strongly curved. Area narrow, sometimes slightly convex, and as far as mid-growth set at little more than a right angle to the flank. After mid-growth it rapidly becomes less steeply inclined and the marginal carina degenerates into a smooth fold. Radial costellae occur on the proximal part of the area and a median groove extends further than the other radial ornament. Escutcheon large, well impressed, sometimes with curved radial grooves. Ligament pit lanceolate, not very long.

Flank displays a broad, flat, somewhat depressed ante-carinal space, delimited anteriorly by a curving line from the umbo defined by local upward inflection of the posterior ends of the flank costae. The lower edge of the ante-carinal space which is generally smooth, but with some encroachment of the flank costae in later growth, occupies about half the pallial border of the shell. Anterior part of the flank ornamented with rather fine, sub-concentric, generally regular costae with inter-costal spaces about equal in width to the costae. A flattened frontal face, developed to a varying extent, is separated from the remainder of the flank by a well defined angulation at which the flank costae are inflected and often enlarged. Slight lunule occasionally developed. Hinge (left valve only observed) typically trigoniid, resembling that of Trigonia s. str., with dominant massive bifid central cardinal tooth 2, strong cardinal 4a and weak cardinal 4b.

Localities and Material.

Hunterian Museum Collection: Locs. WA.961 (S.11985 - S.12004); WA.1627 (S.12019 - S.12020); WA.1628 (S.12005 - S.12015); WA.2179 (S.12016); WA.2267 (S.12017 - S.12018).

Geological Survey of Tanganyika Collection: Loc. WA.961 /WA.961(d), (q), (t)/. WA.961(30) is determined as O. cf. curvata.

(See Appendix II).

Hunterian Museum Specimen S.12005 (Pl.XL, figs.1a-d) is designated holotype.

Dimensions.

In almost all cases, the extreme posterior part of the shell is not preserved. However, only nearly complete specimens have been measured for purposes of comparison. It happens that the largest of the available specimens is nearly complete.

	L mm.	H mm.	T mm.	A mm.	E mm.	H/L	A/L	T/L	No. of ribs in 25 mm. below umbo.
S.11985	43.0	27.0	10.0	14.5	18.5	62.8%	33.7%	23.3%	16
S.11991	46.0*	29.3	10.5	11.0	24.0	63.7%	23.9%	22.8%	16
S.11995	46.0	27.0	9.0	11.0	21.5	58.7%	23.9%	19.6%	16
S.12005	54.0*	36.3	13.2	19.0	24.0	67.2%	35.2%	24.5%	15
S.12015	53.0*	34.5	10.5	17.0	25.0	65.9%	32.1%	19.8%	15

L - Length
H - Height
T - Thickness (one valve)
A - Length of anterior end
E - Length of escutcheon.

* Estimated.

Further Description and Discussion.

Variation in the form of the anterior end of the shell is dependent on the development of the flattened frontal face. The profile of the commissure between the valves is invariably a convex curve. This curve is concealed to a greater or less extent in the lateral view of the anterior end, which is modified by the form of the angulation bounding the flattened frontal face. The ridge formed on the angulation may be due almost entirely to the thickening of each rib at the angulation, or the direction of growth of the shell wall may be mainly responsible. On the flattened frontal face the costae sometimes die away, leaving a smooth area adjacent to the anterior border of the shell. The ribbing on the frontal face varies, usually passing horizontally across the upper part of the face (if present there), and in later growth sloping progressively more steeply downwards, or the ribs may have the appearance of radiating from the mid-point of the anterior margin.

Across the main part of the ribbed portion of the flank, the costae are generally regular and sub-parallel to the slightly convex pallial border. Any obliquity of ribbing occurs in the upper part of the shell and any irregularity in the lower posterior part of the ribbed portion. An elongated node is usually developed, where each rib is inflected upwards towards its termination, on the slope from the ribbed portion of the flank to the relatively depressed, smooth ante-carinal space. The later ribs may encroach on the ante-carinal space. The shape of the pallial border reflects the upward inflection of the costae, the lower of which are sometimes crowded in larger specimens.

The few ribs encroaching on the ante-carinal space in some specimens may be in direct extension of those on the anterior part of the flank. In some instances, however, they start as new ribs opposite interspaces between flank costae, or occupy this position, but are connected to the rib above or below on the anterior part of the flank.

The dentition has been examined only in the holotype (Pl.XL, fig.1b). This is the left valve of a well-grown individual with strongly opisthogyral umbones and a long anterior end. There is a general posterior inclination of the teeth, apparently associated with the opisthogyral growth. The posterior limb of the strongly bifid tooth 2 of this specimen is broken, but apparently tapered off below the posterior pedal retractor muscle scar.

Comparison.

Apart from the smaller adult size, other differences which serve to distinguish O. curvata from the type species are as follows:-

1) The height/length ratio is less (the available measurements for Cutch specimens from illustrations and from certain specimens from the Blake Collection, give the values 69%, 73%, 74%, 74.4%, 69.5% approximately).

2) The posterior end of the shell is more pointed since the short posterior margin is strongly oblique. Only in one specimen has the posterior extremity a somewhat rostrate appearance.

3) There is a sharper break in the pallial border at the point corresponding to the inflection of the flank costae in front of the ante-carinal space.

4) Passage of costae unaltered from the anterior part of the shell on to the ante-carinal space is more common in O. curvata. In O. retrorsa the costae that do cross on to the ante-carinal space tend to fuse together giving the appearance of growth rugae.

5) The umbones are sometimes placed at over one third of the length from the anterior end, while in O. retrorsa they are stated to be always less. This can be confirmed in the case of three measured specimens from the Blake Collection.

6) It is not clear that in O. curvata the proportionate length decreases with age after mid-growth as in O. retrorsa.

7) In O. curvata the escutcheon is always narrower than the area.

8) Curved radial grooves on the escutcheon have been observed on a few specimens of O. curvata, but not in O. retrorsa.

9) No specimen of O. curvata has been noted with the inflation so great as in the specimen of O. retrorsa figured by Kitchin (1903, Pl.VII, fig.2).

Associations and Age.

At Locality WA.961, O. curvata has been found in association with Virgatosphinctes cf. communis Spath, determined by Dr. W.J. Arkell (in litt. to W.G. Aitken, 30 Sept. 1952) and dated as Tithonian, probably slightly younger than the "Trigonia smeei" Bed of Tendaguru.[1] All the specimens of O. curvata occur above the "smeei" Oolite in the Mandawa - Mahokondo area, and are probably of this age. The species has been found accompanying most of the other Trigoniids of the Tithonian of the area: T. (Indotrigonia) africana (or aff. africana) (Locs. WA.961, 1628, 2179); T. (Indotrigonia) robusta (or aff. robusta) (Locs. WA.961, 2267); T. (Indotrigonia) aff. beyschlagi (Loc. WA.2179); T. (Indotrigonia) v-striata (Loc. WA.1628); Megatrigonia (Iotrigonia) cf. vau (Loc. WA.2267); M. (Rutitrigonia) dietrichi (Loc. WA.1628).

Other associated lamellibranchs include: Arcomya robustissima Dietrich (Loc. WA.961); Astarte krenkeli Dietrich (Loc. WA.2179); Corbis (Sphaera) subcorrugata Dietrich (Loc. WA.961); Cucullaea eminens Cox (Loc. WA.961); Seebachia janenschi Dietrich (Locs. WA.1628, WA.2267); cf. Thracia incerta Agassiz and species of Anomia, Astarte, Exogyra, Gervillea (Gervilliella), Hinnites, Lima, Modiolus, Ostrea and Pecten.

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1) See footnote Part I, p.91.

9. "TRIGONIA" s. lato.

Trigoniid gen. et sp. indet.
(Pl.XLI, figs.1a-d).

A single incomplete specimen of a large Trigoniid appears to be distinct from any previously described.

Locality and Material.

Hunterian Museum Collection: Loc. WA.2316 (S.12120).
(See Appendix II).

Description.

The shell is large, ovately trigonal, massive, somewhat elongated, inequilateral and rather compressed. The anterior margin is convex, passing in a smooth curve into the convex lower border. The flank occupies about 2/3 of the surface of the shell and is ornamented by rounded, massive, concentric costae parallel to the growth lines and broken into elongated segments in late growth. The interspaces are about equal to the width of the costae. The costae, which usually broaden posteriorly, curve upwards sharply to meet the anterior border, crossing a narrow, ill-defined frontal face. They terminate, with rounded ends, at the edge of the area. The surfaces of the flank and area are not separated, there being no marginal carina or fold. To about ½ of the full growth of the shell the area is ornamented by wide, smooth, rounded, transverse costellae, rather less robust, closer spaced and less sharply defined than the flank costae, and ending towards the flank in a small swelling. The separation of the ends of the flank costae and the costellae of the area gives the effect of a marginal groove. After about ¼ of the full growth of the shell, the costellae degenerate into faint growth rugae on the otherwise smooth surface of the area. The hinge is very massive, but ill-preserved and only recognisable as of general trigoniid pattern.

It is not clear to what genus the shell could best be assigned. The reconstruction suggested from observation of the growth-lines indicates a shape reminiscent of Indotrigonia. The flank ornament and the relation of the transverse costellae of the area to the flank costae, together with the development of a frontal face, would be consistent with this assignment. No species of Indotrigonia is known, however, on which the costellae of the area do not persist throughout growth. Since the flank ribs are separated from the transverse costellae of the area by a groove, close relation to Rutitrigonia is unlikely.

Pl.XLI, fig.1a shows a tentative reconstruction of the complete outline of the shell (on which are based the measurements given below). The figure also indicates the outline of the broken-off hinge teeth, and as well as showing the strong adductor muscle scars, shows a wide groove on the inner posterior surface, presumably corresponding to the position of the siphons.

Dimensions.

Length	115.0 mm.	(very approximately)
Height	92.0 mm.	" "
Thickness (one valve)	26.5 mm.	
Length of anterior end	28.0 mm.	

Associations and Age.

Although the specimen was obtained from a loose boulder, this was certainly local. The same boulder yielded a specimen of Iotrigonia cf. vau and strata in the immediate vicinity have yielded Indotrigonia africana, Gervillella sp. and Astarte sp., and the age is Tithonian.

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APPENDIX I

LOCALITY LIST 1)

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1)

The list includes localities mentioned in the text, together with localities of fossils deposited in various Museums or with various authorities as follows:

A - Ammonites B - Belemnites	Sedgwick Museum, Cambridge: determinations by Dr. W.J. Arkell, F.R.S., Dr. A.G. Brighton and Dr. C.W. Wright.
L - Lamellibranchs	Hunterian Museum, Glasgow: Astirisk indicates that the collection includes Trigoniids dealt with in Part II.
G - Gastropods	British Museum (Natural History): with Dr. L.R. Cox, F.R.S.
Br - Brachiopods	British Museum (Natural History): with Dr. H.M. Muir-Wood.
C - Corals	British Museum (Natural History): with Dr. H.D. Thomas
E - Echinoids	Hunterian Museum, Glasgow: with Dr. E.D. Currie.

P - Localities in Pindiro Shales yielding gastropod and lamellibranch fossils: British Museum (Natural History): determinations by Dr. L.R. Cox, F.R.S.

I. MANDAWA-MAHOKONDO AREA (see Plates III and XV)

"WA" No.	Locality
793a A,L	Pt.13/14 Mandawa-Namakongoro Stream. (=WA.812; = WA.2001).

"WA" No.	Locality	
794 G	Just downstream of WA.793 (not in situ)	
796 A	Near Pt.42 Lonji Path	
801*L	Pt.19 Mkomangoni Tributary "B".	
803 L	80 feet upstream Pt.4 Mandawa-Namakongoro Stream.	
806 L	Cliff at Pt.9	-ditto-
812* L,G,Br	Pt.13/14 (= WA.793; = WA.2001).	-ditto-
817 G	Pt.21/22	-ditto-
820 L	Pt.23/24	-ditto-
821 L	Pt.23/24	-ditto-
822 L	Pt.26	-ditto-
823 A,G	Pt.26	-ditto-
826* B,L,Br	Pt.70	-ditto-
828* A,L,Br	Pt.71	-ditto-
831 A,L,G,Br	Pt.80	-ditto-
832 A	Pt.80	-ditto-
834*L	Pt.81	-ditto-
835* A,B,L,G,Br	Just upstream Pt.81	-ditto-
855* L,G	Pt.19 Mkomangoni Tributary "B"	
868 L	Pt.16 Kikundi Stream	
869 L	Near Pt.16 -ditto-	
878* L	Pt.22/23 -ditto-	
881 A	Pt.25/26 -ditto-	
924* L	Pt.23/24 Nchia traverse.	
934 L	Pt.10 Mkomangoni Tributary "A".	

"WA" No.	Locality
938* L	Pt.19 Mkomangoni Tributary "A".
939 L	Pt.19 -ditto-
940* L	Pt.22 -ditto-
942 C	Pt.23/24 -ditto-
943* L	Mkomore Stream just west of Manyuli village
944 A,L,G	About 100 yrds. W. of Pt.1, Lindi-Kilwa Road (N) I traverse.
946 C	Near Pt.18 Kikundi Limestone Traverse I.
948 L,C	Various points (between Pt.18 and Pt.30) on Kikundi limestone Traverse I.
961* A,L,E	Just west of Pt.62 Mkomangoni Tributary "C" Traverse extension. (= WA.2261).
963* L,C	Just downstream Pt.14 Mkomangoni Stream.
967 C	Pt.40 -ditto-
971* L,G,Br	Below Pt.4, Nchia Traverse. (= WA.1006).
979* L	Near Pt.22 -ditto-
982 A,B,L,G,Br	Pt.23/24 -ditto- (= WA.1004;= WA.1182).
992 L	Pt.29 -ditto-
993 L	Pt.29 -ditto-
1002 L	Pt.39 -ditto-
1004* A,B,L,G,Br	Pt.23/24 -ditto- (= WA.982)
1005 A,L,G	Pt.25 -ditto- (= WA.1180)
1006 A,L	Below Pt.4 -ditto- (= WA.971)
1007	Near Pt.5 -ditto-
1008 B,L,Br	Pt.24 -ditto-
1009 A	100 yds. at 210° from Pt.18 -ditto-

"WA" No.	Locality
1010 A,L	Near Pt.46 extension of Lindi-Kilwa Road (South) Traverse. (= WA.1152).
1011 A	Near Pt.35 Lonji Path
1152 A,B,L,G,C	Near Pt.46 extension of Lindi-Kilwa Road (South). (= WA.1010).
1156 G	Pt.51 -ditto-
1159 A	Near Pt.11F Telegraph Line (South)
1180* A,L,G	Pt.25 Nchia Traverse (= WA.1005)
1181 L,Br	Pt.24 -ditto-
1182 L,Br	Pt.23/24 -ditto- (= WA.982; = WA.1004)
1183 A	Pt.23/24 -ditto- 5 yds. upstream WA.118
1186 A	Pt.12/12F Lonji-Runjo Stream
1189 Br	Pt.13 -ditto-
1191* L	Near Pt.13 -ditto-
1194 L	Pt.14/14F -ditto-
1195 A	Pt.14F -ditto-
1201 L	Near Pt.18F -ditto-
1205 B	Near Pt.19 -ditto-
1213 L	Pt.21F -ditto-
1216* A,L,Br	25 yards short of Pt.12F -ditto-
1217* A,L,Br	Near Pt.13 -ditto- (= WA.1191)
1218* A,L	Pt.13/13F -ditto-
1219* B,L	Pt.13/13F -ditto-
1220* A,L,G,Br	Pt.13/13F -ditto-
1221 B	Pt.13/13F -ditto-

"WA" No.	Locality		
1226* A,L,Br,E	Pt.26 Lonji-Runjo Stream		
1229 A,L	Pt.27/27F	-ditto-	
1232 A	Pt.27/27F	-ditto-	
1242* L	Pt.38F/39	-ditto-	
1245* L	Near Pt.40F	-ditto-	
1248 L	Pt.41F/42	-ditto-	
1252* L	Near Pt.43	-ditto-	
1254 A,L,G	Pt.43F	-ditto-	
1255 L	Pt.44	-ditto-	
1256 L	Pt.44	-ditto-	
1257 L	Pt.44	-ditto-	
1258 Br	Near Pt.44	-ditto-	
1259* L	Just upstream Pt.44	-ditto-	
1261* B,L,Br	Just upstream Pt.45	-ditto-	
1263 B,L,Br	Pt.46F	-ditto-	
1264 A,L	Upstream Pt.47	-ditto-	
1265* L	150 feet upstream of Pt.14 Kikundi Stream		
1266 L	Pt.1F Lonji Stream		
1267 A	Pt.4F	-ditto-	
1273 L	Just upstream Pt.10	-ditto-	
1274 C	Near Pt.10	-ditto-	
1275 L	Pt.10F/11	-ditto-	
1276 L	Pt.10F/11	-ditto-	(Band above WA.1275)
1282 L	Pt.14	-ditto-	

"WA" No.	Locality
1284 L,G	Pt.14 Lonji Stream
1287 L,G	Pt.15F/16 -ditto-
1290 L,Br	Near Pt.19 -ditto-
1292* L	Pt.19/19F -ditto-
1293 L	Near Pt.20 -ditto-
1294 L,C	Pt.20F/21 -ditto-
1296	Pt.21F/22 -ditto-
1297 L	Near Pt.22F -ditto-
1298* L	Mahokondo-Manyuli path, near Pt.11 Upper Mkomore Traverse.
1310 L	Pt.4F Lihimaliao Stream I
1317 A	Pt.6F -ditto-
1322* L	Pt.16F Telegraph Line Traverse(south)
1323* L	Near Pt.16F -ditto-
1335 L	Pt.23/23F -ditto-
1338 L	Pt.23/23F -ditto-
1342 B,L,G	Pt.6F Lonji Stream
1343 L,Br	Pt.10 -ditto-
1344 L,Br	Pt.10F -ditto-
1345 L,G,Br	Pt.14 -ditto-
1346* A,L,G	Pt.15F -ditto-
1348	Pt.8/8F Njenga Path
1371 L	S. of Pt.22 Njenga Path midway up slope of Matiriro Ridge.
1381* L	Pt.41 Njenga Path Traverse (Lihimaliao Stream).

"WA" No.	Locality
1390* L	Pt.9 Namakambi-Lonji Path
1443 L	Near Pt.26F Mahokondo-Mitole Path
1474* L	Near Pt.15F Kimbarambara Stream
1477* L	Near Pt.16 -ditto-
1479* L	Near Pt.17 -ditto-
1483* L	Near Pt.17F -ditto-
1510* L	Pt.4F Lihimaliao Stream I
1516* L	Pt.1 Ngirito Stream (Lower)
1519* L	Pt.1F -ditto-
1591* A,L,Br	50^{x}N. of Pt.23 Namakumbira-Manyuli Path.
1592 L	-ditto- (above WA.1591)
1593 L,Br	-ditto- (above WA.1592)
1594 A,L	-ditto- (above WA.1593)
1595 A,C	Pt.24 Namakumbira-Manyuli Path
1598 L	Pt.41 -ditto-
1603 L	Pt.11 Ngirito oolite Traverse.
1613 L	Near Pt.8 Nambango Stream
1627* L	Mpilepile Stream just upstream of Pt.5 Kikundi limestone Traverse (North) II. (= WA.1691)
1628* A,L,G	Pt.18/19 Nambango Stream (= WA.2003)
1629 L	Pt.12F Mbaru oolite Traverse
1634* A,L,G,Br,E	Pt.2F/3 Mbaru Stream Traverse I
1653* B,L,G,C	Pt.23F Ngirito-Runyu Traverse
1654	Pt.25F -ditto-

"WA" No.	Locality
1656^{x} L	Pt.1 Ngirito Stream (Lower)
1665 C	Pt.4 Njenga Road (West)
1676^{x} L	Near Pt.17F -ditto-
1680 L	100 yards S. of Pt.20 Njenga Path
1681 L	-ditto-
1683 A	300 yards at 26° from Pt.20 Njenga Path
1691 G,Br, E	Mpilepile Stream just upstream Pt.5 Kikundi Limestone (North) II. (= WA.1627)
1699 L	Pt.4F Mpilepile Stream
1705^{x} A,L,Br	Pt.32 Telegraph Line (North)
1706^{x} A,L,Br	Just short of Pt.42 -ditto-
1707 L	300^{x} upstream Telegraph Line crossing of Manyuli Stream
1710 L	Near Pt.42 Lonji Path
1715 L	Namakambi Stream, 200 yards upstream of Lonji Path crossing
1720	Pt.7F Njenga Limestone Traverse I
1723 A	100 yards East of Pt.17F -ditto-
1738 A	Near Pt.25 Njenga Path
1740^{x} L	Above Pt.4F Lihimaliao Stream II
1742 L	End of side traverse from Pt.5F Namakambi Path
1743 L	Pt.3 Traverse 27F Njenga Path to 20F Njenga Road. (West)
1746 C	Matiriro area, base of oolite sequence 1150 yds. SE. of crossing of this junction over Njenga Road.
1751 Br	Matiriro area, base of oolite sequence 650 yds. SE. of crossing of this junction over Njenga Road

"WA" No.	Locality
1753 C	Matiriro area, base of oolite sequence 450 yds. SE of crossing of this junction over Njenga Road
1757* L,G,Br	Pt.6F Nloweka Stream (Upper)
1759 L,Br	Pt.8F -ditto-
1762* L	Pt.8F -ditto-
1763 L	Pt.8F -ditto-
1764* L	Pt.9F -ditto-
1767 Br	Pt.10 -ditto-
1772 L	Pt.1 Kindole-Mikaramu Traverse
1774 L	Pt.23/23F Njenga Path
1775 A,L,Br	Near 4F Lihimaliao Stream II
1779* L,C	Pt.4F Lihimaliao Stream IV
1781 C	Pt.4F -ditto-
1782* A,L	Pt.5 -ditto-
1788 L	Pt.11 -ditto-
1791 L	Near Pt.4 -ditto-
1799	South side of Namarombe Hill
1802 L,Br	Pt.1 Lihimaliao Stream II
1804* L,Br	Near Pt.1 -ditto-
1806* L	Near Pt.1 -ditto-
1810* L,G,Br	Pt.1F -ditto-
1812 L,G,Br	Pt.3 -ditto-
1813 A,L,Br	Pt.3F -ditto-
1815* L,Br	Pt.4 -ditto-
1816	Pt.5/5F -ditto-

"WA" No.	Locality
1817* A,L,G,Br	Pt.5/5F Lihimaliao Stream II
1818 A,L,Br	Pt.9F -ditto-
1825	Pt.4F on Traverse west from Pt.7 Mikaramu Path
1826* L	Near Pt.5 -ditto-
1847 L	Pt.4 Lihimaliao Stream III
1850 L	Pt.4F/5 -ditto-
1852* L	Pt.6 -ditto-
2001 B,L,G	Pt.13/14 Mandawa-Namakongoro Stream. (= 793, = 812)
2002* L	As 2001 but 15 feet above
2005 L,C	Pt.18/19 Nambango Stream (= 1628)
2013 L,G,Br	Pt.47F Nchia Traverse
2014 Br	Pt.48F -ditto-
2015 L,Br	Pt.48F/49 -ditto-
2016* A,L,Br	Pt.48F/49 -ditto-
2019* A,B,L,Br	Near Pt.51 -ditto-
2024 Br	Near Pt.56F -ditto-
2033 G	Near Pt.31 Kikundi Stream
2044 A	Near Pt.1 Namitambo Stream
2046 Br	Pt.3F -ditto-
2051	Near Pt.8 -ditto-
2053 A	Pt.9F -ditto-
2064 B,L	Pt.17F Mitole-Mkomore Stream
2068 L	Near Pt.21 -ditto-

"WA" No.	Locality
2100 B	Pt.29F Namtama Limestone
2108 L,G	Pt.3/3F Upper Mkomore Traverse
2115 L	Near Pt.4 -ditto-
2117 L	Pt.5 -ditto-
2123 L	Pt.8F/9 -ditto-
2125 L	Pt.8F/9 -ditto-
2127 L	Pt.9 -ditto-
2129 L	Near Pt.10 -ditto-
2130 L	Pt.11F -ditto-
2140* L	Pt.13 Mahokondo Stream
2148* L	Pt.18F/19 Mkundi Stream (Upper)
2149 L	About ¾ mile W. of Pt.15 Lonji Firebreak
2150	About ¾ mile W.of Pt.8 -ditto-
2151 Br	Near Pt.15 Mkundi Stream (Upper)
2153 L	Pt.18F -ditto-
2154* A,L	Pt.19 -ditto-
2155 L	Near Pt.6F Lonji Firebreak
2158 G	Near Pt.21 -ditto-
2159 A,L,G	Pt.84F Manyuli Stream
2160 L	Pt.74F -ditto-
2161* A,B,L,C	Pt.30 -ditto-
2162 L,G,Br	Pt.23 -ditto-
2164 Br	Pt.15 Mkundi Stream (Upper)
2169 Br	Pt.9 Nalweke Stream
2172	Pt.14F -ditto-

"WA"No.	Locality
2176* L	Pt.20F Malwehe Stream
2177 L	Pt.20F -ditto-
2179* L	Pt.24F -ditto-
2180 A,L	Pt.26F -ditto-
2185* L	Pt.14F -ditto-
2187 B	Pt.8/8F Upper Nunga Traverse
2188	Pt.8F -ditto-
2189* L	Pt.8F -ditto-
2190 L	Pt.9/9F -ditto-
2192 L	Near Pt.12 -ditto-
2193 L	Near Pt.12 -ditto-
2194* L	Near Pt.12 -ditto-
2195* L,Br	Near Pt.12 -ditto-
2196 Br	Near Pt.1F of traverse South from Pt.5 Malwehe Path.
2203 A,L,Br,C	Pt.2F Manyuli Stream
2204 A,B,L,C	Pt.3 -ditto-
2205 L	Pt.5 -ditto-
2209 L	Pt.13F/14 -ditto-
2215 L	Pt.16F -ditto-
2218* L,Br	Near Pt.18F -ditto-
2219* A,L,Br	Pt.19 -ditto-
2220 A,L,Br	Pt.20F -ditto-
2221* L,Br	Pt.20F -ditto-
2222 Br	Pt.21/21F -ditto-

"WA" No.	Locality	
2223 C	Near Pt.23 Manyuli Stream	
2225* L,Br	Near Pt.24	-ditto-
2226 A,L	Pt.24/24F	-ditto-
2227* A,L,Br	Pt.28	-ditto-
2228 L,Br	Pt.29F	-ditto-
2229* L	Pt.33	-ditto-
2230 L,Br	Pt.34	-ditto-
2244* L,G	Near Pt.60	-ditto-
2245 A,L	Pt.8F Nunga Stream	
2246* L	Pt.6	-ditto-
2247 A	Pt.3	-ditto-
2252 L	Pt.79F Manyuli Stream	
2255 L,G	Pt.84F	-ditto-
2257 B,L	Pt.10	-ditto-
2258 B,L,G,Br	Pt.2F Nunga Stream	
2259* A,L,Br	Pt.3	-ditto-
2260 L	Near Pt.3	-ditto-
2261 L,G	Just west of Pt.62 Mkomangoni Tributary "C" Traverse extension (= WA.961).	
2266* L,C	Pt.4 Closing Traverse N.oolite-Kiwawa	
2267* L,G	Pt.6F	-ditto-
2268C	Pt.3F/4	-ditto-
2286 L	Pt.2 Namakumbira Stream	
2292 G	Pt.17	-ditto-
2293 Br	Pt.27/27F	-ditto-
2294 L	Pt.27/27F	-ditto-

"WA" No.	Locality
2295 B	Pt.30F Namakumbira Stream
2296 L,G,Br,C,E	Pt.31F -ditto-
2297* L	Pt.31F -ditto-
2298 A,L,G	Pt.33F -ditto-
2302* A,L,C	Pt.14 Mkomore Tributary I
2303* A,L	Pt.5F Mkomore Tributary II
2304 L	Pt.10F -ditto-
2307 A,Br	Pt.21 Namakambi Stream
2308 A	Near Pt.22 -ditto-
2309* A,L,Br	Pt.22F -ditto-
2311* L	Pt.10 Lonji (Nandenga) Stream
2312* L	Pt.12 -ditto-
2313* L	Pt.21 -ditto-
2315* L	Pt.13/13F -ditto-
2316* L	Near Pt.22 -ditto-
2326	In gully just West of Pt.1 Lihimaliao Scarp Traverse
2328* L,Br	800 ft. WSW. of Pt.39 Lindi-Kilwa Road (South)
2329	-ditto-
2330* L	Pt.7 Lihimaliao Scarp Traverse
2331 L	30 yards south of Pt.16 Namakambi Path Traverse
2337 A,L	Eastermost part of Mirumba cultivated area
2349 L,G,P	Near 12F Mbaru Stream II.
2377 P	Pt.24F Namakumbira Tributary

"WA" No.	Locality
2378 P	Pt.26 F Namakumbira Tributary
2583 L	1.6 miles from Njenga Road on Firebreak to south
2539	Near Pt.40 Kikundi Stream
2540	Near Pt.35 -ditto-
2541	Near Pt.40 -ditto-
2542	Near Forest Reserve Boundary west of Mkomore
2548	Minor tributary stream between Mpilepile and Kikundi streams (Mitole area) about 1 mile east of Lindi-Kilwa road.
2549	-ditto-
2550	-ditto-

II. NORTHERN LINDI AND SOUTHERN KILWA DISTRICTS OUTSIDE MANDAWA-MAHOKONDO AREA

"WA" No.	Locality
582	Kilangalanga Stream, 100 yards west of Mtapaia-Ruangwa road about 2 miles from Mtapaia
584 E	Niongala (? German Tendaguru Expedition Locality) (= WA.778)
585	Niongala, about 100 yards NE. of WA.584 (= WA.777)
698* L	600 feet downstream from road in Nachihawi (N) Stream (Matapwa)
755* L	Nambango-Ntandi path, 1st stream gully before Ntandi
756* L	Nambango-Ntandi path, 2nd stream gully before Ntandi
758	Kikotwa area, between Nambango and Ntandi
765 B,C	Tingutinguti Stream near Tendaguru, 100 yds. upstream of waterhole

"WA" No.	Locality
766	Tingutinguti Stream near Tendaguru, 60 yds. upstream of waterhole
767	Tingutinguti Stream near Tendaguru, 100 yds. downstream of waterhole
768 L	Tingutinguti Stream (Tendaguru) 100 yds. downstream of waterhole
777 Br	Niongala, about 100 yds. NE. of WA.584 (= WA.585)
778* L,E	Niongala (? German Tendaguru Expedition Locality).(= WA.584)
779 L	Niongala Gully SE. of WA.778
781 L	Kilangalanga Stream, 100 yds. west of Mtapaia-Ruangwa road ca.2 miles from Mtapaia
1838* L	Ruawa-Mikarawanje Path 1,000 feet south of crossing of Ruawa River (= WA.2544)
2273 P	½ mile east of Bwatabwata Village, Makangaga-Ruawa area
2274* L,G	North of Ruawa-Mikarawanje Path at entrance to East-West valley west of the Ruawa Stream
2275 P	Ruawa-Mikarawanje Path at western end of alluvial flat of east-west valley west of the Ruawa Stream
2305* L,G	Nangororo area, East of Tunduru Village, S. Kilwa District
2359 L	Near west end of cultivated area on path _via_ valley N. of Mtande Village to Fire-break
2361	East end of old inhabited area of Lihange
2369 L	200 ft. below summit of Nahumba Hill on ENE. flank
2404* L	250 yds. N. of Mtande-Makangaga path on W. side of watershed between Kikundi Tributaries and Mtande

"WA" No.	Locality
2412* L	On Forest Reserve Boundary 650 yards east of Runjo Stream
2415* L	Gully joining Makumba Stream (at SE. of Itukuru) at base of steep falls in stream
2416* L	As WA.2415 but 30 ft. above
2459* L	Just S. of Old Lindi-Kilwa Road on descent to 1st stream W. of cultivation area near Mto Nyangi
2460* L	100 yards N. of old Lindi-Kilwa Road on east side of 1st stream W. of cultivation area near Mto Nyangi
2461* L	150 yards N. of WA.2460
2462* L	300 yards N. of WA.2460
2463* L	Just below WA.2462
2466* L	Near top of steep rise in Makumba Stream
2488 L	Turikira Stream 400 yards upstream of crossing of Makangaga-Mtande path
2491	Midway up steep section of Makumba Stream (at SE. of Itukuru)
2492* L	West of the highest point on Turikira Ridge, 50 feet below top
2493	On elephant track West from highest point on Turikira Ridge, 165 feet below top.
2494* L	Nossa Stream (Kigombo area) 300 yds. upstream in east fork
2496* L	Eastern end of scarp and dip slope feature just east of Kihimbwi/Mbemkuru confluence
2498* L	North bank of Mbemkuru River where it cuts low hills at E. end of the Makangaga swamp area
2499* L	West slope of Tunduru Village hillock just north of path from village to river

"WA" No.	Locality
2500	About midway between Mchinjiri and Mtapaia on road
2533	On road at east end of Nambango-Ndondonga Ridge
2534	Western end of scarp and dip-slope feature just east of Kihimbwi/Mbemkuru confluence
2535	1¼ miles ESE. of Kihimbwi/Mbemkuru confluence
2536	-ditto-
2542*	Near Forest Reserve boundary west of Mkomore
2544*	Ruawa-Mikarawanje path, 1000 feet south of crossing of Ruawa River (= WA.1838)
2545*	North of Ruawa-Mikarawanje path at entrance to east-west valley west of the Ruawa Stream (= WA.2274)
2547*	Immediately east of Lake Mbuo, near top of first rise
2556*	Southern end of Kikundi escarpment in gully near Mbemkuru flats
2558	On Forest Reserve boundary near south end of Kikundi escarpment, above Mbemkuru flats
2559	100 yds. south of Matapwa/Mchinjiri road fork on path to Mbambala Hill
2560	Near base of steep rise up northern side of Mbambala Hill
2562	Near top of steep rise up northern side of Mbambala Hill
2563	Top of steep rise up northern side of Mbambala Hill
2565	300 yds. north of road just east of Mtapaia Village
2580	Lindi-Kilwa road, ½ mile south of the Mandawa River crossing

APPENDIX II.

LOCALITY LIST OF TRIGONIIDAE FROM SOUTHERN TANGANYIKA

A. HUNTERIAN MUSEUM COLLECTION

Hunt. Mus. No.		Locality	Identification
S.11340 - S.11342	WA.2494	Nossa Stream (Kigombo area) 300 yards upstream in east fork	Megatrigonia (Rutitrigonia) nossae
S.11343 - S.11344	WA.2459	Just S. of Lindi-Kilwa Road on descent to 1st stream W. of cultivation area near Mto Nyangi	-ditto-
S.11345	WA.2460	100 yards N. of old Lindi-Kilwa Road on east side of 1st stream W. of cultivation area near Mto Nyangi	-ditto-
S.11346 - S.11347	WA.2461	150 yards N. of WA.2460	-ditto-
S.11348 - S.11366	WA.2415	Gully joining Makumba Stream (at SE. of Itukuru) at base of steep falls in stream	Megatrigonia (Rutitrigonia) schwarzi
S.11367 - S.11373	WA.755	Nambango-Ntandi path, 1st stream gully before Ntandi	Megatrigonia (Rutitrigonia) bornhardti
S.11374 - S.11379	WA.756	Nambango-Ntandi path, 2nd stream gully before Ntandi	-ditto-
S.11380 - S.11381	WA.2185	Pt.14F Naiwehe Stream	Megatrigonia (Rutitrigonia) sp.
S.11382 - S.11392	WA.1655	Pt.25F Ngirito-Runyu Traverse	Megatrigonia (Rutitrigonia) bornhardti
S.11393 - S.11438	WA.801	Pt.19 Mkomangoni Tributary "B"	Megatrigonia (Iotrigonia) cf. haughtoni
S.11439 - S.11448	WA.2499	West slope of Tunduru Village hillock just north of path from village to river	Megatrigonia (Rutitrigonia) aff. nyangensis
S.11449 - S.11451	WA.2498	North bank of Mbemkuru River where it cuts low hills at E. end of the Makangaga swamp area	Megatrigonia (Rutitrigonia) nyangensis
S.11452	WA.2494	Nossa Stream (Kigombo area) 300 yards upstream in east fork	-ditto-
S.11453 - S.11454	WA.2461	150 yards N. of WA.2460 (see S.11345)	-ditto-
S.11455	WA.2463	Just below WA.2462	-ditto-
S.11456 - S.11463	WA.2462	300 yards N. of WA.2460 (see S.11345)	-ditto-
S.11464	WA.1762	Pt.8F Nloweka Stream (Upper)	Megatrigonia (Rutitrigonia) cf. bornhardti
S.11465 - S.11466	WA.1764	Pt.9F -ditto-	Megatrigonia (Rutitrigonia) bornhardti
S.11467 - S.11475	WA.1757	Pt.6F -ditto-	Megatrigonia (Rutitrigonia) cf. bornhardti
S.11476 - S.11478	WA.2494	Nossa Stream (Kigombo area) 300 yards upstream in east fork	Yaadia hennigi
S.11479	WA.2140	Pt.13 Mahokondo Stream	Trigonia (Trigonia) sp. (2)
S.11480 - S.11481	WA.2498	North bank of Mbemkuru River where it cuts low hills at E. end of the Makangaga swamp area	Linotrigonia (Linotrigonia) sp.
S.11482	WA.1628	Pt.18/19 Nambango Stream (=WA.2003)	Megatrigonia (Rutitrigonia) cf. dietrichi
S.11483	WA.2154	Pt.19 Mkundi Stream (Upper)	? Myophorella (Myophorella) sp.
S.11484	WA.2195	Near Pt.12 Upper Nunga Traverse	? Prosogyrotrigonia sp.
S.11485	WA.963	Just downstream Pt.14 Mkomangoni Stream	? Yaadia sp.
S.11486	WA.778	Niongala (? German Tendaguru Expedition Locality) (=WA.564)	Megatrigonia (Rutitrigonia) nyangensis
S.11520 - S.11556	WA.971	Below Pt.4 Nchia Traverse (=WA.1006)	Trigonia (Indotrigonia) mandawae
S.11557 - S.11576	WA.793	Pt.13/14 Mandawa-Namakongoro Stream (=WA.812, = WA.2001)	-ditto-

Hunt. Mus. No.		Locality	Identification
S.11577 - S.11582	WA.1852	Pt.6 Lihimaliao Stream III	Trigonia (Indotrigonia) mandawae
S.11583	WA.2002	As WA.793 but 15 feet above (see S.11557)	-ditto-
S.11584	WA.2189	Pt.8F Upper Nunga Traverse	-ditto-
S.11585	WA.1676	Near Pt.17F Njenga Road (West)	-ditto-
S.11586	WA.2148	Pt.18F/19 Mkundi Stream (Upper)	Trigonia (Indotrigonia) cf. africana
S.11587 - S.11696	WA.1628	Pt.18/19 Nambango Stream (=WA.2003)	Trigonia (Indotrigonia) africana
S.11697 - S.11711	WA.961	Just west of Pt.62 Mkomangoni Tributary "C" Traverse extension (=WA.2261)	Trigonia (Indotrigonia) robusta
S.11712 - S.11715	WA.961	-ditto-	Trigonia (Indotrigonia) aff. robusta
S.11716 - S.11717	WA.961	-ditto-	Trigonia (Indotrigonia) cf. robusta
S.11718 - S.11719	WA.961	-ditto-	Trigonia (Indotrigonia) aff. africana
S.11720 - S.11722	WA.961	-ditto-	Trigonia (Indotrigonia) cf. africana
S.11723 - S.11735	WA.2179	Pt.24F Naiwehe Stream	Trigonia (Indotrigonia) aff. africana
S.11736 - S.11737	WA.2179	-ditto-	Trigonia (Indotrigonia) aff. beyschlagi
S.11738 - S.11748	WA.2176	Pt.20F -ditto-	Trigonia (Indotrigonia) beyschlagi
S.11749 - S.11754	WA.1628	Pt.18/19 Nambango Stream (=WA.2003)	Trigonia (Indotrigonia) v-striata
S.11755 - S.11759	WA.1265	130 feet upstream of Pt.14 Kikundi Stream	-ditto-
S.11760 - S.11761	WA.1782	Pt.5 Lihimaliao Stream IV.	-ditto-
S.11762	WA.963	Just downstream Pt.14 Mkomangoni Stream	-ditto-
S.11763	WA.2266	Pt.4 Closing Traverse N.oolite-Kiwawa	-ditto-
S.11764	WA.1656	Pt.1 Ngirito Stream (Lower)	Trigonia (Indotrigonia) aff. robusta
S.11765 - S.11766	WA.1656	-ditto-	Trigonia (Indotrigonia) aff. beyschlagi
S.11767 - S.11792	WA.1656	-ditto-	Trigonia (Indotrigonia) africana
S.11793 - S.11807	WA.2154	Pt.19 Mkundi Stream (Upper)	Trigonia (Indotrigonia) aff. africana
S.11808	WA.2154	-ditto-	Trigonia (Indotrigonia) aff. beyschlagi
S.11809	WA.878	Pt.22/23 Kikundi Stream	Trigonia (Indotrigonia) aff. africana
S.11810	WA.958	Pt.19 Mkomangoni Tributary "A"	Trigonia (Indotrigonia) cf. africana
S.11811 - S.11812	WA.940	Pt.22 -ditto-	Trigonia (Indotrigonia) aff. africana
S.11813	WA.963	Just downstream Pt.14 Mkomangoni Stream	Trigonia (Indotrigonia) africana
S.11814 - S.11819	WA.1265	130 feet upstream of Pt.14 Kikundi Stream	-ditto-
S.11820	WA.1381	Pt.41 Njenga Path Traverse (Lihimaliao Stream)	Trigonia (Indotrigonia) cf. mandawae
S.11821	WA.1474	Near Pt.13F Kimbarambara Stream	Trigonia (Indotrigonia) aff. africana
S.11822	WA.1479	Near Pt.17 -ditto-	Trigonia (Indotrigonia) africana
S.11823	WA.1483	Near Pt.17F -ditto-	-ditto-
S.11824	WA.1516	Pt.1 Ngirito Stream (Lower)	Trigonia (Indotrigonia) aff. africana
S.11825	WA.1519	Pt.1F -ditto-	Trigonia (Indotrigonia) africana
S.11826 - S.11831	WA.1779	Pt.4F Lihimaliao Stream IV.	Trigonia (Indotrigonia) aff. africana
S.11832	WA.1782	Pt.5 -ditto-	Trigonia (Indotrigonia) africana
S.11833	WA.1826	Near Pt.5 on Traverse west from Pt.7 Mikaramu Path	-ditto-
S.11834 - S.11835	WA.1826	-ditto-	Trigonia (Indotrigonia) aff. africana
S.11836 - S.11841	WA.2266	Pt.4 Closing Traverse N.oolite-Kiwawa	Trigonia (Indotrigonia) aff. beyschlagi
S.11842 - S.11843	WA.2267	Pt.6F -ditto-	Trigonia (Indotrigonia) aff. robusta
S.11844	WA.2312	Pt.12 Lonji (Nandenga) Stream	Trigonia (Indotrigonia) africana
S.11845	WA.2313	Pt.21 -ditto-	-ditto-
S.11846 - S.11849	WA.2315	Pt.13/13F -ditto-	-ditto-
S.11850 - S.11851	WA.2404	250 yards N. of Mtande-Makangaga path on W.side of watershed between Kikundi Tributaries and Mtande	Trigonia (Indotrigonia) aff. africana

Hunt. Mus. No.		Locality	Identification
S.11852 - S.11854	WA.2496	Eastern end of scarp and dip slope feature just east of Kihimbwi/Mbemkuru confluence	Trigonia (Indotrigonia) aff. africana
S.11855 - S.11856	WA.2412	On Forest Reserve Boundary 650 yards east of Runjo Stream	Trigonia (Indotrigonia) aff. africana
S.11857	WA.1838	Ruawa-Mikarawanje Path 1,000 feet south of crossing of Ruawa River (=WA.2544)	Trigonia (Indotrigonia) aff. africana
S.11858 - S.11861	WA.2305	Nangororo area, East of Tunduru Village, S. Kilwa District	Trigonia (Indotrigonia) aff. africana
S.11862	WA.826	Pt.70 Mandawa-Namakongoro Stream	Trigonia (Trigonia) cf. elongata
S.11863 - S.11867	WA.828	Pt.71 -ditto-	Trigonia (Trigonia) elongata
S.11868	WA.834	Pt.81 -ditto-	Trigonia (Trigonia) cf. elongata
S.11869 - S.11879	WA.835	Just upstream Pt.81 Mandawa-Namakongoro Stream	Trigonia (Trigonia) elongata
S.11880	WA.924	Pt.23/24 Nchia Traverse	Trigonia (Trigonia) cf. elongata
S.11881	WA.979	Near Pt.22 -ditto-	-ditto-
S.11882 - S.11883	WA.1004	Pt.23/24 -ditto- (=WA.982)	Trigonia (Trigonia) elongata
S.11884	WA.1180	Pt.25 -ditto- (=WA.1005)	Trigonia (Trigonia) aff. elongata
S.11885	WA.1191	Near Pt.13 Lonji-Runjo Stream	Trigonia (Trigonia) elongata
S.11886	WA.1216	25 yards short of Pt.12F -ditto-	Trigonia (Trigonia) cf. elongata
S.11887 - S.11890	WA.1217	Near Pt.13 -ditto- (=WA.1191)	Trigonia (Trigonia) elongata
S.11891	WA.1218	Pt.13/13F -ditto-	-ditto-
S.11892 - S.11894	WA.1219	Pt.13/13F -ditto-	-ditto-
S.11895 - S.11901	WA.1220	Pt.13/13F -ditto-	-ditto-
S.11902 - S.11912	WA.1226	Pt.26 -ditto-	-ditto-
S.11913 - S.11915	WA.1259	Just upstream Pt.44 -ditto-	-ditto-
S.11916	WA.1261	Just upstream Pt.45 -ditto-	Trigonia (Trigonia) aff. elongata
S.11917	WA.1292	Pt.19/19F Lonji Stream	Trigonia (Trigonia) aff. prora
S.11918	WA.1298	Kahokondo-Manyuli path, near Pt.11 Upper Mkomore Traverse	Trigonia (Trigonia) aff. elongata
S.11919	WA.1322	Pt.16F Telegraph Line Traverse (south)	Trigonia (Trigonia) cf. elongata
S.11920	WA.1323	Near Pt.16F -ditto-	Trigonia (Trigonia) elongata
S.11921	WA.1390	Pt.9 Namakambi-Lonji Path	-ditto-
S.11922	WA.1591	50 yards N. of Pt.23 Namakumbira-Manyuli Path	Trigonia (Trigonia) elongata
S.11923	WA.1591	-ditto-	Trigonia (Trigonia) aff. elongata
S.11924	WA.1591	-ditto-	Trigonia (Trigonia) elongata
S.11925 - S.11927	WA.1591	-ditto-	Trigonia (Trigonia) aff. elongata
S.11928	WA.1591	-ditto-	Trigonia (Trigonia) aff. prora
S.11929	WA.1591	-ditto-	Trigonia (Trigonia) prora
S.11930	WA.1591	-ditto-	Trigonia (Trigonia) aff. prora
S.11931	WA.1591	-ditto-	Trigonia (Trigonia) elongata
S.11932	WA.1591	-ditto-	Trigonia (Trigonia) aff. propinqua
S.11933	WA.1705	Pt.32 Telegraph Line (North)	Trigonia (Trigonia) cf. elongata
S.11934	WA.1706	Just short of Pt.42 -ditto-	-ditto-
S.11935 - S.11937	WA.1804	Near Pt.1 Lihimaliao Stream II.	Trigonia (Trigonia) elongata
S.11938	WA.1806	-ditto-	Trigonia (Trigonia) cf. elongata
S.11939 - S.11941	WA.1815	Pt.4 -ditto-	Trigonia (Trigonia) elongata
S.11942	WA.1817	Pt.5/5F -ditto-	Trigonia (Trigonia) aff. elongata
S.11943	WA.1817	-ditto-	Trigonia (Trigonia) elongata
S.11944	WA.1817	-ditto-	Trigonia (Trigonia) cf. elongata

Hunt. Mus. No.		Locality	Identification
S.11945	WA.2019	Near Pt.51 Nchia Traverse	Trigonia (Trigonia) aff. elongata
S.11946	WA.2019	-ditto-	Trigonia (Trigonia) elongata
S.11947 - S.11948	WA.2019	-ditto-	Trigonia (Trigonia) cf. elongata
S.11949 - S.11951	WA.2161	Pt.30 Manyuli Stream	-ditto-
S.11952	WA.2161	-ditto-	Trigonia (Trigonia) elongata
S.11953	WA.2219	Pt.19 -ditto-	Trigonia (Trigonia) prora
S.11954 - S.11955	WA.2219	-ditto-	Trigonia (Trigonia) aff. prora
S.11956 - S.11959	WA.2221	Pt.20F -ditto-	Trigonia (Trigonia) elongata
S.11960 - S.11966	WA.2225	Near Pt.24 -ditto-	-ditto-
S.11967 - S.11971	WA.2227	Pt.28 -ditto-	-ditto-
S.11972	WA.2229	Pt.33 -ditto-	Trigonia (Trigonia) aff. elongata
S.11973	WA.2246	Pt.6 Nunga Stream	Trigonia (Trigonia) cf. elongata
S.11974 - S.11975	WA.2259	Pt.3 -ditto-	Trigonia (Trigonia) elongata
S.11976 - S.11978	WA.2297	Pt.51F Namakumbira Stream Traverse	-ditto-
S.11979 - S.11980	WA.2302	Pt.14 Mkomore Tributary I.	Trigonia (Trigonia) cf. elongata
S.11981	WA.2303	Pt.5F -ditto- II.	-ditto-
S.11982 - S.11984	WA.2309	Pt.22F Namakambi Stream	Trigonia (Trigonia) elongata
S.11985 - S.12004	WA.961	Just west of Pt.62 Mkomangoni Tributary "C" Traverse extension (=WA.2261)	Opisthotrigonia curvata
S.12005 - S.12015	WA.1628	Pt.18/19 Nambango Stream (=WA.2003)	-ditto-
S.12016	WA.2179	Pt.24F Malwehe Stream	-ditto-
S.12017 - S.12018	WA.2267	Pt.6F Closing Traverse N.oolite-Kiwawa	-ditto-
S.12019 - S.12020	WA.1627	Mpilepile Stream just upstream of Pt.5 Kikundi limestone Traverse (North) II. (=WA.1691)	-ditto-
S.12021	WA.1477	Near Pt.16 Kimbarambara Stream	Laevitrigonia curta
S.12022 - S.12023	WA.1656	Pt.1 Ngirito Stream (Lower)	-ditto-
S.12024	WA.1779	Pt.4F Lihimaliao Stream IV.	-ditto-
S.12025 - S.12035	WA.2416	As WA.2415 but 50 ft. above (see S.11348)	Megatrigonia (Rutitrigonia) krenkeli
S.12036	WA.2460	100 yards N. of old Lindi-Kilwa Road on east side of 1st stream W. of cultivation area near Mto Nyangi	Megatrigonia (Rutitrigonia) kigombona
S.12037 - S.12043	WA.2462	300 yards N. of WA.2460 (see S.12036)	-ditto-
S.12044	WA.2466	Near top of steep rise in Makumba Stream	Megatrigonia (Rutitrigonia) krenkeli
S.12045	WA.2499	West slope of Tunduru Village hillock just north of path from village to river	Megatrigonia (Rutitrigonia) cf. krenkeli
S.12046	WA.2312	Pt.12 Lonji (Nandenga) Stream	Megatrigonia (Iotrigonia) cf. vau
S.12047	WA.2315	Pt.13/13F -ditto-	-ditto-
S.12048	WA.2267	Pt.6F Closing Traverse N.oolite-Kiwawa	-ditto-
S.12049	WA.2316	Near Pt.22 Lonji (Nandenga) Stream	-ditto-
S.12050 - S.12075	WA.2148	Pt.18F/19 Mkundi Stream (Upper)	Megatrigonia (Megatrigonia) conocardiiformis
S.12076	WA.2311	Pt.10 Lonji (Nandenga) Stream	Megatrigonia (Rutitrigonia) dietrichi
S.12077	WA.1656	Pt.1 Ngirito Stream (Lower)	-ditto-
S.12078 - S.12082	WA.1628	Pt.18/19 Nambango Stream (=WA.2003)	-ditto-
S.12083 - S.12112	WA.855	Pt.19 Mkomangoni Tributary "B"	Trigonia (? Pleurotrigonia) sp. nov.
S.12113	WA.1310	Pt.4F Lihimaliao Stream I.	Megatrigonia (Rutitrigonia) cf. dietrichi
S.12114	WA.1740	Above Pt.4F -ditto- II.	Trigonia (Trigonia) sp. nov. aff. T.triangularis
S.12115	WA.2194	Near Pt.12 Upper Nunga Traverse	-ditto-
S.12116 - S.12118	WA.812	Pt.13/14 Mandawa-Namakongoro Stream (=WA.793, =WA.2001)	Trigonia (Trigonia) tanganyicensis

Hunt Mus. No.		Locality	Identification
S.12119	WA.698	600 feet downstream from road in Nachihawi (N) Stream (Matapwa)	Trigonia (Trigonia) sp. (1)
S.12120	WA.2516	Near Pt.22 Lonji (Nandenga) Stream	"Trigonia" s. lato (gen. et. sp. indet.)
S.12121	WA.2528	800 feet WSW. of Pt.59 Lindi-Kilwa Road (South)	Trigonia (Indotrigonia) sp. nov.
S.12122	WA.2274	North of Ruawa - Mikarawanje Path at entrance to East-West valley west of the Ruawa Stream (=WA.2545)	Myophorella (Orthotrigonia) sp. nov.
S.12123	WA.2244	Near Pt.60 Manyuli Stream	-ditto-
S.12124	WA.945	Mkomore Stream just west of Manyuli village	Myophorella (Orthotrigonia) cf. kutchensis
S.12125	WA.1242	Pt.38F/39 Lonji-Runjo Stream	-ditto-
S.12126	WA.2218	Near Pt.18F Manyuli Stream	-ditto-
S.12127	WA.1180	Pt.25 Nchia Traverse (=WA.1005)	-ditto-
S.12128	WA.1546	Pt.15F Lonji Stream	-ditto-
S.12129	WA.1654	Pt.2F/3 Mbaru Stream Traverse I.	-ditto-
S.12130	WA.2016	Pt.48F/49 Nchia Traverse	-ditto-
S.12131	WA.1245	Near Pt.40F Lonji-Runjo Stream	-ditto-
S.12132	WA.1810	Pt.1F Lihimaliao Stream II.	-ditto-
S.12133	WA.2016	Pt.48F/49 Nchia Traverse	-ditto-
S.12134	WA.2230	Pt.34 Manyuli Stream	-ditto-
S.12135	WA.1180	Pt.25 Nchia Traverse (=WA.1005)	-ditto-
S.12136	WA.1810	Pt.1F Lihimaliao Stream II.	-ditto-
S.12137	WA.1252	Near Pt.43 Lonji-Runjo Stream	-ditto-
S.12138 - S.12167	WA.2492	West of the highest point on Turikira Ridge, 50 feet below top	Megatrigonia (Rutitrigonia) turikirae
S.12168 - S.12173	WA.2459	Just S. of Lindi-Kilwa Road on descent to 1st stream W. of cultivation area near Mto Nyangi	Megatrigonia (Rutitrigonia) spp. juv. indet.
S.12174 - S.12176	WA.2460	100 yards N. of old Lindi-Kilwa Road on east side of 1st stream W. of cultivation area near Mto Nyangi	-ditto-
S.12177 - S.12179	WA.2462	300 yards N. of WA.2460 (see S.12174)	-ditto-

B. GEOLOGICAL SURVEY OF TANGANYIKA COLLECTION

Geol. Surv. Tang. No.	Locality	Identification
WA.582(1)	Kilangalanga Stream, 100 yards west of Mtapaia-Ruangwa road about 2 miles from Mtapaia	Trigonia (Indotrigonia) aff. africana
(2)	-ditto-	Trigonia (Indotrigonia) mandawae
(3)	-ditto-	Trigonia (Indotrigonia) africana
(4)	-ditto-	Trigonia (Indotrigonia) aff. africana
(5)	-ditto-	Trigonia (Indotrigonia) aff. mandawae
(6)	-ditto-	Trigonia (Indotrigonia) africana
(7)	-ditto-	Trigonia (Indotrigonia) aff. africana
(8)	-ditto-	-ditto-
(9)	-ditto-	-ditto-
(10)	-ditto-	Trigonia (Indotrigonia) cf. mandawae
(11)	-ditto-	-ditto-
(12)	-ditto-	Trigonia (Indotrigonia) aff. africana
(13)	-ditto-	-ditto-
(14)	-ditto-	-ditto-
(15)	-ditto-	-ditto-
(16)	-ditto-	Trigonia (Indotrigonia) cf. africana

Geol. Surv. Tang. No.	Locality	Identification
WA.582(17)	Kilangalanga Stream, 100 yards west of Mtapaia-Ruangwa road about 2 miles from Mtapaia	Trigonia (Indotrigonia) aff. africana
(18)	-ditto-	-ditto-
(19)	-ditto-	Trigonia (Indotrigonia) cf. africana
(20)	-ditto-	Trigonia (Indotrigonia) africana
(21)	-ditto-	Trigonia (Indotrigonia) cf. mandawae
(22)	-ditto-	Trigonia (Indotrigonia) aff. africana
(23)	-ditto-	-ditto-
(24)	-ditto-	-ditto-
(25)	-ditto-	-ditto-
WA.755(6)	Nambango-Ntandi path, 1st stream gully before Ntandi	Megatrigonia (Rutitrigonia) bornhardti
WA.755(9-26)	-ditto-	-ditto-
WA.756(6)	Nambango-Ntandi path, 2nd stream gully before Ntandi	-ditto-
WA.756(8-33)	-ditto-	-ditto-
WA.758(1- 3)	Kikotwa area, between Nambango and Ntandi	-ditto-
WA.766(1)	Tingutinguti Stream near Tendaguru, 60 yards upstream of waterhole	Trigonia (Indotrigonia) africana
(2)	-ditto-	Trigonia (Indotrigonia) aff. africana
(3)	-ditto-	-ditto-
(4)	-ditto-	Trigonia (Indotrigonia) cf. africana
(5)	-ditto-	Trigonia (Indotrigonia) aff. africana
(6)	-ditto-	Trigonia (Indotrigonia) africana
(7)	-ditto-	Trigonia (Indotrigonia) aff. africana
(8)	-ditto-	-ditto-
(9)	-ditto-	Trigonia (Indotrigonia) cf. africana
(10)	-ditto-	-ditto-
(11)	-ditto-	-ditto-
(12)	-ditto-	-ditto-
(13)	-ditto-	-ditto-
(14)	-ditto-	-ditto-
(15)	-ditto-	Trigonia (Indotrigonia) aff. africana
(16)	-ditto-	-ditto-
(17)	-ditto-	Trigonia (Indotrigonia) cf. africana
(18)	-ditto-	Trigonia (Indotrigonia) aff. africana
(19)	-ditto-	Trigonia (Indotrigonia) cf. africana
(20)	-ditto-	-ditto-
(21)	-ditto-	Trigonia (Indotrigonia) africana
(22)	-ditto-	-ditto-
(23)	-ditto-	Trigonia (Indotrigonia) cf. africana
(24)	-ditto-	Trigonia (Indotrigonia) africana
(25)	-ditto-	Trigonia (Indotrigonia) cf. africana
(26)	-ditto-	-ditto-
(27)	-ditto-	-ditto-
(28)	-ditto-	-ditto-
(29)	-ditto-	-ditto-

Geol. Surv. Tang. No.	Locality	Identification
WA.766(30)	Tingutinguti Stream near Tendaguru, 60 yards upstream of waterhole	Trigonia (Indotrigonia) cf. africana
(31)	-ditto-	-ditto-
(32)	-ditto-	-ditto-
(33)	-ditto-	-ditto-
(34)	-ditto-	-ditto-
(35)	-ditto-	-ditto-
(36)	-ditto-	-ditto-
(37)	-ditto-	-ditto-
WA.767(1- 2)	Tingutinguti Stream near Tendaguru, 100 yards downstream of waterhole	Trigonia (Indotrigonia) aff. africana
WA.779(1- 5)	Niongala Gully	Megatrigonia (Rutitrigonia) nossae
WA.779(6)	Niongala Gully	Megatrigonia (Rutitrigonia) sp. juv. indet.
WA.781(1)	Kilangalanga Stream, 100 yards west of Mtapaia-Ruangwa road ca. 2 miles from Mtapaia	Trigonia (Indotrigonia) aff. africana
(2)	-ditto-	-ditto-
(3)	-ditto-	-ditto-
(4)	-ditto-	-ditto-
(5)	-ditto-	-ditto-
(6)	-ditto-	Trigonia (Indotrigonia) africana
(7)	-ditto-	Trigonia (Indotrigonia) aff. mandawae
(8)	-ditto-	Trigonia (Indotrigonia) aff. africana
(9)	-ditto-	-ditto-
(10)	-ditto-	Trigonia (Indotrigonia) africana
(11)	-ditto-	-ditto-
(12)	-ditto-	-ditto-
(13)	-ditto-	Trigonia (Indotrigonia) aff. mandawae
(14)	-ditto-	Trigonia (Indotrigonia) africana
(15)	-ditto-	-ditto-
(16)	-ditto-	-ditto-
(17)	-ditto-	Trigonia (Indotrigonia) aff. africana
(18)	-ditto-	Trigonia (Indotrigonia) africana
(19)	-ditto-	Trigonia (Indotrigonia) aff. africana
(20)	-ditto-	Trigonia (Indotrigonia) africana
(21)	-ditto-	-ditto-
(22)	-ditto-	Trigonia (Indotrigonia) aff. africana
(23)	-ditto-	Trigonia (Indotrigonia) cf. africana
(24)	-ditto-	Trigonia (Indotrigonia) aff. africana
(25)	-ditto-	Trigonia (Indotrigonia) cf. africana
(26)	-ditto-	Trigonia (Indotrigonia) aff. africana
(27)	-ditto-	-ditto-
(28)	-ditto-	Trigonia (Indotrigonia) cf. africana
(29)	-ditto-	Trigonia (Indotrigonia) africana
(30)	-ditto-	Trigonia (Indotrigonia) aff. africana
(31)	-ditto-	-ditto-
(32)	-ditto-	Trigonia (Indotrigonia) cf. africana
(33)	-ditto-	Trigonia (Indotrigonia) aff. africana
(34)	-ditto-	Trigonia (Indotrigonia) cf. africana
(35)	-ditto-	-ditto-

Geol. Surv. Tang. No.	Locality	Identification
WA.781(36)	Kilangalanga Stream, 100 yards west of Mtapaia-Ruangwa road ca 2 miles from Mtapaia	Trigonia (Indotrigonia) aff. africana
(37)	-ditto-	-ditto-
(38)	-ditto-	-ditto-
(39)	-ditto-	Trigonia (Indotrigonia) cf. africana
(40)	-ditto-	Trigonia (Indotrigonia) africana
(41)	-ditto-	Trigonia (Indotrigonia) cf. africana
(42)	-ditto-	Trigonia (Indotrigonia) aff. africana
(43)	-ditto-	Trigonia (Indotrigonia) africana
(44)	-ditto-	Trigonia (Indotrigonia) cf. africana
(45)	-ditto-	Trigonia (Indotrigonia) aff. africana
(46)	-ditto-	-ditto-
(47)	-ditto-	-ditto-
(48)	-ditto-	-ditto-
(49)	-ditto-	Trigonia (Indotrigonia) africana
WA.793(21-23)	Pt.13/14 Mandawa Namakongoro-Stream (=WA.812, =WA.2001)	Trigonia (Indotrigonia) mandawae
WA.801(47-61)	Pt.19 Mkomangoni Tributary "B" (=WA.855)	Megatrigonia (Iotrigonia) cf. haughtoni
WA.812(a)	Pt.13/14 Mandawa-Namakongoro Stream (=WA.793, =WA.2001)	Trigonia (Trigonia) tanganyicensis
WA.855(32-52,3)	Pt.19 Mkomangoni Tributary "B" (=WA.801)	Trigonia (?Pleurotrigonia) sp. nov.
WA.961(22)(33)(38)(41)	Just west of Pt.62 Mkomangoni Tributary "C" Traverse extension (=WA.2261)	Trigonia (Indotrigonia) aff. africana
WA.961(8)(15)(25)(31-32)(34-37)(40)	-ditto-	Trigonia (Indotrigonia) robusta
WA.961(39)	-ditto-	Trigonia (Indotrigonia) cf. robusta
WA.961(d)(q)(t)	-ditto-	Opisthotrigonia curvata
WA.961(30)	-ditto-	Opisthotrigonia cf. curvata
WA.963(2)(4)(6)	Just downstream Pt.14 Mkomangoni Stream	Trigonia (Indotrigonia) cf. africana
WA.971(4)(11)(40-62)	Below Pt.4 Nchia Traverse (=WA.1006)	Trigonia (Indotrigonia) mandawae
WA.1180(1)	Pt.25 -ditto-(=WA.1005)	Myophorella (Orthotrigonia) cf. kutchensis
WA.1216(a)	25 yards short of Pt.12F Lonji-Runjo Stream	Trigonia (Trigonia) cf. elongata
WA.1220(a)(a')	Pt.13/13F -ditto-	Trigonia (Trigonia) elongata
WA.1265(4)	130 feet upstream of Pt.14 Kikundi Stream	Trigonia (Indotrigonia) cf. africana
WA.1265(c)	-ditto-	Trigonia (Indotrigonia) v-striata
WA.1591	50 yards N. of Pt.25 Namakumbira-Lanyuli Path	Trigonia (Trigonia) cf. prora
WA.1628(29)(37)(63)(95)(113)(116)	Pt.18/19 Namboango Stream (=WA.2003)	Trigonia (Indotrigonia) africana
WA.1628(d)	-ditto-	Trigonia (Indotrigonia) v-striata
WA.1628(b)	-ditto-	Megatrigonia (Rutitrigonia) dietrichi
WA.1654(1)	Pt.2F/3 Mbaru Stream Traverse I.	Myophorella (Orthotrigonia) cf. kutchensis
WA.1653(1)(5)	Pt.23F Ngirito-Runyu Traverse	Megatrigonia (Rutitrigonia) bornhardti
WA.1656(1)(22)	Pt.1 Ngirito Stream (Lower)	Trigonia (Indotrigonia) africana
WA.1656(32-41)	-ditto-	Trigonia (Indotrigonia) cf. africana
WA.1779(1)	Pt.4F Lihimaliao Stream IV.	Laevitrigonia curta
WA.1815(2)	Pt.4 -ditto- II.	Trigonia (Trigonia) elongata
WA.1817(4)	Pt.5/5F -ditto-	Trigonia (Trigonia) prora
WA.2002(b)	As WA 812 but 15 feet above	Trigonia (Indotrigonia) cf. mandawae
WA. 2148 (2), (4), (10), (19)	Pt.18F/19 Mkundi Stream (Upper)	Megatrigonia (Megatrigonia) conocardiiformis
WA.2154(4)(5)	Pt.19 Mkundi Stream (Upper)	Trigonia (Indotrigonia) aff. africana

Geol. Surv. Tang. No.	Locality	Identification
WA.2176(1),(3)	Pt.20F Nalwehe Stream	Trigonia (Indotrigonia) beyschlagi
WA.2221(5)	Pt.20F Manyuli Stream	Trigonia (Trigonia) elongata
WA.2244(1)	Near Pt.60 -ditto-	Myophorella (Orthotrigonia) sp. nov.
WA.2404(3)	250 yards N. of Mtande-Makangaga path on W. side of watershed between Kikundi Tributaries and Mtande	Trigonia (Indotrigonia) aff. africana
(4)	-ditto-	-ditto-
(5)	-ditto-	Trigonia (Indotrigonia) africana
(6)	-ditto-	Trigonia (Indotrigonia) aff. africana
(7)	-ditto-	Trigonia (Indotrigonia) cf. africana
(8)	-ditto-	-ditto-
(9)	-ditto-	-ditto-
(10)	-ditto-	Trigonia (Indotrigonia) aff. africana
(11)	-ditto-	-ditto-
(12)	-ditto-	Trigonia (Indotrigonia) africana
WA.2412(1)	On Forest Reserve Boundary 650 yards east of Runjo Stream	Trigonia (Indotrigonia) cf. africana
WA.2415(4)(7)(13)(17)(23-40)	Gully joining Makumba Stream (at SE. of Itukuru) at base of steep falls in stream	Megatrigonia (Rutitrigonia) schwarzi
WA.2416(2)(6)(14-31)	As WA.2415 but 30 feet above	Megatrigonia (Rutitrigonia) krenkeli
WA.2459(4)(10-28)	Just S. of Lindi-Kilwa Road on descent to 1st stream W. of cultivation area near Mto Nyangi	Megatrigonia (Rutitrigonia) spp. juv. indet.
WA.2460(3)(6)(7- 9)	100 yards N. of old Lindi-Kilwa Road on east side of 1st stream W. of cultivation area near Mto Nyangi	-ditto-
WA.2462(2)(6)	300 yards N. of WA.2460	Megatrigonia (Rutitrigonia) nyangensis
WA.2462(9-13)	-ditto-	Megatrigonia (Rutitrigonia) spp. juv. indet.
WA.2492(2)(16)(17)(24)(34-62)	West of the highest point on Turikira Ridge, 50 feet below top	Megatrigonia (Rutitrigonia) turikirae
WA.2494(1)	Nossa Stream (Kigombo area) 300 yards upstream in east fork	Megatrigonia (Rutitrigonia) cf. bornhardti
WA.2494(4)	-ditto-	Yaadia hennigi
WA.2496(1)	Eastern end of scarp and dip slope feature just east of Kihimbwi/Mbemkuru confluence	Trigonia (Indotrigonia) cf. africana
WA.2499(4)(9)(13-18)	West slope of Tunduru Village hillock just north of path from village to river	Megatrigonia (Rutitrigonia) aff. nyangensis
WA.2533(1)	On road at east end of Nambango-Ndondonga Ridge	Trigonia (Indotrigonia) mandawae
WA.2534(1)	Western end of scarp and dip-slope feature just east of Kihimbwi/Mbemkuru confluence	Trigonia (Indotrigonia) aff. africana
WA.2535(1)	1½ miles ESE. of Kihimbwi/Mbemkuru confluence	Megatrigonia (Rutitrigonia) cf. bornhardti
WA.2539(A)	Near Pt.40 Kikundi Stream	Megatrigonia (Rutitrigonia) cf. bornhardti
WA.2539(B)	-ditto-	-ditto-
WA.2541(1)	-ditto-	Megatrigonia (Rutitrigonia) [redacted] bornhardti
WA 2542	Near Forest Reserve Boundary W. of Mkomore	Trigonia (Indotrigonia) aff. africana
WA.2544(1)	Ruawa-Mikarawanje path, 1,000 feet south of crossing of Ruawa River (=WA.1858)	Trigonia (Indotrigonia) cf. africana
(2)	-ditto-	-ditto-
(3)	-ditto-	-ditto-
(4)	-ditto-	Trigonia (Indotrigonia) aff. africana
(5)	-ditto-	Trigonia (Indotrigonia) africana
(6)	-ditto-	-ditto-
(7)	-ditto-	Trigonia (Indotrigonia) cf. africana
(8)	-ditto-	Trigonia (Indotrigonia) aff. africana

Geol. Surv. Tang. No.	Locality	Identification
WA.2544(9)	Ruawa-Mikarawanje path, 1,000 feet south of crossing of Ruawa River (=WA.1836)	Trigonia (Indotrigonia) africana
(10)	-ditto-	Trigonia (Indotrigonia) cf. africana
(11)	-ditto-	-ditto-
(12)	-ditto-	Trigonia (Indotrigonia) aff. africana
(13)	-ditto-	Trigonia (Indotrigonia) africana
(14)	-ditto-	Trigonia (Indotrigonia) cf. africana
WA.2545(A)	North of Ruawa-Mikarawanje Path at entrance to east-west valley west of the Ruawa Stream (=WA.2274)	Myophorella (Orthotrigonia) sp. nov.
WA.2547(1)	Immediately east of lake Mbuo, near top of first rise	Trigonia (Indotrigonia) africana
(2)	-ditto-	-ditto-
(3)	-ditto-	Trigonia (Indotrigonia) cf. africana
(4)	-ditto-	-ditto-
(5)	-ditto-	Trigonia (Indotrigonia) aff. africana
(6)	-ditto-	Trigonia (Indotrigonia) cf. africana
(7)	-ditto-	-ditto-
(8)	-ditto-	Trigonia (Indotrigonia) africana
(9)	-ditto-	Trigonia (Indotrigonia) aff. africana
(10)	-ditto-	-ditto-
(11)	-ditto-	-ditto-
(12)	-ditto-	Trigonia (Indotrigonia) cf. africana
(13)	-ditto-	-ditto-
(14)	-ditto-	-ditto-
WA.2546(1- 8)	Minor tributary stream between Mpilepile and Kikundi streams (Mitole area) about 1 mile east of Lindi Kilwa road	Trigonia (Indotrigonia) robusta
WA.2546(9)	-ditto-	Trigonia (Indotrigonia) aff. africana
WA.2556(1- 2)	Southern end of Kikundi escarpment in gully near Mbemkuru flats	Trigonia (Indotrigonia) aff. mandawae
WA.2556(3)	-ditto-	Trigonia (Indotrigonia) aff. africana
WA.2558(A)	On Forest Reserve boundary near south end of Kikundi escarpment, above Mbemkuru flats	-ditto-
WA.2560(A, B)	Near base of steep rise up northern side of Mbambala Hill	-ditto-
WA.2562(1, 4)	Near top of steep rise up northern side of Mbambala Hill	Trigonia (Indotrigonia) aff. beyschlagi
WA.2562(2- 3)	-ditto-	Trigonia (Indotrigonia) aff. africana
WA.2563	Top of steep rise up northern side of Mbambala Hill	-ditto-
WA.2565(A)	300 yards north of road just east of Mtapaia Village	Yaadia hennigi
WA.2565(1-17)	-ditto-	Megatrigonia (Rutitrigonia) turikirae

PLATES

PLATE I.

Illustration of the community of _Trigonia (Trigonia)_ from Locality WA.1226, Runjo Stream; Callovian. Page 23.

(All figures are of natural size).

FIG.1. _Trigonia (Trigonia) elongata_ Sowerby; (Hunt. Mus. No. S.11902). Lateral view of a large shell with strong, widely spaced costae; prominent, straight, corded marginal carina; and area rather steeply inclined to the flank. The postero-dorsal margin is steeply sloping.

FIG.2. _Trigonia (Trigonia) elongata_ Sowerby; (Hunt. Mus. No. S.11907). Lateral view of a specimen with a curved marginal carina and the area set at an obtuse angle to the flank. Transverse ornament predominates over radial ornament on the area. The ante-carinal groove is well marked.

Fig.3. _Trigonia (Trigonia) elongata_ Sowerby; (Hunt. Mus. No. S.11903).

(a) Lateral view of a right valve showing strong development of an ante-carinal groove.

(b) Escutcheon view showing detail of area and escutcheon. The shell was apparently strongly gaping.

FIG.4. _Trigonia (Trigonia) elongata_ Sowerby; (Hunt. Mus. No. S.11912). Lateral view showing a small right valve with "cut-away" lower anterior margin and general outline similar to the holotype of _T. prora_, but with strong corded marginal carina and more widely spaced costae.

FIG.5. _Trigonia (Trigonia) elongata_ Sowerby; (Hunt. Mus. No. S.11908).

(a) Lateral view of incomplete specimen showing marked anterior irregularity of the costae.

(b) Escutcheon view showing detail of the upper part of the area and escutcheon. The escutcheon is very wide.

(c) Anterior view showing the marked undulation of the rather sharp costae.

1

2

3a

3b

4

5a

5b

5c

PLATE II.

Illustration of the community of Trigonia (Trigonia) from Locality WA.1591 near the Namakumbira - Manyuli Path; ?Callovian, ?Oxfordian. Page 23.

(All figures are of natural size).

FIG.1. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11922). Lateral view of a large incomplete specimen with wide flank and widely spaced, massive costae.

FIG.2. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11924). Lateral view of an almost complete shell, showing fairly wide flank, widely spaced costae, well marked ante-carinal groove and coarsely corded marginal carina. The postero-dorsal margin, formed by the raised inner edge of the escutcheon, slopes at a moderate angle.

FIG.3. Trigonia (Trigonia) aff. elongata Sowerby; (Hunt. Mus. No. S.11926).

(a) Lateral view showing the slightly more elongate figure, slightly closer spaced costae and finer cording of the marginal carina than is usual in T. elongata.

(b) Escutcheon view showing detail of the area and escutcheon, and the partly preserved external ligament (calcified).

FIG.4. Trigonia (Trigonia) aff. elongata Sowerby; (Hunt. Mus. No. S.11923).

(a) Lateral view of a left valve showing the narrower flank than is usual in East African and Cutch examples of T. elongata s. str., and the "cut-away" lower anterior border. The ante-carinal groove is well marked but the marginal carina, though worn, cannot have been very robust or strongly corded. The elevated inner edge of the escutcheon is visible.

(b) Lateral view of a right valve showing the absence of an ante-carinal groove.

(c) Escutcheon view showing detail of the area and escutcheon, and the wide short ligament groove with nymphal plates.

FIG.5. Trigonia (Trigonia) aff. propinqua Kitchin; (Hunt. Mus. No. S.11932).

(a) Lateral view of an incomplete shell, more finely ribbed than T. elongata but at least as elongated.

(b) Escutcheon view showing detail of the area and escutcheon. The inwardly protruding massive striated tooth 2 is visible.

(c) Interior view showing the typically trigoniid dentition. The striated surfaces of all the teeth (2, 4a,b) are visible. The posterior pedal retractor muscle scar can be seen. The anterior adductor muscle scar is partly filled by matrix and the posterior completely concealed.

FIG.6. Trigonia (Trigonia) aff. prora Kitchin; (Hunt. Mus. No. S.11928). Lateral view of a poorly preserved specimen with fairly narrow flank and close ribbing. A fairly strong corded marginal carina is visible in late growth.

FIG.7. Trigonia (Trigonia) aff. prora Kitchin; (Hunt. Mus. No. S.11930).

(a) Lateral view of an incomplete large shell with a narrow flank, steeply sloping postero-dorsal margin and a not very obtuse angle between flank and area.

(b) Escutcheon view showing detail of the area and escutcheon. The escutcheon is very wide.

FIG.8. Trigonia (Trigonia) prora Kitchin; (Hunt. Mus. No. S.11929). Lateral view of a rather small, incomplete shell showing the narrow flank with rather close-spaced costae, sharp marginal carina; the flank rather steeply inclined to the area; and a steeply sloping postero-dorsal margin.

Plate II

PLATE III.

(All figures are of natural size).

FIGS. 1 - 4.

Illustration of the community of Trigonia (Trigonia) from Locality WA.835, Namakongoro Stream; Callovian. Page 22.

FIG.1. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11869). Lateral view of a medium-sized shell with strong, widely spaced costae and straight, corded, marginal carina.

FIG.2. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11878). Lateral view of a rather small specimen with a strong, evenly convex curve from the umbo to the postero-ventral extremity. The costae are rather close-spaced, separated from the curved marginal carina by a slight groove. Both the upper and lower divisions of the area are concave. The inner edge of the escutcheon is elevated.

FIG.3. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11870). Lateral view of a medium-sized shell with strong widely spaced costae, the lower ones slightly swollen posteriorly and terminating abruptly at a well-marked ante-carinal groove. Cording of the straight marginal carina passes into a strong lateral component of the area ornament.

FIG.4. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11877). Lateral view of medium-sized shell, with strong widely-spaced costae. In the most posterior part of the area, the transverse component of the ornament excludes the radial component.

FIGS. 5 - 7.

Trigonia (Trigonia) of the prora/elongata Group from miscellaneous localities. Page 25.

FIG.5. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11946). Locality WA.2019, Nchia Stream; Callovian.

(a) Lateral view of a fairly narrow-flanked specimen with strong costae. The marginal carina is not very prominent and the ante-carinal groove is not strong. Each half of the area is concave.

(b) Escutcheon view showing the strong lateral component of ornamentation in the lower part of the area.

FIG.6. Trigonia (Trigonia) aff. elongata Sowerby; (Hunt. Mus. No. S.11945). Locality WA.2019, Nohia Stream; Callovian.
Lateral view of a shell with slightly less robust ornament than is usual in T. elongata.

FIG.7. Trigonia (Trigonia) cf. elongata Sowerby; (Hunt. Mus. No. S.11880). Locality WA.924, Nohia Stream; ?Callovian ?Oxfordian.

(a) Lateral view of a worn, large, slightly elongated shell with wide-spaced costae, the lower ones turning down slightly at the posterior end. The postero-ventral extremity is slightly rostrate.

(b) Eschutcheon view showing the strong inflation of the shell. Detail of the area and eschutcheon is not preserved but the short, wide ligament groove is visible.

Plate III

1

2

3

4

5a

5b

7a

7b

6

PLATE IV.

Trigonia (Trigonia) of the prora/elongata Group from miscellaneous localities. Pages 25-27.

(All figures are of natural size).

FIG.1. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11960). Locality WA.2225, Manyuli Stream; Callovian.

(a) Lateral view of fairly large, rather quadrate shell showing strong costae and nearly straight, corded marginal carina. The upper part of the area is more concave than the lower.

(b) Escutcheon view showing detail of the ornament of the area and escutcheon. Radial riblets are more numerous in the upper part of area than in the lower. Radial ornament is almost obscured posteriorly by transverse ornament.

(c) Anterior view showing undulation of the costae near the anterior margin. The costae taper out before reaching the anterior margin.

FIG.2. Trigonia (Trigonia) aff. elongata Sowerby; (Hunt. Mus. No. S.11972). Locality WA.2229, Manyuli Stream; Callovian. Lateral view of a fairly large specimen. The maximum spacing of the costae is attained at about $\frac{3}{4}$ of the full growth, and then decreases. The marginal carina is prominent.

FIG.3. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11935). Locality WA.1804, Lihimaliao Stream; ?Callovian ?Oxfordian.

(a) and (b) Lateral views of right and left valves of a small individual which is slightly more elongate than the usual T. elongata of Tanganyika. The ornament is robust, and the ante-carinal groove of the left valve is very prominent. Both halves of the area on each valve are concave.

(c) Anterior view showing the considerable tumidity.

(d) Escutcheon view showing the well-marked marginal, median and inner carinae on each valve. The escutcheon is large and depressed. The ligament groove is short and rather wide.

FIG.4. Trigonia (Trigonia) elongata Sowerby; [Geol. Surv. Tanganyika No. WA.1815(2)]. Locality WA.1815, Lihimaliao Stream; ?Callovian ?Oxfordian. Lateral view of a well-grown, fairly elongate specimen, with

the anterior and lower borders forming an even convex curve. The ornament is robust.

FIG.5. Trigonia (Trigonia) prora Kitchin; [Geol. Surv. Tanganyika No. WA.1817(4)]. Locality WA.1817, Lihimaliao Stream; ?Callovian ?Oxfordian.

(a) Lateral view showing the narrow flank and the rather straight anterior margin curving sharply into the lower border. The costae are not very widely spaced and the marginal carina is not robust. The area is steeply inclined to the flank. The postero-dorsal margin is short and slopes steeply back from the umbo.

(b) Anterior view showing the costae undulating slightly on approach to the anterior margin.

(c) Escutcheon view showing the well-marked median and inner carinae and the wide, depressed escutcheon. The two halves of the area are each concave. The ornament is largely destroyed.

FIG.6. Trigonia (Trigonia) aff. elongata Kitchin; (Hunt. Mus. No. S.11942). Locality WA.1817, Lihimaliao Stream; ?Callovian ?Oxfordian. Lateral view showing the fairly robust flank ornament, but not very strong marginal carina. The postero-dorsal margin is short, sloping steeply back from the umbo, and the area is steeply inclined to the flank.

FIG.7. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11943). Locality WA.1817, Lihimaliao Stream; ?Callovian ?Oxfordian. Lateral view of an incomplete specimen showing the robust ornament of the flank and area. The area is not steeply inclined to the flank.

FIG.8. Trigonia (Trigonia) elongata Sowerby; (Hunt. Mus. No. S.11895). Locality WA.1220, Lonji Stream; Callovian.

(a) Lateral view of an incomplete specimen showing the robust flank ornament.

(b) Interior view showing the typical trigoniid dentition of the left valve. The position of the anterior adductor muscle scar can be seen but the shell is not complete enough to show the posterior adductor muscle scar. The posterior pedal retractor muscle scar is visible.

FIG.9. Trigonia (trigonia) aff. prora Kitchin; (Hunt. Mus. No. S.11917). Locality WA.1292, Lonji Stream; Callovian. Lateral view of a slightly prorate shell with convex anterior end, and not very robust flank ornament. The marginal carina is strong but not cordate and the area is large and at a moderate inclina-

tion to the flank. The postero-dorsal margin slopes fairly steeply back from the umbo and is rather long.

Plate IV

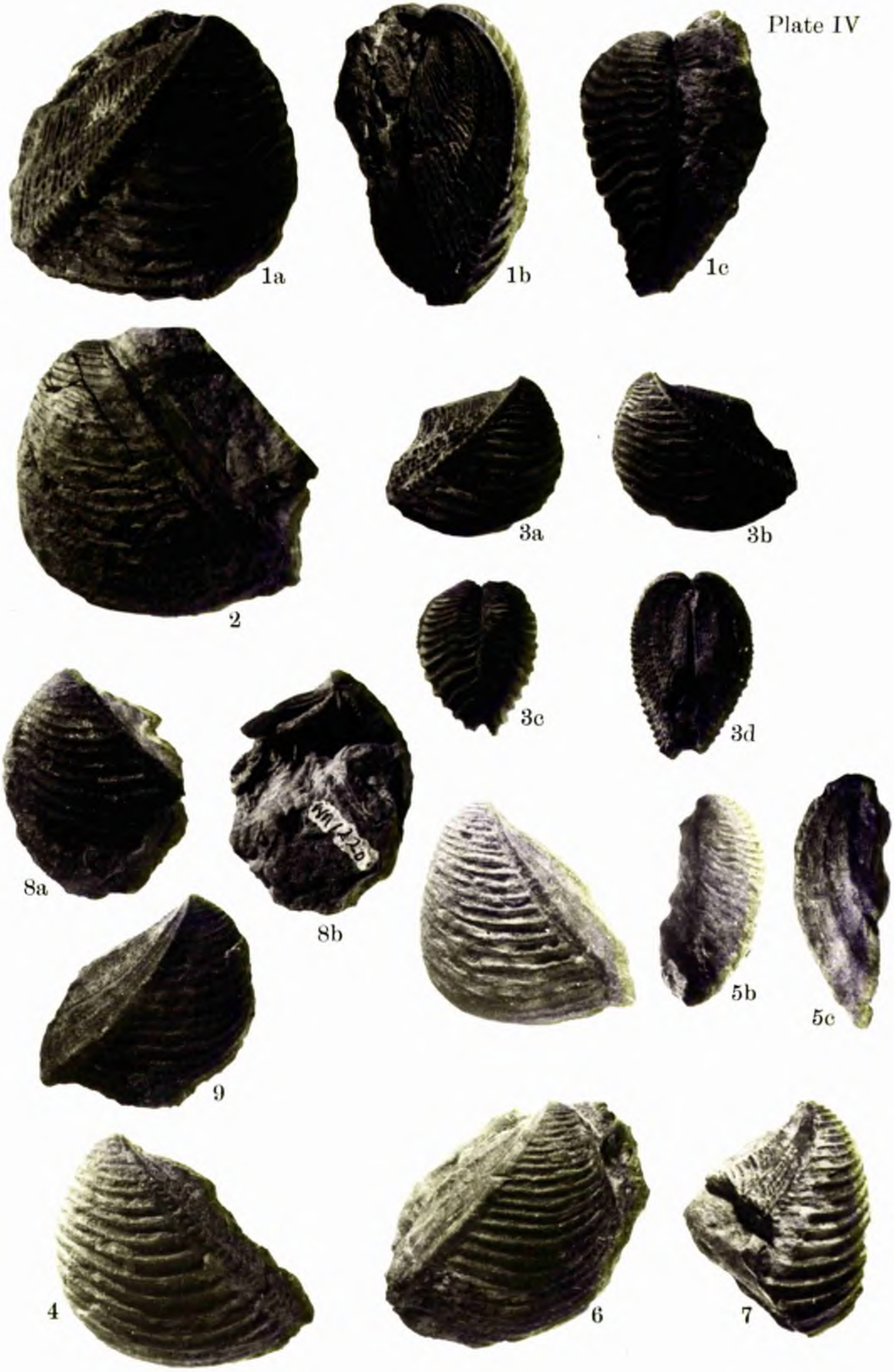


PLATE V.

Trigonia (Trigonia).

(All figures are of natural size).

FIG.1. Trigonia (Trigonia) tanganyicensis sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.12118). Locality WA.812, Mandawa Stream; Middle or Upper Kimmeridgian. Page 33.

(a) Lateral view of an almost complete shell showing the wide flank with the area set at little more than a right angle to it to mid-growth. The costae are close-spaced, slightly irregular and not quite parallel to the lower border. The marginal carina is sharply rounded and not prominent; there is a narrow ante-carinal groove and a fine secondary carina in front of this into which the costae run.

(b) Escutcheon view showing the fine radial ornament of the area, and the long depressed escutcheon separated from the area by the inner carina.

(c) Anterior view of the rather compressed shell showing the costae approaching the anterior almost horizontally. The anterior commissure is slightly sunken below the level of a "shoulder" forming the foremost part of the shell.

FIG.2. Trigonia (Trigonia) tanganyicensis sp. nov.; (Hunt. Mus. No. S.12117). Locality WA.812, Mandawa Stream; Middle or Upper Kimmeridgian.

(a) Lateral view showing the costae almost concentric and parallel to the lower border, and separated by a fine groove from the marginal carina. The area is set at little more than a right angle to the flank throughout growth.

(b) Escutcheon view showing the sharply rounded marginal carina and a weak median carina separating the radially ornamented area into two portions at slightly different levels.

(c) Anterior view showing the ratio of thickness to height to be larger in this small shell than in the holotype.

FIG.3. Trigonia (Trigonia) sp. (1); (Hunt Mus. No. S.12119). Locality WA.698, Mchinjiri Valley; ?Upper Kimmeridgian ?Tithonian. Page 36.

(a) Lateral view of a small, rather tumid, slightly incomplete specimen. The marginal carina is tuberculate and there is a narrow ante-carinal groove. The posterior ends of the costae are linked by a very fine secondary carina.

(b) Escutcheon view showing the reticulate area ornament and the obscurely denticulate inner carina separating the area from the wide escutcheon. Gaps in the rows of denticles on the area and escutcheon indicate halts in growth.

FIG.4. Trigonia (Trigonia) sp. nov. aff. T. triangularis Goldfuss; (Hunt. Mus. No. S.12114). Locality WA.1740, Lihimaliao Stream; ?Oxfordian. Page 29.

(a) Lateral view showing the roughly triangular shape and very robust ornament. The slightly nodose costae plunge downwards from the anterior end to terminate at the edge of a hollowed ante-carinal space occupying 1/3 of the flank. The marginal carina is very strong and nodose. The slight concavity of the two halves of the area can be seen. The lower margin is incomplete but growth lines on the ante-carinal space indicate that there was a sulcus in the lower border corresponding to this space.

(b) Escutcheon view showing the well marked division of the area at the weak median carina which is scarcely stronger than the radial ribs of the area. The escutcheon is long and depressed but its ornament is not seen.

(c) Anterior view showing the frontal face with the costae thickening at the angulation of the shell, but disappearing before reaching the anterior commissure adjacent to which there is a smooth band.

FIG.5. Trigonia (Trigonia) sp. nov. aff. T. triangularis Goldfuss; (Hunt. Mus. No. S.12115). Locality WA.2194, Upper Nunga Traverse; ?Middle Kimmeridgian. Page 29.

(a), (b) & (c). Lateral, escutcheon and anterior views respectively showing much the same features (allowing for the younger stage of growth) as S.12114. Nodosity of the costae has not developed but the marginal carina is irregularly nodose.

FIG.6. Trigonia (Trigonia) sp. (2); (Hunt. Mus. No. S.11479). Locality WA.1740, Mahokondo Stream; Tithonian. Page 39.

(a) Lateral view of the trigonally ovate, strongly costate shell with prominent serrated marginal carina and smooth ante-carinal space.

(b) Escutcheon view showing the prominent, tuberculate, median carina and strong supra-median groove. The tubercles of the median carina tend to merge into lateral extensions of the serrations of the marginal carina (incipient transverse costellae). The radial ornament of the proximal part of the area is too fine for illustration. The escutcheon is not exposed.

1a

2a

2b

2c

1b

1c

3a

3b

4a

4b

4c

5a

5b

5c

6a

6b

PLATE VI.

Illustrations of Trigonia (Indotrigonia) smeei

J. de C. Sowerby from Cutch. Page 81.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) smeei J. de C. Sowerby. Reproduction of the original figure of the holotype. Shahpoor, Cutch; Argovian.

FIG.2. Trigonia (Indotrigonia) smeei J. de C. Sowerby; Blake Collection (British Museum No. L.75421); Moondan, Iddurghur, Cutch; Argovian.

(a) Lateral view of a specimen very much resembling the holotype in outline, but smaller.

(b) Escutcheon view showing the extension of the median groove as far as the shell is preserved, the narrow escutcheon and the long, lanceolate ligament groove with nymphal plates.

FIG.3. Trigonia (Indotrigonia) smeei J. de C. Sowerby; Blake Collection (British Museum No. L.75422); Moondan, Iddurghur, Cutch; Argovian.

(a) Lateral view showing the elongate, rather quadrangular shape; the area is proportionately large with closely spaced, imbricate costellae.

(b) Anterior view showing poor definition of the frontal face and no change in the direction of the costae across it. The costae do not quite reach the anterior margin.

(c) Escutcheon view showing the rather compressed appearance of this well-grown shell. The escutcheon is defined from the area mainly by change in the direction of the costellae which almost all pass on to it. The marginal carina is rounded-off over much of the shell's growth.

FIG.4. Trigonia (Indotrigonia) smeei J. de C. Sowerby; Blake Collection (British Museum No. L.75421); Moondan, Iddurghur, Cutch; Argovian.

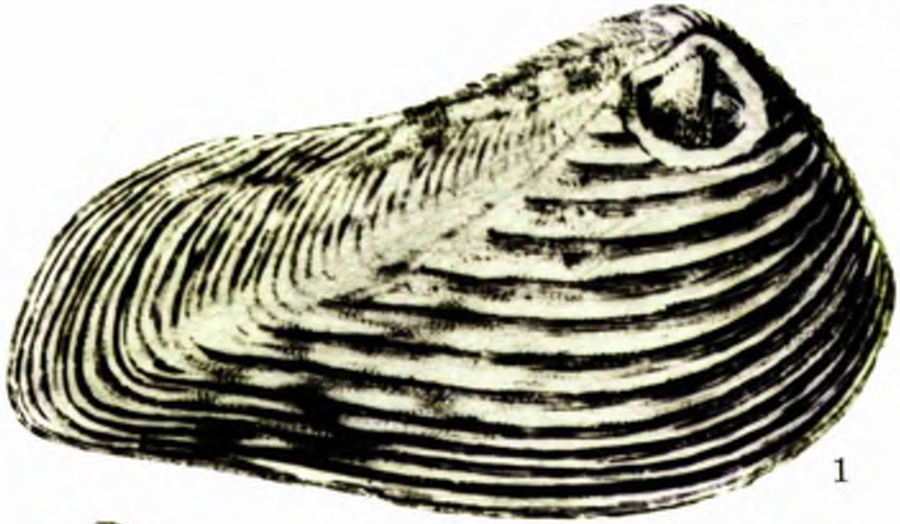
(a) Lateral view showing the very marked marginal groove, the marginal carina being rounded-off in the lower 2/3 of the shell's growth.

(b) Escutcheon view showing traces of radial ornament near the umbo; the median groove extends to the posterior end and marks a change in direction of the areal costellae. Except near the umbo, where a trace of an inner carina is visible, the escutcheon is defined only by a change in the direction of the costellae which pass on to it and by the angle between the surfaces of the area and the escutcheon. This smaller shell has a less compressed appearance than that in Fig.3.

(c) Anterior view showing the relatively large ratio of thickness to height. The frontal face (partly masked by erosion of the shell) is not well developed.

Plate VI


2b


1


2a


3b


3c


3a


4a


4b


4c

PLATE VII.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.971, north of the Mandawa Stream (see also Plate IX, figs.1,2); Middle or Upper Kimmeridgian. Pages 60,87.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) mandawae sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11524).

(a) Lateral view showing the elongate shape, short anterior end and obtusely V-ed costae; a marginal groove is visible to past mid-growth.

(b) Anterior view showing the frontal face on which the ornament is not well preserved.

(c) Escutcheon view showing the radial ornament of the area and a well marked marginal carina in the umbonal region. The depressed escutcheon is well defined near the umbo by an inner carina.

FIG.2. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11520). Lateral view of a specimen with a more convex anterior end than usual and with a small area set at a right angle to the flank almost to mid-growth. The costae are obtusely V-ed in the umbonal region but lower down are smoothly convex for $\frac{3}{4}$ of their length from the anterior end where they are sharply kinked to the horizontal.

FIG.3. Trigonia (Indotrigonia) mandawae sp. nov.; [Geol. Surv. Tanganyika, No. WA.971(4)].

(a) Lateral view of a shell with rather steep postero-dorsal margin and rather pointed posterior end. The costae are V-ed only in the upper part of the shell. Later they are nearly horizontal over a large part of their length. A marginal groove is visible to beyond mid-growth.

(b) Anterior view showing the well developed frontal face over which the costae, for the most part, pass horizontally but do not reach the anterior margin. The lower costae follow the growth lines and are asymptotic to the earlier costae.

(c) Escutcheon view showing the marginal carina in the umbonal region and change in direction of costellae along the extension of the line of a median groove, itself only visible near the umbo. The escutcheon is wider than usual.

Plate VII

1a

1b

1c

2

3a

3b

3c

PLATE VIII.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.793, Mandawa Stream; Middle or Upper Kimmeridgian. Pages 60, 87.

(All figures are approx. 9/10ths of natural size).

FIG.1. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11559).

(a) Lateral view showing the elongate shape, the rather pointed posterior end, and the concave postero-dorsal margin; the anterior outline is more convex than in the generality of specimens. The area is not steeply inclined to the flank and is well separated from it by the ante-carinal groove. There is slight V-ing of the upper flank costae.

(b) Escutcheon view showing the ligament groove and nymphal plates; the escutcheon is rather ill-defined, with sparse oblique ridges; the marginal carina is well-defined umbonally.

(c) Anterior view showing the well-defined frontal face, with the costae thickened at the angulation of the flank but not extending to the anterior margin.

FIG.2. Trigonia (Indotrigonia) mandawae sp. nov. (Hunt. Mus. No. S.11557). Lateral view showing the roughly triangular outline; the nearly terminal umbones; and the area steeply inclined to the flank. There is some crowding of the lower costae, which here pass unbroken into the areal costellae, though splitting higher in the shell.

FIG.3. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11558).

(a) Lateral view showing the slightly V-ed and warped upper costae; the marginal groove extending to mid-growth; and the area set at a rather abrupt angle to the flank.

(b) Escutcheon view, showing the well-defined marginal carina umbonally; traces of radial ornament of the area to 10 mm. and of a median groove to beyond this; slight angulation of the areal costellae along the continuation of the line of the median groove, and thickening of these towards the edge of the escutcheon; and slight imbrication of the costellae distally.

(c) Anterior view, showing a smooth band at the anterior margin.

FIGS.4-5. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. Nos. S.11561-2). Incomplete shells showing marked irregularity of the costae, which, in both cases, are grooved in the lower part of the shell.

Plate VIII

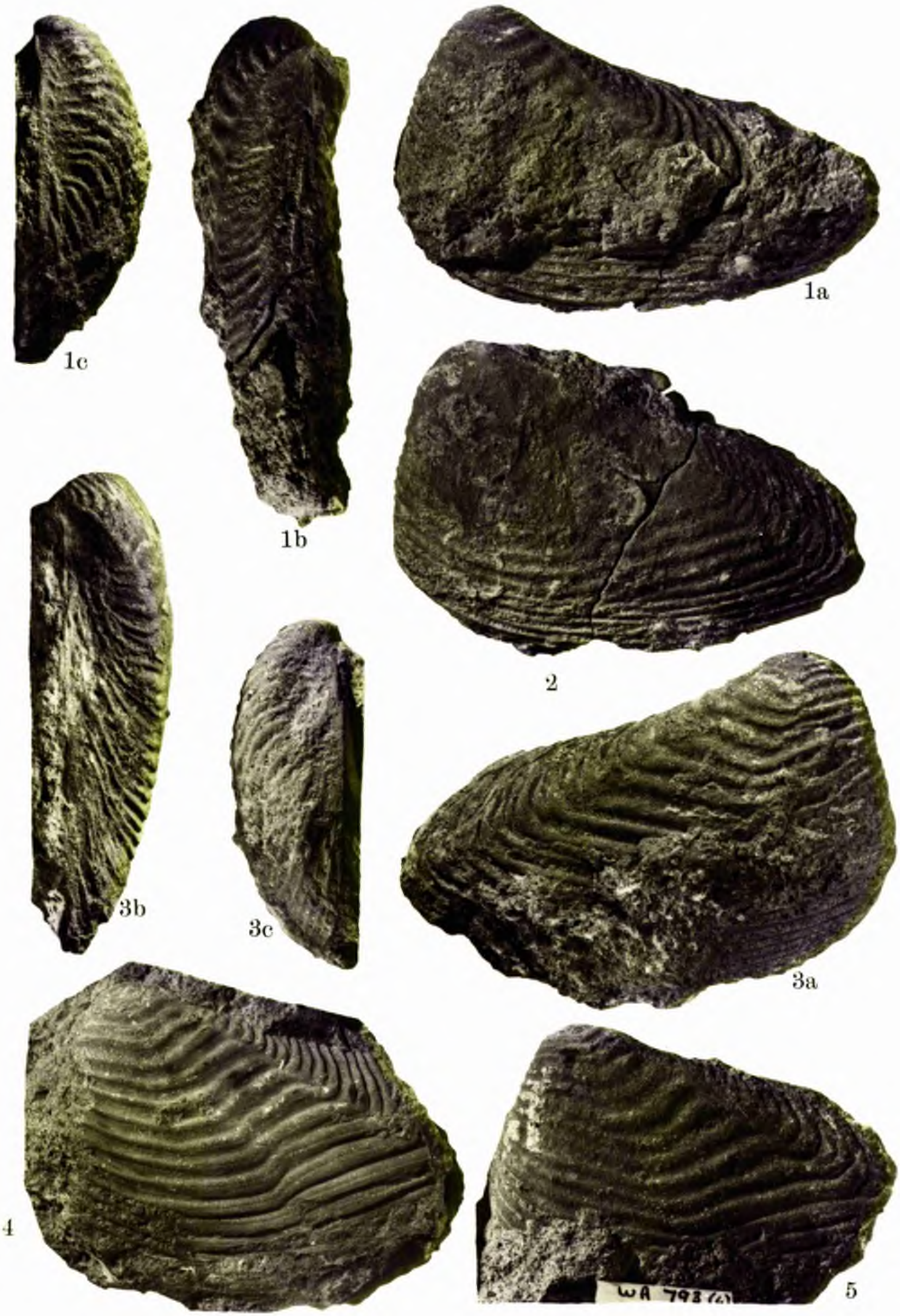


PLATE IX.

Trigonia (Indotrigonia) mandawae sp. nov.; Middle or Upper Kimmeridgian. Pages 60, 87.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) mandawae sp. nov.; Hunt. Mus. No. S.11533). Locality WA.971, north of the Mandawa Stream (see also Plate VII). Specimen showing the hinge, typically trigoniid, with the posterior portion of the bifid tooth 2 elongated. Tooth 4b is much reduced. The posterior pedal retractor muscle scar is visible.

FIG.2. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11525). Locality WA.971, north of the Mandawa Stream (see also Plate VII). Elongate shell with straight lower border. The costae are irregular, each being kinked or off-set near the middle of its length. The costellae appear slightly imbricate.

FIG.3. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11577). Locality WA.1852, Lihimaliao Stream. Shell showing elongate shape, but well defined, oblique posterior margin.

FIG.4. Trigonia (Indotrigonia) mandawae sp. nov.; (Hunt. Mus. No. S.11585). Locality WA.1676, Mbinga - Njenga road. Incomplete and eroded shell with shape and elongation as in T. (Indotrigonia) mandawae, but with flank costae wider spaced and irregularly undulating, probably due to abnormality.

1

2

3

4

PLATE X.

Illustration of the community of _Trigonia (Indotrigonia)_ from Locality WA.1628, Nambango Stream (see also Plate XI); Tithonian. Pages 65, 93.

(All figures are approx. 4/5ths of natural size).

FIG.1. _Trigonia (Indotrigonia) africana_ sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11599).

(a) Lateral view showing the marked roundness of the anterior and lower borders; the marginal groove is visible to a late stage of growth.

(b) Anterior view showing slight development of a frontal face which the flank costae cross with some irregularity. There is no thickening of the costae at the angulation of the flank.

(c) Escutcheon view showing the very slight median depression on the area without any marked change in the direction of the areal costellae; no radial ornament is visible. The escutcheon is large and smooth except for occasional encroachment of areal costellae. The ligament groove is visible.

FIG.2. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11619).

(a) Lateral view of a specimen with a proportionately rather larger area than usual.

(b) Escutcheon view showing an almost total lack of differentiation of the escutcheon and area; the escutcheon is fully or partly crossed by extensions of numerous areal costellae.

FIG.3. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11642). Lateral view showing some tendency to the pattern of _T. (Indotrigonia) robusta_ sp. nov., with clear-cut upstanding costae and areal costellae, becoming more prominent towards the marginal groove which is well marked on this account.

FIG.4. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11620).

(a) Lateral view showing the short figure and proportionately rather small area; the marginal groove is not distinct, but the area is separated from the flank by a distinct angulation.

(b) Anterior view showing the scarcely noticeable frontal face, and the flank costae extending uninterrupted to the anterior margin.

(c) Escutcheon view showing the large escutcheon, well marked-off from the area by depression and the almost total lack of ornament.

Plate X

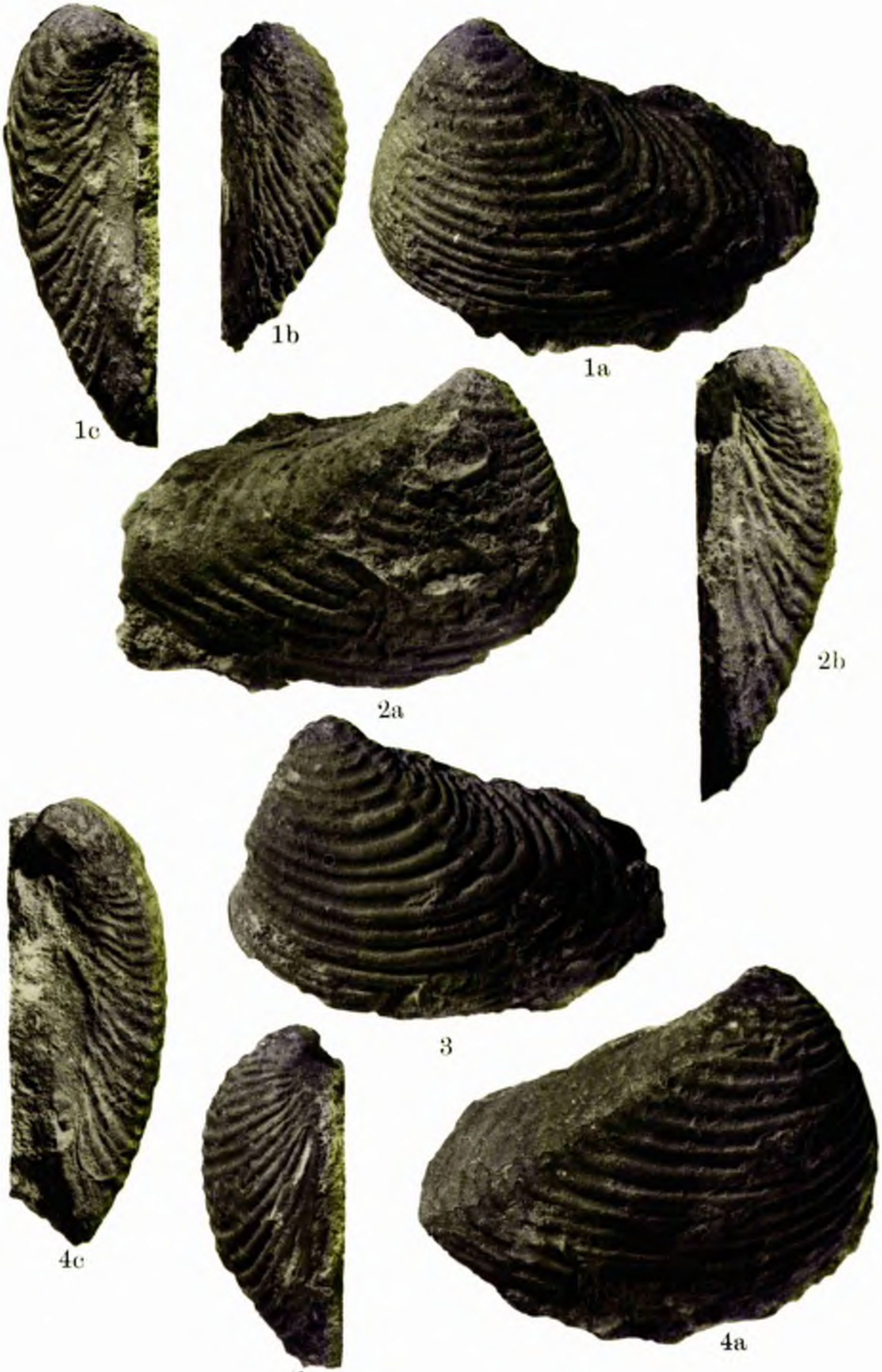


PLATE XI.

Further illustration of the community of _Trigonia_ (_Indotrigonia_) from Locality WA.1628, Nambango Stream (see also Plate X); Tithonian. Pages 65, 93.

(All figures are approx. 9/10ths of natural size).

FIG.1. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11639).

(a) Lateral view of the immature specimen, showing its marked roundness. The flank costae and areal costellae are of equal strength but the latter are slightly closer spaced near the umbo; there is a very strong marginal groove.

(b) Escutcheon view showing traces of a marginal carina near the umbo and a median groove extending throughout most of the shell's growth; the areal costellae are rather irregular.

(c) Anterior view showing the absence of a frontal face.

FIG.2. _Trigonia (Indotrigonia) africana_ sp. nov.; broken immature specimen; [Geol. Surv. Tanganyika No. WA.1628(113)]. Escutcheon view of a broken immature specimen showing a marginal carina and radial ornament of the area near the umbo; the escutcheon is ribbed by extensions of the areal costellae.

FIG.3. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11595).

(a) Lateral view showing the general roundness of outline; the prominent marginal groove; the areal costellae nearly as strong as the costae but not continuing them across the groove.

(b) Escutcheon view showing a trace of the median groove throughout growth; the escutcheon is broad, depressed and ribbed by extensions of some of the areal costellae; large ligament groove.

FIG.4. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11592). Interior view partly exposed showing the eroded hinge.

FIG.5. _Trigonia (Indotrigonia) africana_ sp. nov.; (Hunt. Mus. No. S.11672). Interior view partly exposed showing the eroded hinge.

FIG. 6. *Trigonia (Indotrigonia) africana* sp. nov.; (Hunt. Mus. No. S.11645). Lateral view showing some tendency to the pattern of *T. (Indotrigonia) robusta* sp. nov., with rather swollen costae and strongly marked marginal groove.

1a

1b

1c

2

3a

4

5

6

PLATE XII.

Illustration of the community of (*Trigonia*) *Indotrigonia* from Locality WA.1656, Ngirito Stream; Tithonian.

Pages 67, 93.

(All figures are approx. 9/10ths of natural size).

FIG.1. *Trigonia (Indotrigonia) africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.1656(5)].

(a) Lateral view showing marked roundness of the anterior and lower borders and concavity of the postero-dorsal margin, the marginal groove is distinct to an advanced stage of growth and the areal costellae are thinner and more numerous than the costae of the flank.

(b) Escutcheon view showing a median groove on the area well marked near the umbo. The wide, depressed, mainly smooth escutcheon has only irregular extension on to it at a young stage of areal costellae.

(c) Anterior view showing a well developed frontal face on to which the flank ribs scarcely encroach; it is ornamented only by growth lines.

FIG.2. *Trigonia (Indotrigonia) africana* sp. nov.; (Hunt. Mus. No. S.11777).

(a) Lateral view of a specimen incomplete posteriorly; it is the largest example of the species in the collection, but apparently shows normal characters throughout growth.

(b) Anterior view showing occasional encroachment of the costae on to the ill-defined frontal face.

FIG.3. *Trigonia (Indotrigonia) africana* sp. nov.; (Hunt. Mus. No. S.11784). Interior view, showing partly exposed, long hinge teeth.

FIG.4. *Trigonia (Indotrigonia)* aff. *robusta* sp. nov.; (Hunt. Mus. No. S.11764). Lateral view showing robust development of the flank costae with some swelling towards a strongly marked marginal groove; there is rather more marked swelling towards this groove of the areal costellae, which are, however, more numerous than the flank costae.

FIG.5. _Trigonia (Indotrigonia)_ aff. _beyschlagi_ Müller; (Hunt. Mus. No. S.11766).

(a) Lateral view of a comparatively small specimen exhibiting rather wide flattened costae on the flank, some of them passing unbroken into the costellae of the rather narrow area. The shape, with rather straight postero-dorsal and anterior borders is typical of the species, but the smoothed-off appearance of the flank is absent.

(b) Escutcheon view showing poor definition of the escutcheon, with the areal costellae crossing on to it.

(c) Anterior view showing the poorly developed frontal face, with the flank costae extending across it almost to the valve margin.

Plate XII

PLATE XIII.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.2179, Nalwehe Stream; ?Tithonian.

Pages 70, 93.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11724).

(a-b) Right and left valves respectively in lateral view showing the rather prominent marginal groove with broadening of the costae towards it in the lower half of the shell and some irregularity in the general concentric disposition of the costae.

(c) Escutcheon view showing the coarse ornamentation of irregular ridges.

(d) Anterior view showing feeble development of the frontal face.

FIG.2. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11726). Lateral view of a large specimen, showing broadening of the costae and occasional irregular insertion of costae posteriorly, in the lower half of the shell.

FIG.3. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11733).

(a) Lateral view showing abrupt up-turning of the broadened, slightly irregular costae near the posterior edge of the flank to give the effect of obtuse V's.

(b) Anterior view showing a well developed frontal face which the costae cross except at a band near the anterior margin.

(c) Escutcheon view showing a median depression on the area. The escutcheon is sharply defined near the umbo, and is obliquely ridged.

FIG.4. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11725).

(a-b) Left and right valves respectively in lateral view. The left valve shows broadening of the costae towards the rear but no visible marginal groove, the costae apparently splitting into more numerous costellae on crossing to the area. On the right valve at mid-growth, separation of the flank costae increases to the rear; they are warped but not broadened.

(c) Escutcheon view showing traces of marginal and inner carinae near the umbo. The escutcheon is slightly depressed and crossed by a few oblique ridges. The ligament groove and nymphal plates are visible.

(d) Anterior view showing the considerable thickness in relation to height, and the frontal face across which the costae turn abruptly upwards.

1a 1b 1c 1d 2 3a 3b 3c 4a 4b 4c 4d

PLATE XIV.

Trigonia (Indotrigonia) beyschlagi Müller; T. (Indotrigonia) aff. beyschlagi. Page 99.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) beyschlagi Müller. Reproduction of the illustration of the holotype (Müller, 1900, Pl.XIX, figs.1-2).

(a) Lateral view showing the high triangular figure. The costae are rounded with narrow interspaces. There is no marginal carina or angulation and no marginal groove. The costae sometimes bifurcate over the curve of the surface from flank to area.

(b) Anterior view showing the frontal face.

FIG.2. Trigonia (Indotrigonia) beyschlagi Müller. Reproduction of an illustration of a paratype (Müller, 1900, Pl.XIX, fig.3) in escutcheon view, showing the poor distinction of the convex area from the escutcheon, with costellae forming irregularly broken ridges over the escutcheon. Ligament groove visible.

FIGS.3 - 5

Trigonia (Indotrigonia) aff. beyschlagi Müller.

[British Museum (Natural History) specimens; ?Tithonian, ?Neocomian; Cutch, India: labelled "T. (Indotrigonia) beyschlagi = crassa"].

FIG.3. Trigonia (Indotrigonia) aff. beyschlagi Müller; B.M. Specimen No. L.75436.

(a) Lateral view showing the rather high triangular outline of a specimen which is incomplete at the posterior end. A marginal groove is visible in the upper part of the shell. The costae are wide, rounded and depressed, especially at the central area of the flank. Two costellae are usually formed by bifurcation of one costa, but the relationship is irregular.

(b) Anterior view showing the frontal face with the costae levelling off to nearly horizontal across it but not thickening at the angulation of the shell's surface. The costae turn upwards at their extreme anterior ends and thin off.

(c) Escutcheon view showing the marginal groove but no radial ornament of the convex area. The escutcheon is ill-defined, with some of the costellae extending on to it. The ligament groove is obscure, apparently long and narrow.

FIG.4. Trigonia (Indotrigonia) aff. beyschlagi Müller; B.M. Specimen No. L. 75435. Lateral view of an incomplete shell showing the persistence of the marginal groove. There is very obtuse V-ing of the wide depressed costae in the upper part of the flank. The lower costae are narrower and close-spaced.

FIG.5. Trigonia (Indotrigonia) aff. beyschlagi Müller; B.M. Specimen No. L. 75438. Lateral view of an incomplete specimen showing irregularity of the costae on the anterior part of the flank.

Plate XIV

2

1b

1a

3c

3b

3a

4

5

PLATE XV.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.2176, Nalwehe Stream (see also Plate XVI, fig.1); ?Tithonian. Pages 68, 99.

(All figures are approx. 9/10ths of natural size).

FIG.1. Trigonia (Indotrigonia) beyschlagi Müller; (Hunt. Mus. No. S.11747).

(a) Lateral view showing the high, rather triangular shape; the area is poorly delimited from the flank. There are flattened, wide, smoothed-off costae on the flank except in the lower part where they are closer and more carinate. There is no regular relation between the flank costae and the areal costellae, several of which may appear to develop out of one wide costa.

(b) Escutcheon view showing the poor definition of the escutcheon, except in the upper part. Some areal costellae cross the escutcheon. A rather short ligament groove is visible.

(c) Anterior view showing the poorly developed frontal face.

FIG.2. Trigonia (Indotrigonia) beyschlagi Müller; (Hunt. Mus. No. S.11738).

(a) Lateral view of a rather small specimen of triangular shape. Generally two areal costellae correspond to one wide flattened flank costa.

(b) Escutcheon view showing the definition of the escutcheon from the area only by change in direction of the ornament and termination of some areal costellae.

(c) Anterior view showing the slightly concave frontal face which the flank ribs do not cross to the anterior margin.

FIG.3. Trigonia (Indotrigonia) beyschlagi Müller; [Geol. Surv. Tanganyika No. WA.2176(3)]. Lateral view of an example with a long posterior margin and hence a quadrangular shape.

FIG.4. Trigonia (Indotrigonia) beyschlagi Müller; [Geol. Surv. Tanganyika No. WA.2176(1)]. Interior view showing part of the massive hinge.

FIG.5. Trigonia (Indotrigonia) beyschlagi Müller; (Hunt. Mus. No. S.11748).

(a) Lateral view showing the distinct change to closer, sharper costae and areal costellae in later stages.

(b) Escutcheon view showing a trace of a marginal groove and median groove on the upper part of the area. The escutcheon is slightly depressed, ornamented by oblique ridges, usually continuations of the areal costellae but, in the upper part, separated from the ends of these by a groove.

Plate XV

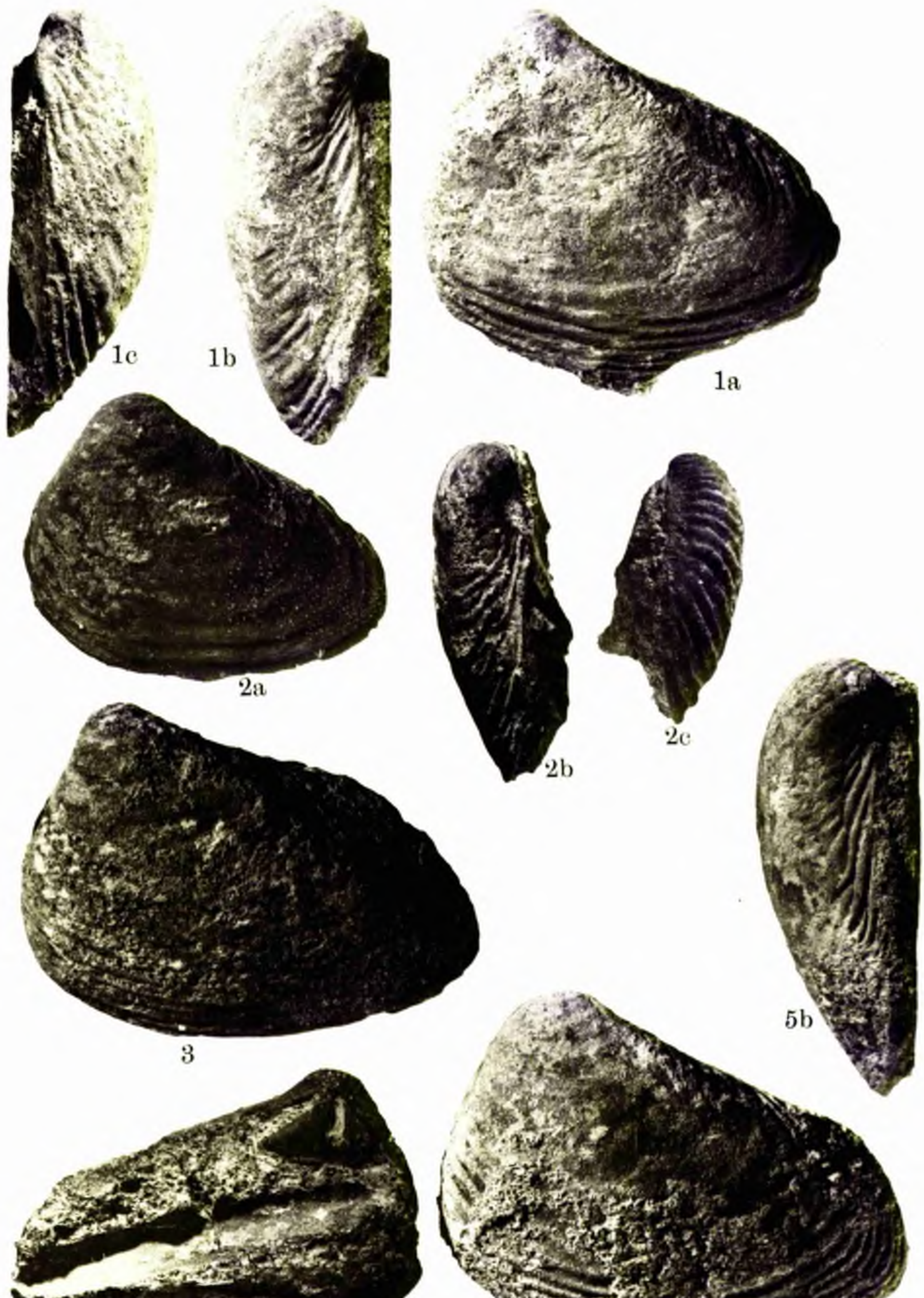


PLATE XVI.

Trigonia (Indotrigonia) beyschlagi: T. (Indotrigonia) aff. africana.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) beyschlagi Müller; (Hunt. Mus. No. S.11738). Locality WA.2176, Nalwehe Stream (see also Plate XV); ?Tithonian. Pages 69,99.

(a) Lateral view of a specimen broken posteriorly but showing the typical high triangular outline with the flank not well differentiated from the area. Some irregularity of the costae occurs about mid-growth.

(b) Escutcheon view showing the slightly depressed, broad escutcheon with strong growth rugae. There is no trace of radial ornament on the area.

(c) Anterior view showing the frontal face over which the costae cross.

FIGS.2 - 4.

Illustration of the community of Indotrigonia from Locality WA.2154, Mkundi Stream (see also Plate XVII); ?Tithonian. Page 71.

FIG.2. Trigonia (Indotrigonia) aff. beyschlagi Müller; (Hunt. Mus. No. S.11808).

(a) Lateral view showing the general triangular shape and smoothed-off appearance of the ornament which cannot be accounted for wholly by weathering. The flank costae broaden posteriorly; there is no marginal groove.

(b) Escutcheon view showing the absence of radial ornament of the area, and the ill-defined escutcheon.

FIG.3. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11802). Lateral view of a large, fairly elongated specimen exhibiting a trace of a marginal groove only near the umbo, but distinct differentiation of the flank and area by multiplication of the transverse costellae.

FIG.4. *Trigonia (Indotrigonia)* aff. *africana sp.* nov.; [Geol. Surv. Tanganyika No. WA.2154(4)]. Lateral view showing distinct obtuse V-ing of the costae until later stages of growth where concentric convex ribbing begins abruptly.

Plate XVI

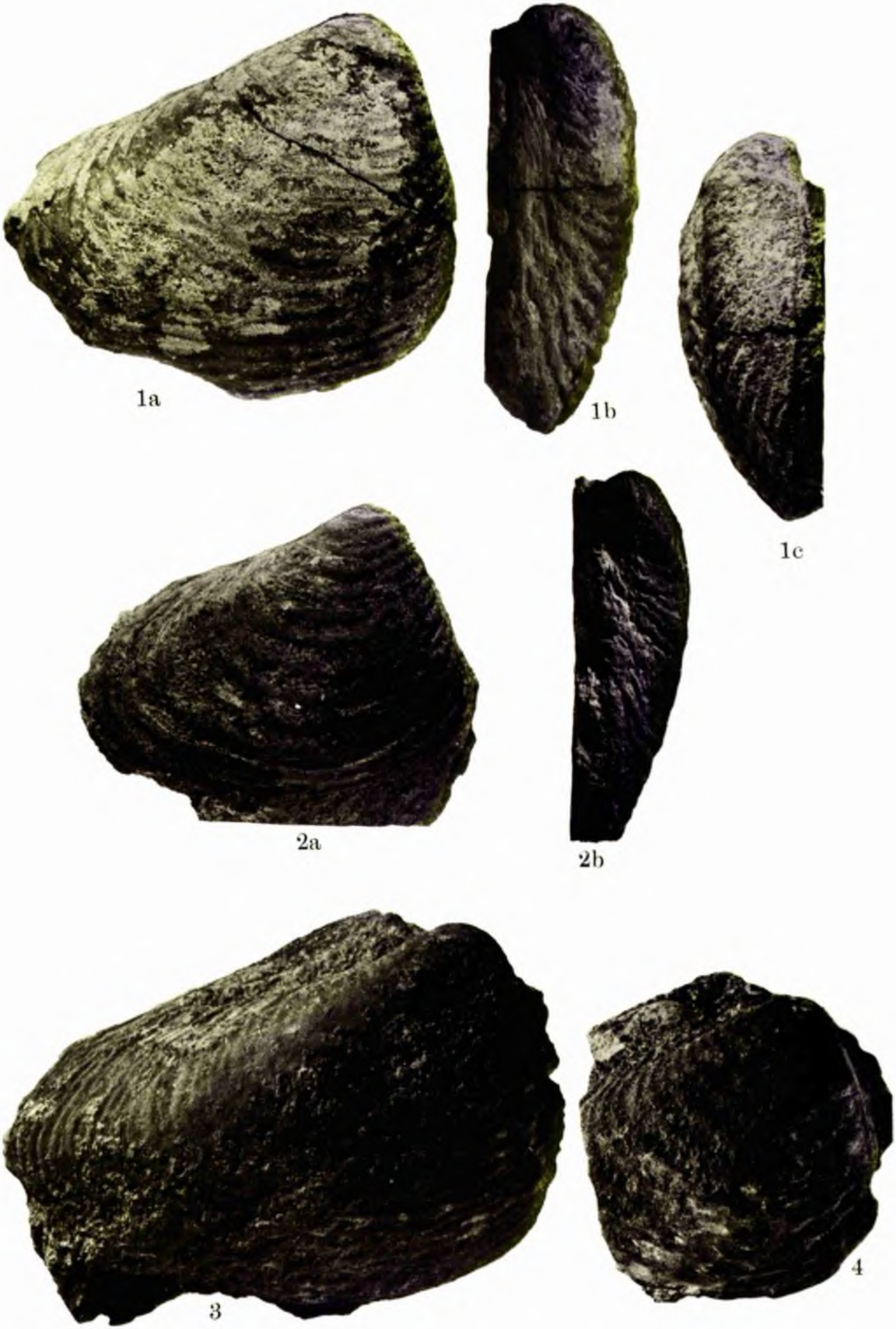


PLATE XVII.

Further illustration (see also Plate XVI, figs.2-4) of the community of Trigonia (Indotrigonia) from Locality WA.2154, Mkundi Stream; ?Tithonian. Page 71.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) aff. africana sp. nov.; /Geol. Surv. Tanganyika No. WA.2154(5)/.

(a) Lateral view showing broadening of the costae towards a well-defined but shallow marginal groove, and upward turning of some costae near the posterior edge of the flank.

(b) Escutcheon view showing a trace of a marginal carina near the umbo. The broad escutcheon is separated from the area in the upper part of the shell by an ill-defined groove. Some of the later areal costellae cross the escutcheon as oblique ridges.

(c) Anterior view showing the costae crossing the frontal face except in the upper part.

FIG.2. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11795). Lateral view showing swelling and irregularity of the costae, which have a V-ed attitude in the upper part but are concentric near the lower margin.

FIG.3. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11793). Lateral view showing V-ing and broadening of the costae, which split on passing over into the areal costellae, there being a trace of a marginal groove only to mid-growth. The lowermost costae are convex and concentric.

FIG.4. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11803). Lateral view showing distinct V-ing of the more or less regular costae in the upper part of the shell. There is abrupt change to crowded convex concentric costae in the lower part.

FIG.5. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11800). Lateral view of a triangular specimen in which costae rise abruptly across the anterior half of the flank and are slightly swollen towards the marginal groove.

FIG. 6. <u>Trigonia (Indotrigonia)</u> aff. <u>africana</u> sp. nov.; (Hunt. Mus. No. S.11801). Lateral view showing the costae swollen towards the posterior, but not V-ed.

1a

1b

1c

2

4

3

5

6

PLATE XVIII.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.961, in a tributary of the Mkomangoni Stream; Tithonian. Pages 67, 106.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) robusta sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11708).

(a) Lateral view showing swelling of the costae and of the areal costellae towards the marginal groove, which is therefore very strongly marked.

(b) Anterior view showing a well marked frontal face with the later costae passing upwards across it, in asymptotic relation to earlier ones.

(c) Escutcheon view, poorly exposed but showing the very narrow escutcheon.

FIG.2. Trigonia (Indotrigonia) aff. robusta sp. nov.; (Hunt. Mus. No.S.11713). Lateral view, showing some swelling of the costae towards the marginal groove, but without the same feature in the areal costellae; the marginal groove is less prominent than in typical examples of the species.

FIG.3. Trigonia (Indotrigonia) robusta sp. nov.; (Hunt. Mus. No. S.11706). Lateral view showing strong swelling towards the marginal groove of both costae and areal costellae, and upcurving of the latter at the groove.

FIG.4. Trigonia (Indotrigonia) robusta sp. nov.; (Hunt. Mus. No. S.11698).

(a) Lateral view of the upper part of an incomplete shell showing the usual characters but with a rather rounded anterior end.

(b) Anterior view showing a slightly concave frontal face, the lower costae crossing it obliquely, in asymptotic relation to earlier ones.

FIG.5. Trigonia (Indotrigonia) robusta sp. nov.; (Hunt. Mus. No. S.11707).

(a) Lateral view showing the usual characters, but the area proportionately larger than normal; the costae pass obliquely downwards from the marginal groove over most of their length.

(b) Escutcheon view showing a slight trace of the median groove; escutcheon ill-defined, crossed by oblique extensions of some of the areal costellae.

FIG.6. Trigonia (Indotrigonia) robusta sp. nov.; [Geol. Surv. Tanganyika No. WA.961(15)]. Lateral view showing areal costellae of equal strength to the flank costae but set opposite inter-spaces between the costae.

FIG.7. Trigonia (Indotrigonia) aff. africana sp. nov.; (Hunt. Mus. No. S.11719).

(a-c) Lateral, anterior and escutcheon views showing typical features of the species except for the proportionately large area and the irregularity of the marginal groove after $^{2}/3$ of the shell's growth.

Plate XVIII

PLATE XIX.

Illustration of the community of *Indotrigonia* from Locality WA.766 in the Tingutinguti Stream near Tendaguru, in the type area of the "*Trigonia smeei*" Bed. Tithonian.

Page 72.

(All figures are of natural size)

FIG. 1. *Trigonia (Indotrigonia)* aff. *africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.766(7)]. Lateral view of a complete, rather elongated specimen. The costellae are rather more crowded than in the typical *I. africana*.

FIG. 2. *Trigonia (Indotrigonia)* aff. *africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.766(6)].

(a) Lateral view showing broad, irregular costae separated from rather sharp, numerous areal costellae by an indistinct groove.

(b) Escutcheon view showing the rather narrow, flat area separated from the flank by a distinct angulation and a carina proximally. Escutcheon large, depressed.

(c) Anterior view showing the lack of a distinct frontal face, the anterior surface being well rounded.

FIG. 3. *Trigonia (Indotrigonia)* aff. *africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.766(3)]. Lateral view of a shell which is incomplete posteriorly. The flank and area are well separated by a marginal groove formed by constriction of the costae, which for the most part pass into the costellae, sometimes bifurcating. The costae are broken by irregular constrictions.

FIG. 4. *Trigonia (Indotrigonia)* aff. *africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.766(2)]. Lateral view of a broken specimen showing the well-elevated shape and poor separation of the area from the flank. The smoothed-off appearance of the costae is due to wear and is not an original feature as in *I. beyschlagi*.

FIG. 5. *Trigonia (Indotrigonia) africana* sp. nov.; [Geol. Surv. Tanganyika No. WA.766(6)]. Broken shell showing well-rounded outline, regularly convex costae, strong marginal groove and marked distinction of flank and area ornament.

Plate XIX

2c

2b

1

2a

3

4

5

PLATE XX.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.582 in the Kilangalanga Stream near Mtapaia Village; ?Upper Kimmeridgian ?Tithonian. Page 73.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) aff. africana sp. nov.; /Geol. Surv. Tanganyika No. WA.582(4)/. Lateral view of a large shell, more elongated than the usual I. africana but with the rounded anterior and lower borders and the rather long posterior margin typical of the species. The marginal groove extends to the postero-ventral extremity.

FIG.2. Trigonia (Indotrigonia) mandawae sp. nov.; /Geol. Surv. Tanganyika No. WA.582(2)/. Lateral view showing the elongate figure; short anterior end; straight, nearly vertical, anterior margin and long, nearly straight, lower margin. The costae are interrupted along a line a little posterior to the middle of their length. There is no marginal groove but the area is distinct from the flank by reason of the numerous costellae.

FIG.3. Trigonia (Indotrigonia) africana sp. nov.; /Geol. Surv. Tanganyika No. WA.582(6)/.

(a) Lateral view of the shell, incomplete posteriorly but with a fairly short figure and convex lower border.

(b) Anterior view showing the considerable thickness. There is some development of a frontal face, and the costae do not reach to the anterior margin.

Plate XX

1

2

3a

3b

PLATE XXI.

Illustration of the community of Trigonia (Indotrigonia) from Locality WA.781 in the Kilangalanga Stream near Mtapaia Village; ?Upper Kimmeridgian ?Tithonian.

Page 73.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) africana sp. nov.; [Geol. Surv. Tanganyika No. WA.781(11)]. Lateral view of a fairly elongate shell with well rounded anterior end and lower border. The costellae are rather sharper and more imbricating than in the usual I. africana.

FIG.2. Trigonia (Indotrigonia) aff. africana sp. nov.; [Geol. Surv. Tanganyika No. WA.781(8)]. Lateral view of the shell, with convex anterior and lower margins and well-marked marginal groove, but with irregularity and widening of the costae reminiscent of "Indotrigonia smeei" Dietrich 1933.

FIG.3. Trigonia (Indotrigonia) aff. mandawae sp. nov.; [Geol. Surv. Tanganyika No. WA.781(13)]. Lateral view of the elongated shell with indistinct marginal groove and small area in relation to the size of the flank. The costae are more evenly convex than is usual in T. (Indotrigonia) mandawae s. str.

FIG.4. Trigonia (Indotrigonia) aff. africana sp. nov.; [Geol. Surv. Tanganyika No. WA.781(3)].

(a) Lateral view of the elongated shell with strongly convex lower border, and fairly long anterior end. The marginal groove extends throughout growth and marks off a rather large area.

(b) Escutcheon view showing the compressed shape of the shell. The area has a median groove. The escutcheon is large and slightly depressed.

(c) Anterior view showing the termination of the costae on the narrow frontal face before reaching the anterior margin.

Plate XXI

1

2

3

4a

4b

4c

PLATE XXII.

Trigonia (Indotrigonia) v-striata sp. nov.

Tithonian. Page 110.

(All figures are of natural size).

FIG.1. Trigonia (Indotrigonia) v-striata sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11749). Locality WA.1628, Nambango Stream.

(a) Lateral view showing the complete outline, and characteristic ornament of strongly V-ed costae.

(b) Anterior view showing the well developed frontal face, thickening of the costae at the angulation of the flank and their thinning towards the anterior margin. Later costae follow the growth lines and are asymptotic to those crossing the frontal face.

(c) Escutcheon view showing traces of radial ornament in the upper part.

FIG.2. Trigonia (Indotrigonia) v-striata sp. nov.; (Hunt. Mus. No. S.11753). Locality WA.1628, Nambango Stream.

(a) Lateral view of a broken specimen, showing thickening and some tuberculation of the costae and marked difference in thickness of the ornament of the flank and area.

(b) Anterior view showing a marked frontal face; the costae are thickened at the angulation of the flank but rapidly die out towards the anterior margin, leaving an almost smooth surface.

FIG.3. Trigonia (Indotrigonia) v-striata sp. nov.; (Hunt. Mus. No. S.11760). Locality WA.1782, Lihimaliao Stream.

(a) Lateral view showing thickening and some tuberculation of the costae. The later concentric ribs are broken into elongated tubercles lying en echelon.

(b) Escutcheon view showing radial ornament of the area in the upper part; the escutcheon is wide, smooth and slightly depressed. The strongly out-jutting hinge tooth 2b is visible.

FIG.4. Trigonia (Indotrigonia) v-striata sp. nov.; (Hunt. Mus. No. S.11755). Locality WA.1265, Kikundi Stream.

(a) Lateral view showing strong differentiation of the flank and area ornament at a deep marginal groove; the posterior limbs of the V's of the flank ornament are broken up into tubercles.

(b) Anterior view showing the frontal face. The costae are thickened at the angulation of the flank; they thin towards the anterior margin and turn upwards parallel to it.

(c) Escutcheon view showing a strong median groove and slight tuberculation of the areal costellae to give a further radial effect to the area ornament; there is an incipient inner-carina. The escutcheon is ornamented by oblique tuberculated ridges.

FIG.5. Trigonia (Indotrigonia) v-striata sp. nov.; (Hunt. Mus. No. S.11757). Locality WA.1265, Kikundi Stream.

(a) Lateral view showing thickening and nodulation of the flank costae which are not broken up into distinct tubercles.

(b) Anterior view showing the well-defined, slightly hollowed, frontal face; the flank costae are thickened at the angulation of the flank, but rapidly thin out on passing across the frontal face. Later fine growth rugae are asymptotic to them.

(c) Escutcheon view showing a very strong, median groove and tuberculate marginal and inner carinae in the upper part of the shell. The escutcheon is smooth and slightly depressed; the upper parts of the ligament groove and nymphal plate are visible.

FIG.6. Trigonia (Indotrigonia) v-striata sp. nov.; (Hunt. Mus. No. S.11762). Locality WA.963, Mkomangoni Stream. Escutcheon view. The escutcheon and area are of about equal width, the former slightly depressed and ornamented by strong oblique rather broken ridges.

Plate XXII

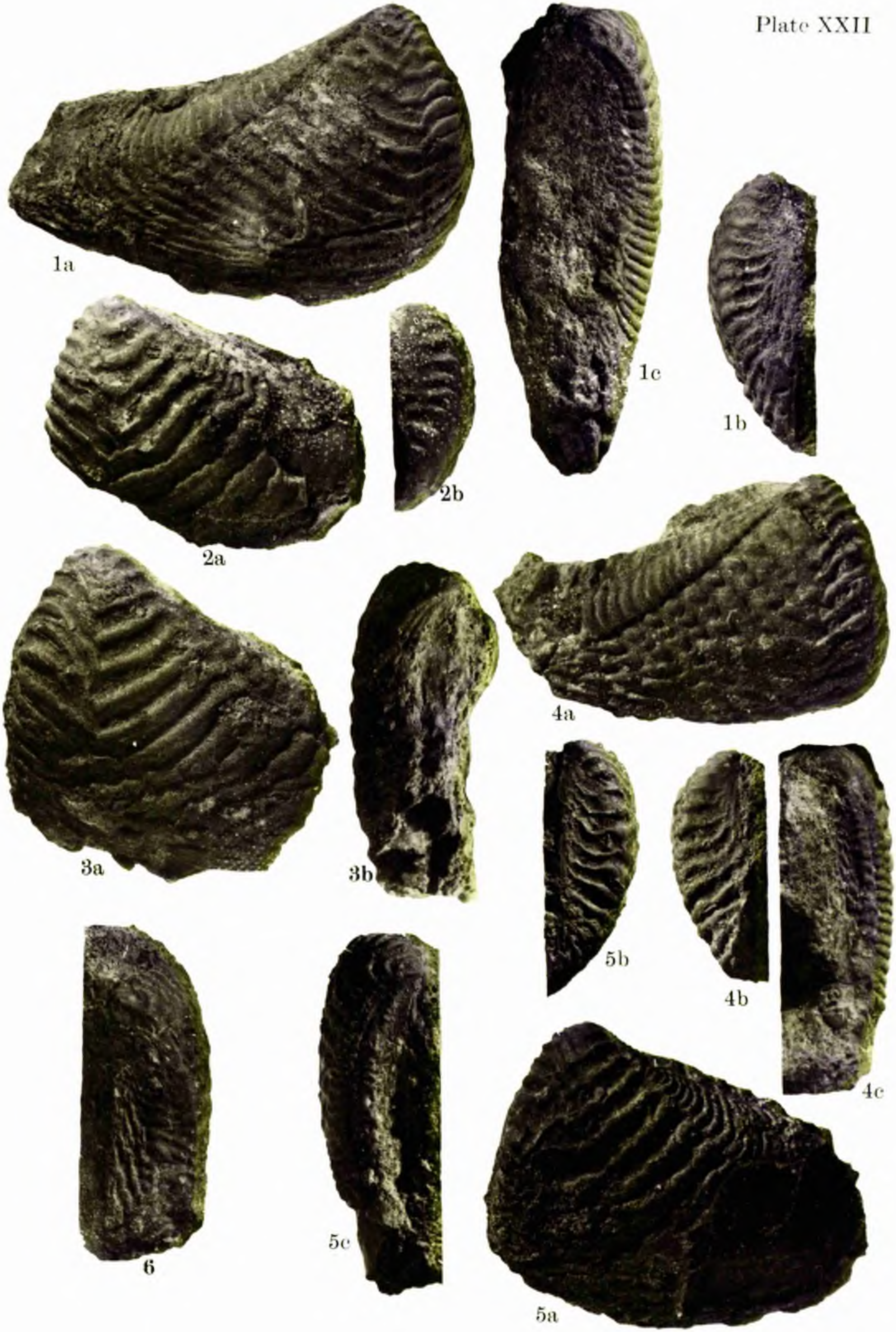


PLATE XXIII.

?Prosogyrotrigonia, ?Pleurotrigonia, Indotrigonia.

(All figures are of natural size).

FIG.1. ?Prosogyrotrigonia sp. nov.; (Hunt. Mus. No. S.11484). Locality WA.2195, Upper Nunga Stream; Middle Kimmeridgian. Page 11.

(a) Lateral view showing the ovately trigonal outline of the small shell, the sharp marginal angulation and the narrow close-spaced concentric costae.

(b) Escutcheon view showing the slightly concave, nearly parallel-sided area with transverse costellae.

FIGS.2 - 8.

Trigonia (?Pleurotrigonia) sp. nov. Locality WA.855, Mkomangoni Tributary "B"; Tithonian. Page 44.

FIG.2. Trigonia (?Pleurotrigonia) sp. nov.; (Hunt. Mus. No. S.12083). Hand specimen with two examples, the upper one only showing detail. Strong, regular, concentric costae are visible, separated from the strong, smooth, marginal carina by only a slight groove. The large smooth area has a well-marked median groove. An original lunate shape is suggested by the impression of the area.

FIG.3. Trigonia (?Pleurotrigonia) sp. nov.; /Geol. Surv. Tanganyika No.WA.855(32)/.

(a) & (b) Cast and plasticine squeeze respectively, showing detail of the area and escutcheon. The area is smooth, divided by a strong median groove into two almost equal parts, both slightly convex. An inner carina of small, well-spaced denticles separates the area from the wide, smooth, depressed escutcheon.

FIG.4. Trigonia (?Pleurotrigonia) sp. nov.; (Hunt. Mus. No. S.12090). Lateral view of a specimen showing slightly swollen and irregular flank costae except for the latest ones which are thinner and regular. The costae terminate at an ante-carinal groove.

FIG.5. Trigonia (?Pleurotrigonia) sp. nov.; /Geol. Surv. Tanganyika No. WA.855(3)/. Lateral view of a specimen lacking most of the actual shell material, showing the rather lunate shape. The flank costae preserved at the anterior end are undulating.

FIG.6. Trigonia (?Pleurotrigonia) sp. nov.; (Hunt. Mus. No. S.12085). Lateral view of a specimen showing obtuse V-ing of the costae, which are separated from the marginal carina by a narrow groove.

FIG.7. Trigonia (?Pleurotrigonia) sp. nov.; (Hunt. Mus. No. S.12084). Lateral view of an ill-preserved specimen showing sharp up-curving and swelling of the costae near their posterior ends. The costae terminate at a narrow ante-carinal groove.

FIG.8. Trigonia (?Pleurotrigonia) sp. nov.; (Hunt. Mus. No. S.12087).

(a) Lateral view of a specimen with a rather narrow flank. The costae are slightly undulating and curve down towards the anterior end.

(b) Escutcheon view showing the strong, marginal carina and smooth area with no median groove visible. The escutcheon is not preserved but must have been rather narrow.

FIG.9. Trigonia (Indotrigonia) sp. nov.; (Hunt. Mus. No. S.12121). Locality WA.2328, north-west of the Lindi-Kilwa road crossing of the Lihimaliao Stream; Neocomian or Aptian. Page115.

(a) Lateral view showing the quadrangular outline; marked marginal groove almost bisecting the shell; crowding of the lower flank costae; and thickening towards the marginal groove of both costae and costellae.

(b) Escutcheon view showing the well defined, depressed escutcheon crossed by sharp oblique ridges continuing the areal costellae. There are traces of radial grooves on the area near the umbo, obscure due to erosion.


1a


1b

2

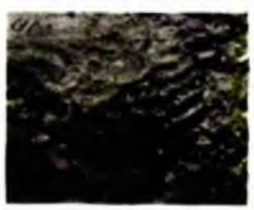

3a


3b


4


5


6


7


8a


8b


9a


9b

PLATE XXIV

Myophorella (Myophorella) and Myophorella (Orthotrigonia)

(All figures are of natural size)

FIG.1. ?Myophorella (Myophorella) sp.; (Hunt. Mus. No. S.11483). Locality WA.2154, Mkundi Stream; probably Tithonian. Page 120.

(a) Lateral view showing the small poorly preserved shell with fine, nearly vertical costae posteriorly, curving towards the horizontal at the anterior.

(b) Escutcheon view showing the strong transverse ridges on the escutcheon. The area is worn and no ornament is preserved.

FIGS.2 - 8.

Myophorella (Orthotrigonia) cf. kutchensis (Kitchin)

Callovian. Page 123.

FIG.2. Myophorella (Orthotrigonia) cf. kutchensis (Kitchin); (Hunt. Mus. No. S.12130). Locality WA.2016, Nchia River.

(a) Lateral view of the upper part of a shell showing the tuberculate concentric costae near the umbo, the tubercles extending as fine ridges into the intercostal spaces. The detail of the sub-vertical rib series is not well exposed. The marginal carina is well-marked in the upper part and the fine, transverse costellae of the wide area can be seen.

(b) Anterior view showing the wide spacing of the anterior horizontal series of costae.

(c) Escutcheon view showing the concentric series of costae near the umbones, the slightly concave, transversely striated area and the large depressed escutcheon (of which the ornament is not exposed). There is a trace of a median groove in the proximal part of the area.

FIG.3. Myophorella (Orthotrigonia) cf. kutchensis (Kitchin); (Hunt. Mus. No. S.12126). Locality WA.2218, Manyuli Stream.

(a) Lateral view of a nearly complete specimen partly obscured by matrix.

(b) Anterior view showing the wide spacing of the short horizontal series of costae, and the distinct frontal band.

FIG.4. <u>Myophorella (Orthotrigonia)</u> cf. <u>kutchensis</u> (Kitchin); (Hunt. Mus. No. S.12134). Locality WA.2230, Manyuli Stream.

(a) Lateral view of an incomplete shell showing the concentric costae near the umbo with tubercles extending into the interspaces. Such tubercles are also visible on the upper costae of the sub-vertical series.

(b) Anterior view showing the strong, widely-spaced, horizontal, anterior series of costae, but no distinct frontal band.

(c) Escutcheon view showing the proportions of area and escutcheon, both of which are eroded.

Fig.5. <u>Myophorella (Orthotrigonia)</u> cf. <u>kutchensis</u> (Kitchin); (Hunt. Mus. No. S.12125). Locality WA.1242, Runyo Stream.

(a & b) Lateral and escutcheon views respectively of a rather eroded shell.

FIG.6. <u>Myophorella (Orthotrigonia)</u> cf. <u>kutchensis</u> (Kitchin); (Hunt. Mus. No. S.12124). Locality WA.943, Mkomore Stream. Interior view showing the obliquely truncated posterior end and the poorly exposed trigoniid dentition.

FIG.7. <u>Myophorella (Orthotrigonia)</u> cf. <u>kutchensis</u> (Kitchin); (Hunt. Mus. No. S.12135). Locality WA.1180, Nchia Stream.

(a & b) Lateral and anterior views respectively of the anterior end of a broken shell, showing the distinct separation of the sub-vertical and horizontal, anterior series of costae.

FIG.8. <u>Myophorella (Orthotrigonia)</u> cf. <u>kutchensis</u> (Kitchin); (Hunt. Mus. No. S.12139). Locality WA.1634, Mbaru Stream. Lateral view of a large, incomplete, eroded shell showing the elongated tubercles on the upper costae encroaching on the intercostal spaces.

Fig.9. <u>Myophorella (Orthotrigonia)</u> sp. nov.; (Hunt. Mus. No. S.12122). Locality WA.2274, Ruawa area; ?Bajocian. Page 130.

(a) Lateral view of the incomplete shell showing the concentric, sub-vertical and horizontal, anterior series of fine, slightly tuberculate costae. The area is wide and ornamented by fine, closely spaced costellae. The elevated inner edge of the transversely ridged escutcheon can be seen.

(b) Anterior view showing the horizontal anterior series of costae.

(c) Escutcheon view showing the fine marginal carina, the finely costellate area and the large, transversely ridged, slightly depressed escutcheon.

FIG.10. Myophorella (Orthotrigonia) sp. nov.; (Hunt. Mus. No. S.12123). Locality WA.2244, Manyuli Stream; ?Bathonian ?Callovian.

(a) Lateral view of the upper part of the broken shell showing the rather extensive concentric series of costae with elongate tubercles encroaching on the interspaces. The sub-vertical and horizontal, anterior series of costae are finer than the concentric series. The marginal carina is not well developed but there is a distinct angulation between flank and area.

(b) Escutcheon view showing the fine transverse costellae of the area and the trace of a median groove. The escutcheon is depressed and transversely ridged.

Plate XXIV

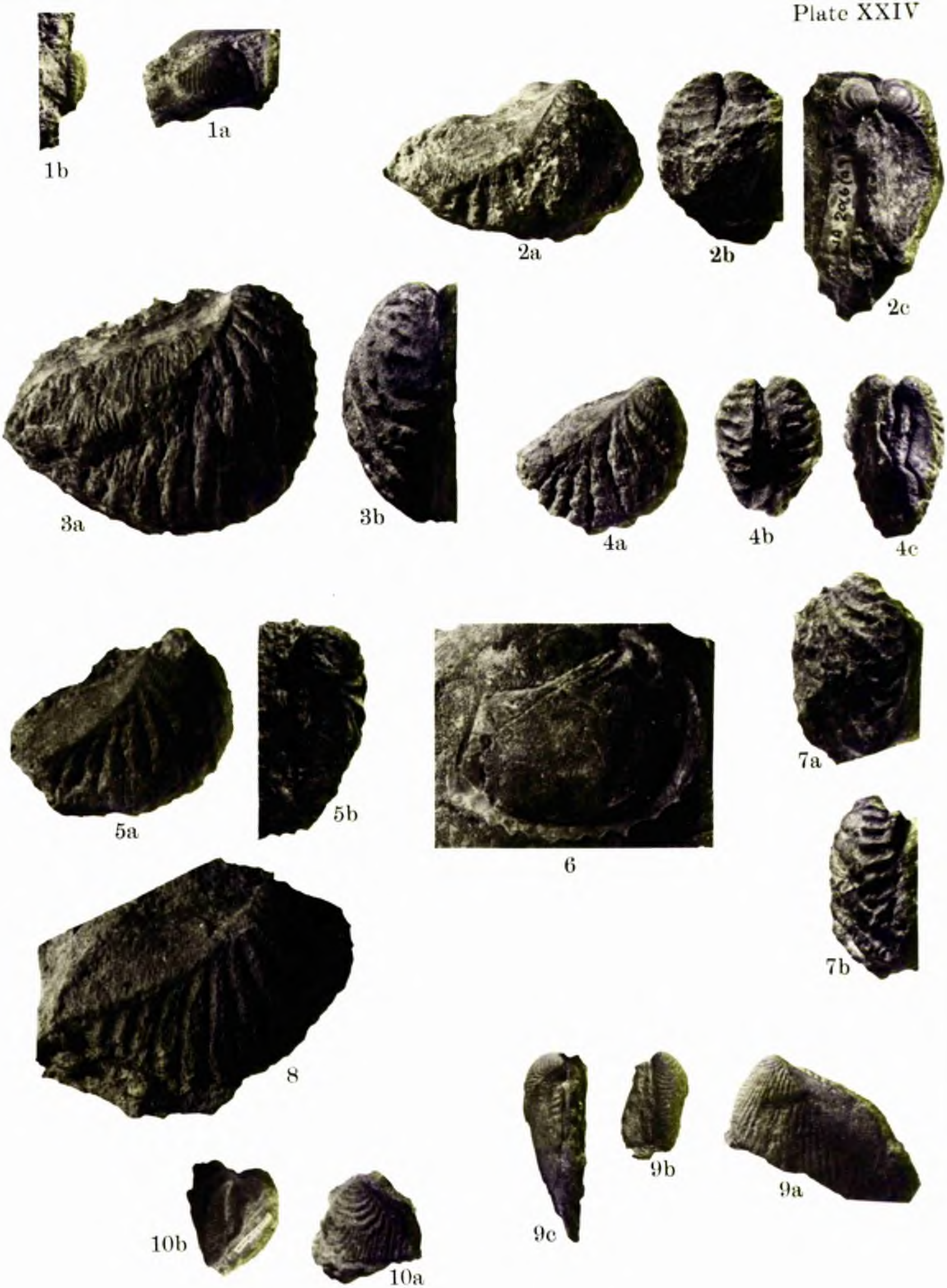


PLATE XXV.

Yaadia, Linotrigonia

(All figures are of natural size).

FIG.1. Yaadia hennigi (Lange); /Geol. Surv. Tanganyika No. WA.2494(4) /. Locality WA.2494, Nossa Stream; ?Neocomian ?Lower Aptian. Page 136. Lateral view of a large specimen partly obscured by matrix, showing the quadrate shape with the umbo nearly terminal and the anterior border curving backwards into the lower border which is strongly convex. The area appears to have been wide and not steeply inclined to the flank. The widely spaced sub-vertical costae are strongly tuberculate.

FIG.2. Yaadia hennigi (Lange); /Geol. Surv. Tanganyika No. WA.2565(A) /. Locality WA.2565, Mtapaia. ?Neocomian ?Lower Aptian.

(a) Lateral view of the incomplete shell in which the umbo is not terminal and the anterior end is convex.

(b) Escutcheon view showing a row of tubercles forming a marginal carina in the proximal part of the shell just below a longitudinal furrow. A slight inner carina is formed by a row of obscure tubercles. Otherwise the area is smooth except for growth wrinkles, and ornament is not preserved on the escutcheon.

FIG.3. ?Yaadia sp.; (Hunt. Mus. No. S.11485). Locality WA.963, Mkomangoni Stream; Tithonian. Page 141. Interior view, ill-exposed, showing the quadrate shape with short anterior end. Crenulations on the postero-ventral border presumably correspond to the ends of sub-vertical costae. Trigoniid dentition can be distinguished.

FIG.4. Linotrigonia (Linotrigonia) sp.; (Hunt. Mus. No. S.11480). Locality WA.2498, just east of the Makangaga Swamp; ?Neocomian ?Lower Aptian. Page 208. Lateral view of a small incomplete shell showing the strong marginal angulation. The costae are sub-concentric near the umbo but rapidly develop into ribs with a sub-vertical posterior limb and a nearly horizontal anterior limb. Costellae on the area form a chevron design with the costae.

FIG.5. Linotrigonia (Linotrigonia) sp.; (Hunt. Mus. No. S.11481). Locality WA.2498, just east of the Makangaga Swamp; ?Neocomian ?Lower Aptian. Lateral view of a small incomplete shell showing fine, vertically elongated tuberculation of the costae. The chevron arrangement of costae and costellae is clearly visible.

1

2a

2b

3

4a

5

PLATE XXVI.

(All figures are of natural size)

FIGS.1 - 4.

Illustrations of the community of *Megatrigonia (Megatrigonia) conocardiiformis* (Krauss) from Locality WA.2148, Mkundi Stream; ?Tithonian. Page 144.

FIG.1. *Megatrigonia (Megatrigonia) conocardiiformis* (Krauss); (Hunt. Mus. No. S.12050).

(a) Lateral view showing the long, narrow, posterior end and the initially concentric, slightly nodose costae becoming oblique and slightly angulated and almost vertical towards the posterior end. A small part of the flank at the posterior end is smooth. The area is narrow. There is no upstanding marginal carina but a distinct marginal angulation.

(b) Anterior view showing the strong costae approaching the anterior margin at about right angles.

FIG.2. *Megatrigonia (Megatrigonia) conocardiiformis* (Krauss); (Hunt. Mus. No. S.12051).

(a) Lateral view of an incomplete specimen showing very distinct angulation of the slightly nodose costae, the upper part of each being nearly vertical and the lower part straight and oblique. The oblique portion is stronger than the vertical portion and the two do not always match.

(b) Anterior view showing the strong costae not in all cases reaching the anterior margin.

FIG.3. *Megatrigonia (Megatrigonia) conocardiiformis* (Krauss); (Hunt. Mus. No. S.12052).

(a) Lateral view of a small incomplete individual. The angulation of the costae takes place much closer to the anterior end than usual; the posterior part of each rib is as strong as the anterior where visible, and there is off-setting of the two parts.

(b) Escutcheon view showing the marginal carina developed in the upper part of the shell. The median groove on the area can be distinguished.

(c) Anterior view showing the widely spaced short anterior portions of the costae.

FIG.4. *Megatrigonia (Megatrigonia) conocardiiformis* (Krauss); (Hunt. Mus. No. S.12054).

(a) Lateral view of an incomplete specimen showing the costae in two series. There is a fine, posterior, nearly vertical series and a widely spaced, oblique, anterior series of strong costae. The series meet at a slightly obtuse angle and the posterior series is about 1½ times as numerous as the posterior.

(b) Escutcheon view showing the narrow area with well-marked median groove. Traces of costae crossing the lower half of the area can be seen to 7 mm. from the umbo. The escutcheon is long, lanceolate, depressed and smooth.

(c) Anterior view showing the strong, widely spaced costae approaching the anterior margin at right angles.

FIGS.5 - 9.

Illustration of the community of Megatrigonia (Iotrigonia) from Locality WA.801 in Mkomangoni Tributary "B"; Tithonian. Page 149.

FIG.5. Megatrigonia (Iotrigonia) cf. haughtoni Rennie; (Hunt. Mus. No. S.11393).

(a) Lateral view of an almost complete shell showing the weak anterior and strong posterior series of costae forming V's on the flank; the anterior series is parallel to the growth lines, the posterior series nearly vertical from an early stage in growth.

(b) Escutcheon view showing the area to be smooth except in the umbonal region where it is crossed by continuations of the uppermost costae of the flank. There is a shallow median groove. The depressed escutcheon is smooth except in the umbonal region which is crossed by continuations of the uppermost costae. An inner carina is produced by tubercles developed on or terminating each rib that crosses the area.

(c) Anterior view showing the anterior series of costae rising concentric with the growth lines to the anterior margin.

FIG.6. Megatrigonia (Iotrigonia) cf. haughtoni Rennie; (Hunt. Mus. No. S.11432). Lateral view of an immature specimen showing the early differentiation of the posterior and anterior series of costae.

FIG.7. Megatrigonia (Iotrigonia) cf. haughtoni Rennie; (Hunt. Mus. No. S.11437). Fragment of the anterior end of a large specimen showing the anterior series

of costae not concentric with the growth lines.

FIG.8. _Megatrigonia (Iotrigonia)_ cf. _haughtoni_ Rennie; (Hunt. Mus. No. S.11407).

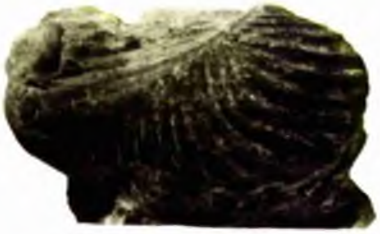
(a) Lateral view of small specimen.

(b) Escutcheon view showing the sharp costae crossing on to the area and tubercles developing on the inner carina to a later stage than the costae cross to the area.

FIG.9. _Megatrigonia (Iotrigonia)_ cf. _haughtoni_ Rennie; (Hunt. Mus. No. S.11395).

(a) Lateral view of an incomplete specimen on which the anterior and posterior series of costae are more equal in strength than usual.

(b) Escutcheon view showing the strong median depression of the area and the prominent tubercles on the inner carina.


1a


1b


2a


2b


3a


3b


3c


4a

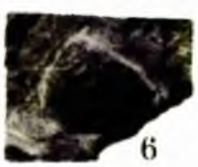

4b


4c


5a


5b


5c


6


7


8a


8b


9a


9b

PLATE XXVII

Megatrigonia (Iotrigonia) cf. *vau* (Sharpe).

Tithonian. Page 154.

(All figures are of natural size).

FIG.1. *Megatrigonia (Iotrigonia)* cf. *vau* (Sharpe); (Hunt. Mus. No. S.12049). Locality WA.2316, Nandonga Stream.

(a) Lateral view showing the elongated shell with long slightly pointed anterior end. The apices of the V's of the costae are initially just in front of the umbo but later just behind it. The anterior series of costae is only slightly weaker than the posterior. The umbonal region is worn.

(b) Escutcheon view showing the smooth, narrow area with only a faint trace of the median groove. The escutcheon is long, depressed and smooth.

(c) Anterior view showing the smooth band adjacent to the anterior margin.

FIG.2. *Megatrigonia (Iotrigonia)* cf. *vau* (Sharpe); (Hunt. Mus. No. S.12046). Locality WA.2312, Nandonga Stream.

(a) Lateral view of the incomplete shell with a slightly flattened, convex anterior end. The apices of the V's are anterior to the umbo, and the posterior series is much more robust than the anterior. The highest preserved rib, very close to the umbo, is V'ed.

(b) Interior view showing the partially preserved hinge line. Tooth 2 is very strongly bifid, 4b is scarcely distinguishable and 4a is strongly divergent from it. Part of the tooth 3a of the right valve is broken off in the socket between 2 and 4a.

(c) Anterior view showing a frontal band over which the costae pass horizontally almost to the anterior margin. At the angulation of the flank where the costae are down-warped, there is a swelling on each.

(d) Escutcheon view showing the well-marked median groove on the narrow smooth area. The escutcheon is strongly depressed and rather wide. Fine, transversely elongated tubercles form an inner carina for a short distance near the umbo. The long narrow ligament groove with its nymphal plate can be seen.

FIG.3. *Megatrigonia (Iotrigonia)* cf. *vau* (Sharpe); (Hunt. Mus. No. S.12047). Locality WA.2315, Nandonga Stream.

(a) Lateral view of the incomplete shell with an evenly convex, fairly short, anterior end and showing a weak, irregular, anterior series of costae. The apices of the V's of the costae are behind the umbo.

(b) Escutcheon view showing narrow, smooth, slightly concave area and smooth, depressed escutcheon.

(c) Interior view showing ill-preserved elements of the hinge.

(d) Anterior view showing the interrupted growth of the shell with a narrow, unornamented band near the anterior margin, but no angulation of the flank to form a frontal band.

FIG.4. Megatrigonia (Iotrigonia) cf. vau (Sharpe), (Hunt. Mus. No. S.12048). Locality WA.2267, north-west of Mitole Village.

(a) Lateral view of a fragmentary specimen showing somewhat irregular costae, down-warped anteriorly in the anterior series, and nodosity of the costae in the posterior series.

(b) Anterior view showing the frontal band with thickening of the costae at the angulation of the flank. The costae pass horizontally across the frontal band but do not quite reach the anterior margin.

Plate XXVII

PLATE XXVIII

Megatrigonia (Rutitrigonia) dietrichi (Lange);

M. (Rutitrigonia) sp.

(All figures are of natural size)

FIGS.1 - 5

Megatrigonia (Rutitrigonia) dietrichi (Lange).

Tithonian Page 162.

FIG.1. Megatrigonia (Rutitrigonia) dietrichi (Lange); (Hunt. Mus. No. S.12080). Locality WA.1628, Nambango Stream.

(a) Lateral view showing the lunate shape and the wide flank with the costae more or less concentric with the growth lines except at the anterior end, towards which they flatten out. The shell is worn and the marginal angulation is much rounded-off and not apparent in the lower part. The costae reach to the edge of the smooth area.

(b) Escutcheon view showing the rather narrow, convex, smooth area and the large, smooth, depressed escutcheon.

FIG.2. Megatrigonia (Rutitrigonia) dietrichi (Lange); [Geol. Surv. Tanganyika No. WA.1628(D)]. Locality WA.1628, Nambango Stream.

(a) Lateral view of an incomplete specimen showing the wide flank with the costae not quite concentric with the growth lines. The marginal angulation extends as far as the shell is preserved and the area is steeply inclined to the flank.

(b) Anterior view showing the costae undulating at the approach to the anterior margin and rising immediately adjacent to it.

(c) Escutcheon view showing the narrow, convex, smooth area and the large, depressed escutcheon.

FIG.3. Megatrigonia (Rutitrigonia) dietrichi (Lange); (Hunt. Mus. No. S.12079). Locality WA.1628, Nambango Stream. Lateral view showing the lunate shape, the marginal angulation rounded-off after mid-growth and the costae reaching to the posterior edge of the flank (though worn there).

FIG.4. Megatrigonia (Rutitrigonia) dietrichi (Lange); (Hunt. Mus. No. S.12076). Locality WA.2311, Nandenga Stream.

(a) Lateral view of an incomplete specimen showing the costae turning rather sharply upwards in the posterior third of the flank.

(b) Anterior view (shell not exposed to anterior margin) showing undulation and thinning out of the costae towards the anterior margin in the upper part of the shell.

(c) Escutcheon view showing the smooth convex area and the ill-defined escutcheon.

FIG.5. Megatrigonia (Rutitrigonia) dietrichi (Lange); (Hunt. Mus. No. S.12077). Locality WA.1656, Ngirito Stream. Lateral view of a rather large specimen not fully exposed in the lower part and not quite complete posteriorly. The undulating costae extend to the well marked marginal angulation and the area is steeply inclined to the flank.

FIG.6. Megatrigonia (Rutitrigonia) sp.; (Hunt. Mus. No. S.11380). Locality WA.2185, Nalwehe Stream; ?Neocomian. Page 178. Lateral view of a small, incomplete, probably immature shell with concentric costae retreating to the anterior part of the flank in the lower part of the shell, but the lowest still extending behind the umbo. The area is narrow and separated from the flank by a marginal fold.

FIG.7. Megatrigonia (Rutitrigonia) sp.; (Hunt. Mus. No. S.11381). Locality WA.2185, Nalwehe Stream; ?Neocomian. Lateral view of a small elongated, incomplete, probably immature shell. The concentric costae have retreated to the anterior part of the flank, the lowest one terminating approximately below the umbo.

Plate XXVIII


1a


1b


2a


2b


2c


4a


4b


4c


3


6


5


7

PLATE XXIX.

Megatrigonia (Rutitrigonia) bornhardti (Müller).

?Neocomian ?Lower Aptian. Page 167.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) bornhardti (Müller); [Geol. Surv. Tanganyika No. WA.758(1)]. Locality WA.758, Kikotwa area near Nambango, Mbemkuru River depression. Lateral view of a complete shell which agrees well in shape with the holotype. The rapid decrease in the inclination of the area to the flank is noticeable after mid-growth, when the marginal angulation degenerates into a fold. The costae, which cross forwards and downwards over the flank, are distinct only at the anterior end and merge posteriorly into the smooth surface of the flank or pass into obscure growth rugae. There is an unornamented band along the lower part of the shell.

FIG.2. Megatrigonia (Rutitrigonia) bornhardti (Müller); [Geol. Surv. Tanganyika No. WA.2541(1)]. Locality WA.2541 in the Kikundi Stream (near Mandawa). Lateral view of a poorly preserved shell, incomplete posteriorly and in its lower part, showing the characteristic flank ornament.

FIG.3. Megatrigonia (Rutitrigonia) bornhardti (Müller); (Hunt. Mus. No. S.11465). Locality WA.1764, Nloweka Stream. Lateral view of a poorly preserved specimen in which the costae are more nearly concentric than in the shells illustrated above, and extend about 2/3 across the flank from the anterior end.

FIG.4. Megatrigonia (Rutitrigonia) cf. bornhardti (Müller); (Hunt. Mus. No. S.11468). Locality WA.1757, Nloweka Stream.

(a) Lateral view of an immature shell which is incomplete posteriorly. The costae are concentric.

(b) Escutcheon view showing the narrow area with the depressed escutcheon attaining an equal width. No ornament is preserved on either the area or the escutcheon.

(c) Anterior view showing the costae rising evenly towards the anterior margin.

1

2

3

4a

4c

4b

PLATE XXX.

Illustration of the community of Megatrigonia (Rutitrigonia) bornhardti (Müller) from Locality WA.1653, Runyu Stream; ?Neocomian ?Lower Aptian. Page 167.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) bornhardti (Müller); (Hunt. Mus. No. S.11382).

(a) Lateral view of an incomplete, badly eroded specimen showing the outline and the remnants of strong costae not parallel with the growth lines.

(b) Anterior view showing the costae approaching the anterior margin at about right angles, crossed by strong growth lines. From their crests, the costae slope steeply on the upper side but gently into the interspace on the lower.

(c) Escutcheon view showing the lack of differentiation between flank and area. The escutcheon is large, smooth and depressed.

FIG.2. Megatrigonia (Rutitrigonia) bornhardti (Müller); (Hunt. Mus. No. S.11385). Lateral view of an incomplete specimen showing the costae crossing the anterior part of the flank slightly obliquely forwards and downwards. The lower costae are irregular but more concentric.

FIG.3. Megatrigonia (Rutitrigonia) bornhardti (Müller); (Hunt. Mus. No. S.11384). Lateral view of a rather small incomplete specimen showing the extent of the nearly concentric costae across the flank. There is some irregularity at the anterior ends of the costae.

FIG.4. Megatrigonia (Rutitrigonia) bornhardti (Müller); /Geol. Surv. Tanganyika No. WA.1653(5)/.

(a) Lateral view of an incomplete specimen with nearly concentric costae. The thickness of the shell material can be seen in the hole broken in it.

(b) Anterior view showing the costae approaching the anterior margin regularly, nearly at right angles, some of them thinning out towards the margin.

FIG.5. Megatrigonia (Rutitrigonia) bornhardti (Müller); (Hunt. Mus. No. S.11383).

(a) Lateral view of a small incomplete specimen showing the nearly concentric costae.

(b) Anterior view showing the costae approaching the anterior margin more or less at right angles.

(c) Escutcheon view showing the costae in the umbonal region crossing on to the area. The escutcheon is large, depressed, and smooth, though not exposed proximally.

Plate XXX

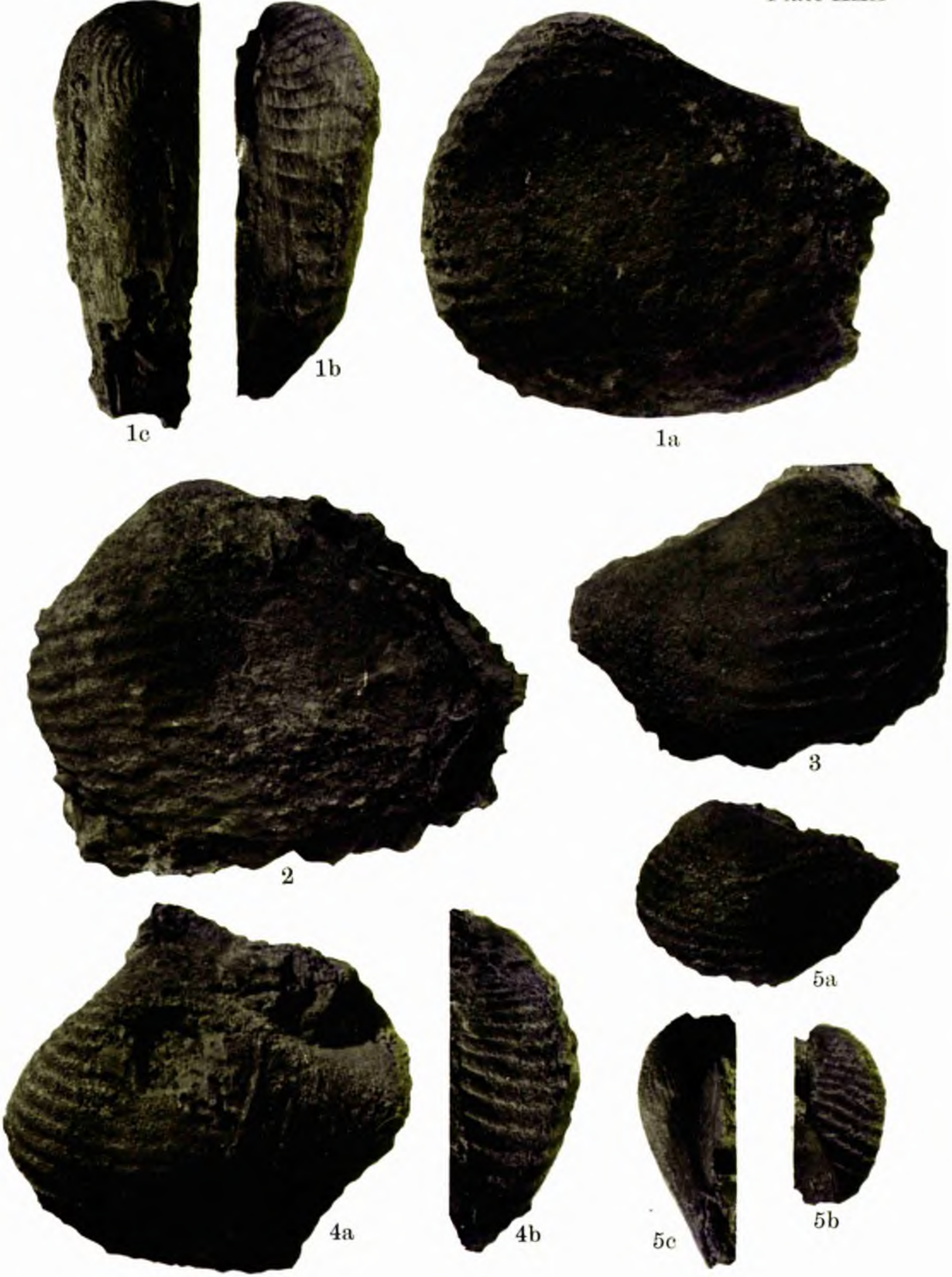


PLATE XXXI.

Illustration of the community of <u>Megatrigonia (Rutitrigonia) turikirae</u> sp. nov. from Locality WA.2492, Turikira Ridge (see also Plates XXXII & XXXIII); ?Neocomian ?Lower Aptian. Page 173.

(All figures are of natural size).

FIG.1. <u>Megatrigonia (Rutitrigonia) turikirae</u> sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.12138).

(a) Lateral view of a specimen which is slightly incomplete posteriorly. The anterior end is long and rather pointed. The wide spaced costae cross the flank forwards and downwards, but accretionary shell material at the anterior end obliterates the costae there. The posterior part of the flank is smooth and is separated from the area by a fold but there is no marginal carina or groove.

(b) Top view showing the narrow smooth area and the upper concentric costae.

(c) Interior view showing the large strongly divergent striated elements of the typically trigoniid dentition.

FIG.2. <u>Megatrigonia (Rutitrigonia) turikirae</u> sp. nov.; (Hunt. Mus. No. S.12160). Interior view of a shell with a comparatively short anterior end, showing the massive dentition.

1a

1c

1b

2

PLATE XXXII.

Further illustration of the community of Megatrigonia (Rutitrigonia) turikirae sp. nov., from Locality WA.2492, Turikira Ridge (see also Plates XXXI & XXXIII). ?Neocomian ?Lower Aptian. Page 173.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12154). Lateral view of an almost complete specimen showing the long anterior end, with a small development of accretionary shell material. The posterior margin is short and oblique. The costae are widely spaced and the interspaces flat-bottomed. The lowermost part of the flank is smooth.

FIG.2. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12162). Lateral view of incomplete specimen showing a fairly small development of accretionary shell material at the anterior end. The costae are rather irregular and in the lower part of the flank they are close spaced. A band near the lower margin is un-ribbed but has strong growth lines.

FIG.3. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12140). Lateral view of incomplete specimen with angular down-warping of the costae along an oblique line posterior to the umbo, the anterior part of each rib being made slightly irregular by the crossing of strong growth lines. The accretionary shell material at the anterior end is more extensive than usual.

1

2

3

PLATE XXXIII.

Further illustration of the community of Megatrigonia (Rutitrigonia) turikirae sp. nov., from Locality WA.2492, Turikira Ridge (see also Plates XXXI & XXXII). ?Neocomian ?Lower Aptian. Page 173.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12142).

(a) Lateral view of a shell with only a small development of accretionary shell material at the anterior end.

(b) Escutcheon view showing the narrow convex area, smooth except in the umbonal region where the flank costae cross on to it. The upper flank costae are concentric. The escutcheon is large and ill-defined, and smooth except for strong growth lines. The ligament groove is about 1/3 of the length of the escutcheon.

FIG.2. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12139). Lateral view of a medium sized shell with almost concentric costae. There is slight hollowing of the smooth posterior part of the flank.

FIG.3. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12156). Lateral view of a small individual with the anterior end rounded, the costae almost concentric and no development of accretionary material at the anterior extremity.

FIG.4. Megatrigonia (Rutitrigonia) turikirae sp. nov.; (Hunt. Mus. No. S.12148).

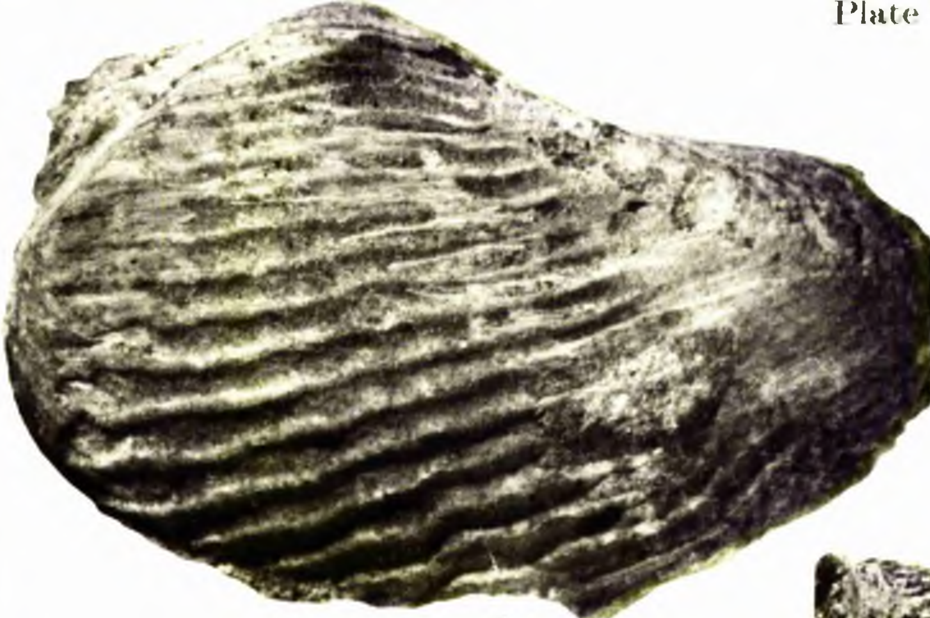
(a) Lateral view of an almost complete shell with the anterior end rounded and having very little development of accretionary shell material. The posterior end is rather narrow. The shell closely approaches R. bornhardti (Müller).

(b) Escutcheon view showing the narrow convex area with the wide escutcheon defined by being flat-bottomed.

(c) Anterior view showing slight development of accretionary material and irregularity of the costae due to the strong growth lines.

Plate XXXIII

1b



1a

2

4b

3

4a

4c

PLATE XXXIV.

Illustration of the community of Megatrigonia (Rutitrigonia) schwarzi (Müller) from Locality Wa.2415, Makumba Stream, near Makangaga; ?Neocomian ?Lower Aptian. Page 179.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) schwarzi (Müller); (Hunt. Mus. No. S.11348).

(a) Lateral view showing the fairly high umbones, the smooth curve of the convex anterior margin into the lower margin, and the obliquely truncated posterior end. The angle between the flank and area increases rapidly with growth and the two are separated only by a marginal fold. Ornament is confined to the anterior part of the flank and consists of rather weak, wide-spaced, undulating costae.

(b) Escutcheon view showing the wedge-shape of the shell. The costae pass on to the area in the umbonal region with a slight posterior warp at the margin. Except in the uppermost part, they terminate at the edge of the slightly depressed escutcheon which becomes indistinct in later growth.

(c) Anterior view showing the well inflated shell, and the costae approaching the anterior border at right angles.

(d) Interior view showing the partly exposed hinge. Part of the massive bifid striated tooth 2 is visible and part of 4a.

FIG.2. Megatrigonia (Rutitrigonia) schwarzi (Müller); (Hunt. Mus. No. S.11355). Lateral view showing the abrupt downwarp of the costae anteriorly, and the slight flanging in the antero-dorsal part of the shell.

FIG.3. Megatrigonia (Rutitrigonia) schwarzi (Müller); (Hunt. Mus. No. S.11358).

(a) Lateral view showing the irregularity of the lower costae.

(b) Escutcheon view (slightly oblique) showing the slight posterior warp of the costae at the edge of the area and V-ing at the middle of the area. No costae are seen to cross to the depressed lanceolate escutcheon.

FIG.4. Megatrigonia (Rutitrigonia) schwarzi (Müller); (Hunt. Mus. No. S.11362).

(a) Lateral view of a young specimen showing the ovate shape, the concentric costae crossing to the area in early growth and the start of their retreat to the anterior end.

(b) Escutcheon view showing the small thickness of the valve. The costae cross the area and the poorly defined escutcheon in the upper part.

(c) Anterior view showing the ends of the costae down-warping from their concentric course.

FIG.5. Megatrigonia (Rutitrigonia) schwarzi (Müller); (Hunt. Mus. No. S.11360). Lateral view showing a slightly larger specimen than that illustrated in Fig.4, showing rapid retreat of the costae to the anterior end after their initial concentric stage, their rapid increase in spacing and the commencement of anterior down-warping.

FIG.6. Megatrigonia (Rutitrigonia) schwarzi (Müller). Reproduction of the illustration of a paratype (Müller, 1900, Pl.XXV, fig.14).
The figure shows a fragment of the antero-ventral part of the flank of the shell, exhibiting the strongly down-warped, widely spaced, fairly delicate costae which are confined to the anterior end.

1a

1b

1c

1d

2

5

4a

4b

4c

6

PLATE XXXV.

Megatrigonia (Rutitrigonia) nossae sp. nov.

?Neocomian ?Lower Aptian.   Page 185.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) nossae sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11340). Locality WA.2494, Nossa Stream, near Kigombo.

(a) Lateral view showing the elevated umbo, the smooth flank posterior to the greatest convexity of the shell, and the ill-defined area. The posterior margin is very oblique. The fairly close-spaced costae are confined to the anterior end and in the lower part of the shell are absent. The upper edges of the costae rise vertically from the surface of the shell and the lower side of each slopes to the base of the upper edge of the next.

(b) Anterior view showing the rather thick valve. The costae pass horizontally across the forward-facing part of the flank and reach the anterior margin. Especially in the upper part of the shell the forward-facing part of the flank is separated by a "shoulder" from the remainder of the flank.

(c) Escutcheon view showing the narrow convex area with the upper concentric flank costae passing on to it. The escutcheon is rather ill-defined, especially in later growth.

FIG.2. Megatrigonia (Rutitrigonia) nossae sp. nov.; (Hunt. Mus. No. S.11343). Locality WA.2459, west of Mto Nyangi Lateral view of the incomplete shell showing the costae down-warped anteriorly.

FIG.3. Megatrigonia (Rutitrigonia) nossae sp. nov.; [Geol. Surv. Tanganyika, No. WA.2462(9)] Locality WA.2462, west of Mto Nyangi.

(a) Lateral view of a very elevated specimen, slightly incomplete posteriorly. The costae are closely spaced and confined to the anterior portion of the flank.

(b) Anterior view showing the rather thick valve with the closely-spaced costae almost confined to the forward-facing portion of the flank.

(c) Escutcheon view showing the lack of definition between the area and escutcheon. The ligament groove is rather short and narrowly lanceolate.

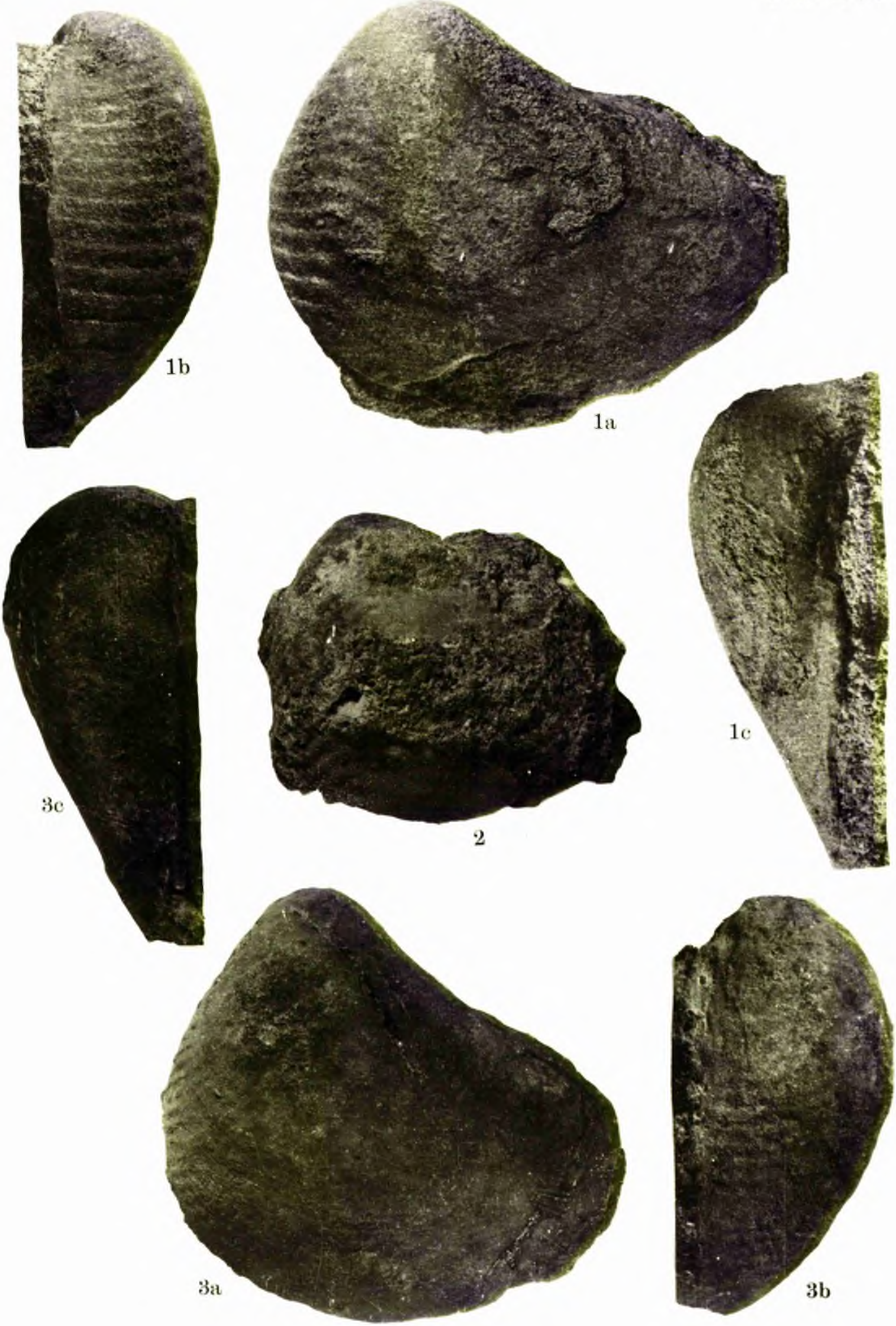

1b
1a
1c
3c
2
3a
3b

PLATE XXXVI.

Megatrigonia (Rutitrigonia) nyangensis sp. nov.

?Neocomian ? Lower Aptian. Page 189.

(All figures are of natural size).

FIG.1. Megatrigonia (Rutitrigonia) nyangensis sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.11453). Locality WA.2461, west of Mto Nyangi.

(a) Lateral view of the rather large, pyriform shell with the flank occupying most of the surface and the area not well defined. Little ornament is visible.

(b) Anterior view showing the great inflation. The ornament is confined to the upper part of the shell, which is slightly flanged in the antero-dorsal region.

(c) Escutcheon view of the gaping shell showing the narrow area which is smooth for the most part. The escutcheon is large, smooth and depressed. The large ligament groove and nymphal plates are visible.

FIGS.2 - 5.

Illustration of the community of Megatrigonia (Rutitrigonia) nyangensis sp. nov. from Locality WA.2462, west of Mto Nyangi.

FIG.2. Megatrigonia (Rutitrigonia) nyangensis sp. nov.; (Hunt. Mus. No. S.11459).

(a) Lateral view of a broken shell of which the posterior end is missing. The anterior end is strongly convex and the antero-dorsal part is flanged. Strong costae cross the anterior end forwards and downwards, but in the lower part of the shell are obscured by strong growth rugae.

(b) Anterior view showing the costae turning upwards across the flanged portion of the shell and meeting the anterior margin at right angles. By mid-growth of the shell, the costae are obscured by the growth rugae.

(c) Interior view showing the straight cardinal margin extending in front of the umbo as well as behind it. The teeth are very divergent and tooth 3b is lathe-like and almost parallel to the postero-dorsal margin.

FIG.3. *Megatrigonia (Rutitrigonia) nyangensis* sp. nov.; (Hunt. Mus. No. S.11456). Lateral view of a shell which is broken posteriorly, showing an inverted V effect of the ornament in the antero-ventral region due to the intercrossing of costae and growth rugae.

FIG.4. *Megatrigonia (Rutitrigonia) nyangensis* sp. nov.; (Hunt. Mus. No. S.11461).

(a) Lateral view of a small broken specimen in which almost concentric costae are present, reaching posterior to the umbo.

(b) Escutcheon view showing concentric costae in the umbonal region, crossing from the flank, with slight backward warping, on to the narrow convex area. The costae are not seen to cross on to the wide lanceolate, smooth, depressed escutcheon.

FIG.5. *Megatrigonia (Rutitrigonia) nyangensis* sp. nov.; (Hunt. Mus. No. S.11458).

(a) Lateral view of a shell which is incomplete posteriorly. The costae are rather swollen and not very distinct from the growth rugae in the lower part of the shell.

(b) Anterior view showing the costae tapering out when approaching the anterior margin over the slightly flanged anterior part of the flank.

(c) Escutcheon view showing the poor distinction of flank, area, and escutcheon.

Plate XXXVI

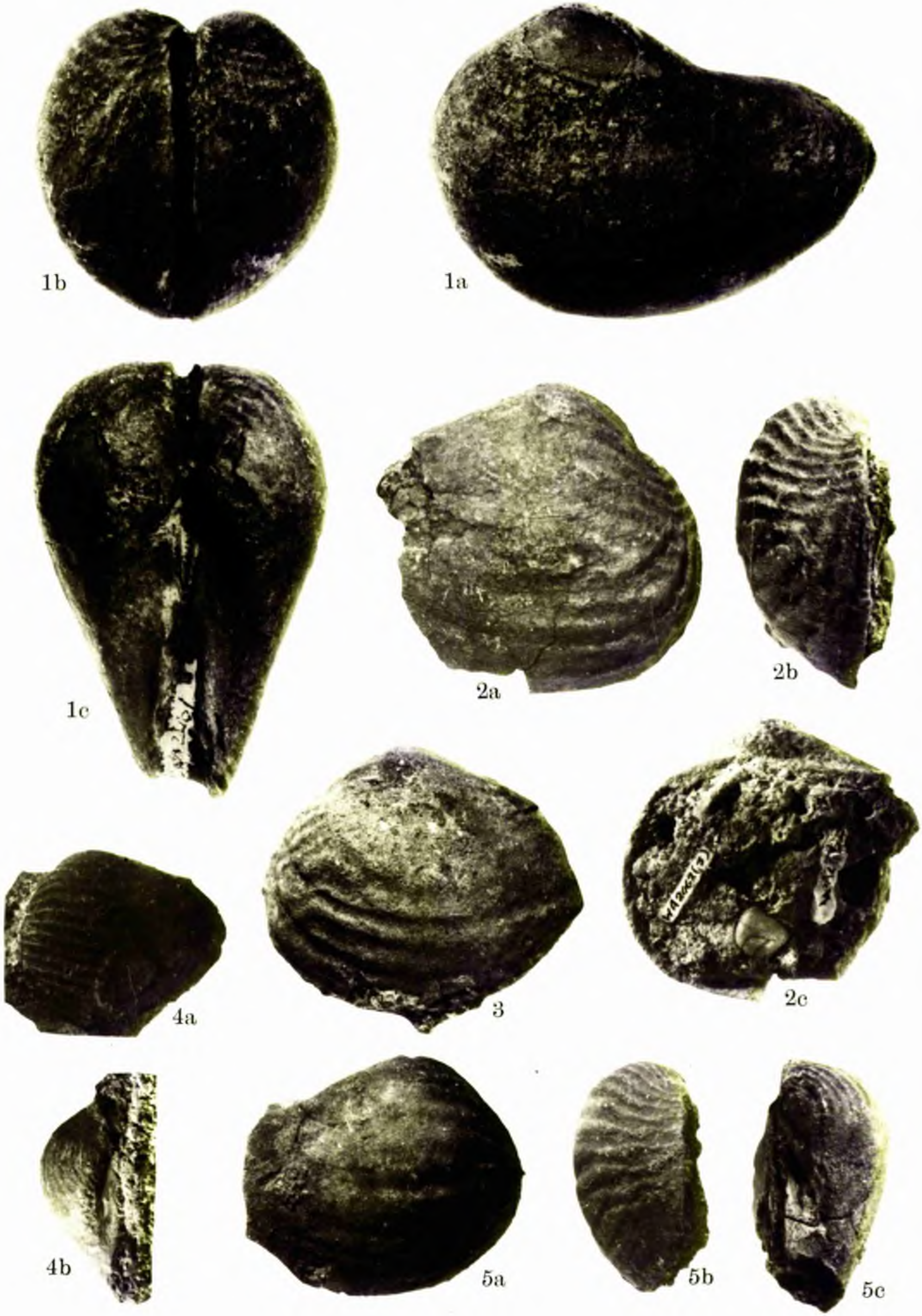


PLATE XXXVII.

(All figures are of natural size).

FIGS. 1 - 5.

Illustration of the community of Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov. from Locality WA.2499, Tunduru Village; ?Neocomian ?Lower Aptian. Page 194.

FIG. 1. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov.; (Hunt. Mus. No. S.11440).

(a) Lateral view of the small pyriform shell with almost concentric costae, which retreat towards the anterior end in the lower part, leaving the remainder of the flank smooth. The area is separated from the flank by a marginal fold.

(b) Anterior view showing the costae rising steeply towards the anterior margin.

(c) Escutcheon view showing the concentric costae crossing from the flank on to the narrow convex area in the umbonal region, but not on to the smooth depressed escutcheon.

FIG. 2. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov.; (Hunt. Mus. No. S.11439). Lateral view of an almost complete shell showing slight concavity of the smooth posterior part of the flank. The marginal fold is rather marked, and the pyriform shell pointed posteriorly.

FIG. 3. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov.; (Hunt. Mus. No. S.11444). Lateral view of the anterior end of a broken shell showing down-turning anteriorly of the costae, which are wider spaced than in most other shells of the community.

FIG. 4. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov.; (Hunt. Mus. No. S.11442). Lateral view of a portion of the posterior part of the flank of a broken specimen, showing the interference of strong growth lines with the flank ornament.

FIG. 5. Megatrigonia (Rutitrigonia) aff. nyangensis sp. nov.; (Hunt. Mus. No. S.11448).

(a) Lateral view of a broken shell.

(b) Escutcheon view showing detail of the ornament on the narrow convex area, and the depressed, smooth, lanceolate escutcheon.

FIGS.6 - 12.

Megatrigonia (Rutitrigonia) sp. juv. indet.

(?=R. niongalensis) from west of Mto Nyangi. ?Neocomian

?Lower Aptian. Page 196.

FIG.6. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12168).

(a) Lateral view of a specimen with slightly lunate shape with rounded posterior end. The concentric costae retreat rapidly to the anterior end with growth, leaving the remainder of the flank smooth.

(b) Escutcheon view showing poor distinction of flank, area and escutcheon. The costae extend from flank to area in the umbonal region.

FIG.7. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12173).

(a) Lateral view of a small shell showing the back-warping of the costae on crossing on to the area.

(b) Anterior view showing the costae rising steeply towards the anterior margin.

(c) Escutcheon view showing the termination of the costae in the umbonal region at the inner edge of the area, with no encroachment on to the escutcheon.

FIG.8. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12170).

(a) Lateral view of a shell with the lower border rising posteriorly to meet the postero-dorsal margin at a sharp curve, there being no distinct posterior margin. There is a slight angulation between flank and area, except at the extreme posterior end.

(b) Anterior view showing the costae meeting the anterior margin at about right angles.

(c) Escutcheon view showing the termination of the costae which have crossed on to the area in the umbonal region, at the edge of the large smooth depressed escutcheon.

FIG.9. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12174). Lateral view of a slightly broken shell with rather lunate shape, the lower border curving into the posterior, and the postero-dorsal margin being concave.

FIG.10. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12177). Lateral view of a small broken shell, originally rather pointed at the posterior end. The costae retreat at an early stage to the anterior end.

FIG.11. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12178). Interior view of a shell (within another lamellibranch of another genus) showing the strongly divergent hinge teeth, tooth 3b being close under the postero-dorsal margin.

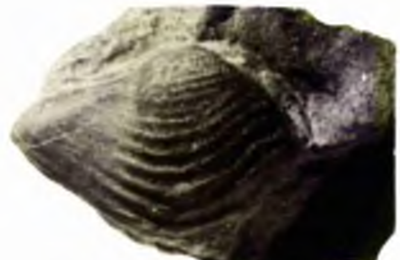
FIG.12. Megatrigonia (Rutitrigonia) sp. juv. indet.; (Hunt. Mus. No. S.12176). Lateral view of a pyriform shell on which the costae cross the flank to behind the umbones to a fairly late stage.

Plate XXXVII


1a


1b


1c


2


3


4


5a


5b


6a


6b


7a


7b


7c


8a


8b


8c


9


10


11


12

PLATE XXXVIII.

Rutitrigonia krenkeli (Lange); R. kigombona sp. nov.

(All figures are of natural size).

FIGS. 1 - 4.

Illustration of the community of Megatrigonia (Rutitrigonia) krenkeli (Lange) from Locality WA.2416, Makumba Stream, near Makangaga; ?Neocomian ?Aptian. Page 200.

FIG. 1. Megatrigonia (Rutitrigonia) krenkeli (Lange); (Hunt. Mus. No. S.12025).

(a) Lateral view showing the prominent umbo, the smooth curve of the convex anterior margin into the lower margin and the obliquely truncated posterior end. The angle between flank and area increases rapidly with growth. The costae are strong and rounded; they curve downwards from the edge of the area and become irregular and weaker in the postero-ventral part of the flank where they are nearly parallel to the growth lines.

(b) Escutcheon view showing the slightly concave area, which is smooth except in the proximal part where the costae cross on to it from the flank and a median groove is visible. There is a distinct angle between flank and area only in the proximal part. The escutcheon is separated from the area by a ridge of shell material.

(c) Anterior view showing the costae approaching the anterior margin at about right angles in the upper part but becoming nearly parallel with the growth lines lower down.

FIG. 2. Megatrigonia (Rutitrigonia) krenkeli (Lange); (Hunt. Mus. No. S.12035).

(a) Lateral view of an incomplete shell showing the costae passing obliquely forwards and downwards across the flank except close to the margin of the area towards which they curve sharply upwards.

(b) Escutcheon view showing the strong median groove on the area and the uppermost costae passing across the escutcheon as well as the area. There is a strong ridge separating the area and escutcheon, at which the costae reaching thus far thicken to give a form of inner carina.

FIG.3. <u>Megatrigonia (Rutitrigonia) krenkeli</u> (Lange); (Hunt. Mus. No. S.12028). Escutcheon view of a small specimen showing the costae crossing the area to a later stage of growth than usual and distinctly marked by the median groove, which is not visible below the point where the costae cross the area. The escutcheon is long and lanceolate, and the costae are not visible on it even in the uppermost part.

FIG.4. <u>Megatrigonia (Rutitrigonia) krenkeli</u> (Lange); (Hunt. Mus. No. S.12027).

(a) Lateral view of a specimen which is rather pointed posteriorly.

(b) Escutcheon view showing the strong median groove and well-defined escutcheon. The course of the costae crossing on to the area is not affected by the median groove.

FIG.5. <u>Megatrigonia (Rutitrigonia) kigombona</u> sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.12037). Locality WA.2462, west of Mto Nyangi; ?Neocomian ?Lower Aptian. Page 206.

(a) Lateral view showing the elongated shape and the considerable extent of the smooth part of the flank between the posterior ends of the costae and the edge of the area.

(b) Anterior view showing the robust costae approaching the anterior margin at about right angles, but thinning off towards the margin and not actually reaching it in the upper part.

(c) Escutcheon view showing the area and escutcheon to be smooth except in the upper part where traces of costae can be seen crossing from the flank to the area. The escutcheon is ill-defined. The narrow lanceolate ligament groove can be seen.

Plate XXXVIII

PLATE XXXIX.

Laevitrigonia : Opisthotrigonia

(All figures are of natural size).

FIGS.1 - 5.

Laevitrigonia curta sp. nov. Tithonian. Page 211.

FIG.1. Laevitrigonia curta sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.12023). Locality WA.1656, Ngirito Stream.

(a) Lateral view showing the rather strong costae (for the size of the shell), which are slightly irregular and sometimes swollen at their posterior ends. The area is sharply inclined to the flank and is not visible in lateral view except at the worn posterior end of the shell. The marginal angulation in lateral view forms a sigmoidal curve. The ante-carinal space is encroached on by costae in the lowermost part; there is a sulcus in the lower margin corresponding to it.

(b) Escutcheon view showing the smooth area with an obscure median depression distally. The smooth escutcheon is depressed and lanceolate.

(c) Anterior view showing the poorly developed frontal face and small lunule.

FIG.2. Laevitrigonia curta sp. nov.; (Hunt. Mus. No. S.12021). Locality WA.1477, Kimbarambara Stream.

(a) Lateral view of a specimen of which the lower border is broken away, but the posterior end is almost complete. The marginal angulation shows the slightly sigmoidal curve and the ante-carinal space is hollowed.

(b) Escutcheon view showing the smooth, slightly convex area and depressed, longitudinally striated escutcheon.

(c) Anterior view showing an ill-defined frontal face over which the costae do not reach to the anterior margin, close to which the surface is smooth.

FIG.3. Laevitrigonia curta sp. nov. (Hunt. Mus. No. S.12022). Locality WA.1656, Ngirito Stream.

(a) Lateral view of an incomplete specimen showing the slightly irregular ornament with swelling of the costae at their anterior ends. The angle between flank and area is sharp.

(b) Anterior view showing no frontal face but the presence of a small lunule.

(c) Escutcheon view showing the slightly convex area and the depressed lanceolate escutcheon which shows fine radial striae.

(d) Interior view showing typical trigoniid dentition.

FIG.4. Laevitrigonia curta sp. nov.; (Hunt. Mus. No. S.12024). Locality WA.1779, Lihimaliao Stream.

(a) Lateral view of the almost complete specimen showing transgression of the regular costae on to the rather narrow ante-carinal space in the lower half of the shell.

(b) Anterior view showing the very poorly developed frontal face.

(c) Escutcheon view showing the slightly concave area which is smooth except for a median groove. The escutcheon has well-marked radial striae.

FIG.5. Laevitrigonia curta sp. nov.; [Geol. Surv. Tanganyika, No. WA.1779(1)]. Locality WA.1779, Lihimaliao Stream. Lateral view of a shell which is incomplete at the lower border but complete posteriorly and shows an obliquely truncated posterior end. The costae encroach on the narrow ante-carinal space in the lower part.

FIG.6. Opisthotrigonia retrorsa (Kitchin); (British Museum No. L.75443); Cutch; ?Tithonian ?Neocomian. Page 216.

(a) Lateral view of a large, almost complete shell showing the high, opisthogyral umbo, and the long, narrow, obliquely truncated posterior end. The costae are rather fine and slightly irregular, and in the lower part encroach on the wide ante-carinal space and combine with growth rugae there.

(b) Escutcheon view showing the smooth, narrow, slightly convex area and the large lanceolate, depressed escutcheon marked only by growth lines.

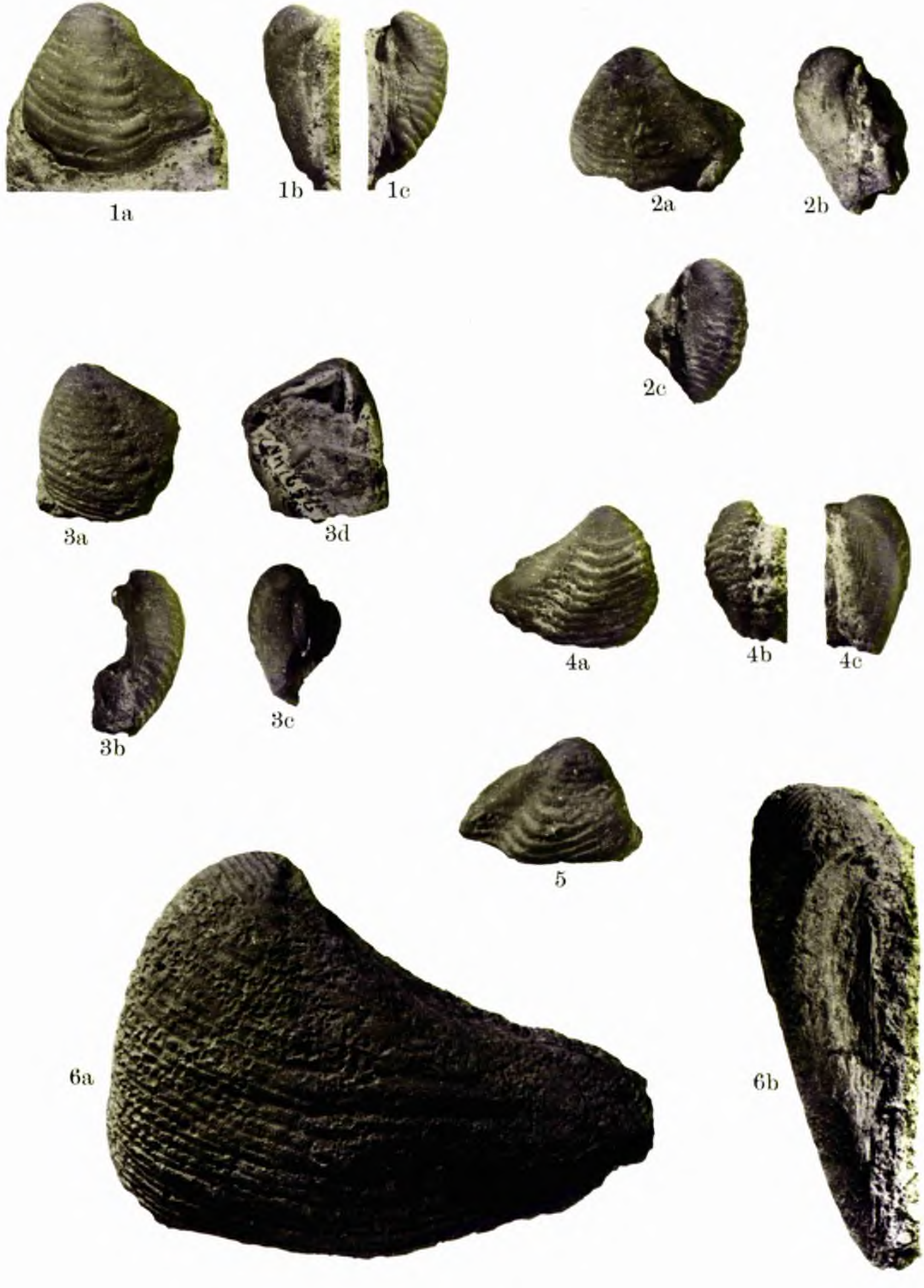

1a
1b
1c
2a
2b
2c
3a
3d
3b
3c
4a
4b
4c
5
6a
6b

PLATE XL.

Opisthotrigonia curvata sp. nov. Page 216.

(All figures are of natural size except Fig.3c).

FIG.1. Opisthotrigonia curvata sp. nov.; HOLOTYPE; (Hunt. Mus. No. S.12005). Locality WA.1628, Nambango Stream; Tithonian.

(a) Lateral view showing the strong sickle-shape, long anterior end with convex margin, and narrow, produced, posterior end. There is some encroachment, in the lower part, of the narrow costae on to the ante-carinal space.

(b) Interior view showing the opisthogyral umbones and the typical trigoniid dentition with slight posterior inclination. The long posterior limb of the bifid tooth 2 is broken away. Tooth 4b is not preserved.

(c) Escutcheon view showing the rather narrow area and wide depressed escutcheon.

(d) Anterior view showing the well-developed frontal face with a distinct angulation of the flank at which the costae are enlarged and inflected towards the horizontal. A slight lunule is developed.

FIG.2. Opisthotrigonia curvata sp. nov.; (Hunt. Mus. No. S.12008). Locality WA.1628, Nambango Stream; Tithonian.

(a) Lateral view of the specimen which is incomplete posteriorly, with a straighter anterior border of the ante-carinal space and a straighter marginal carina than in the holotype.

(b) Escutcheon view showing the long narrow depressed escutcheon with fine longitudinal striations.

FIG.3. Opisthotrigonia curvata sp. nov.; (Hunt. Mus. No. S.12010). Locality WA.1628, Nambango Stream; Tithonian.

(a) Lateral view of a broken and worn specimen similar to the holotype.

(b) Escutcheon view showing the narrow convex area and ill-defined escutcheon.

(c) Escutcheon view, enlarged, showing fine striations on the innermost part of the area.

FIG.4. Opisthotrigonia curvata sp. nov.; (Hunt. Mus. No. S.12016). Locality WA.2179, Nalwehe Stream. ?Tithonian.

(a & b) Lateral views of a double-valved specimen with a slightly rostrate posterior end.

(c) Escutcheon view showing the slightly opisthogyral umbones, the slight lunule, the narrow, flat area and the long, wide depressed escutcheon. The ligament groove is short and narrow and the nymphal plates can be seen.

(d) Anterior view showing the anterior commissure sunken between two shoulders of shell, but no true frontal face developed.

FIG.5. Opisthotrigonia curvata sp. nov.; (Hunt. Mus. No. S.11985). Locality WA.961 in a tributary of the Mkomangoni Stream; Tithonian.

(a) Lateral view of an almost complete shell with a well-marked marginal carina and wider spacing of the costae in the upper part of the flank than the lower.

(b) Anterior view showing the poorly developed frontal face but well marked lunule.

(c) Escutcheon view showing the flat area and wide depressed escutcheon, both with obscure longitudinal striations.

FIG.6. Opisthotrigonia curvata sp. nov.; /Geol. Surv. Tanganyika No. WA.961(d)/. Locality WA.961 in a tributary of the Mkomangoni Stream; Tithonian.

(a) Lateral view of the incomplete specimen in which the lower costae pass uninterrupted from the anterior part of the flank to the "ante-carinal space".

(b) Anterior view showing the anterior commissure well depressed below the shoulder forming the foremost part of the shell.

FIG.7. Opisthotrigonia curvata sp. nov.; (Hunt. Mus. No. S.11995). Locality WA.961, in a tributary of the Mkomangoni Stream; Tithonian.

(a) Lateral view of the specimen which is almost complete posteriorly and shows the marginal carina extending to the postero-ventral extremity, and the short oblique posterior margin.

(b) Escutcheon view showing radial striae on the proximal part of the area.

Plate XL

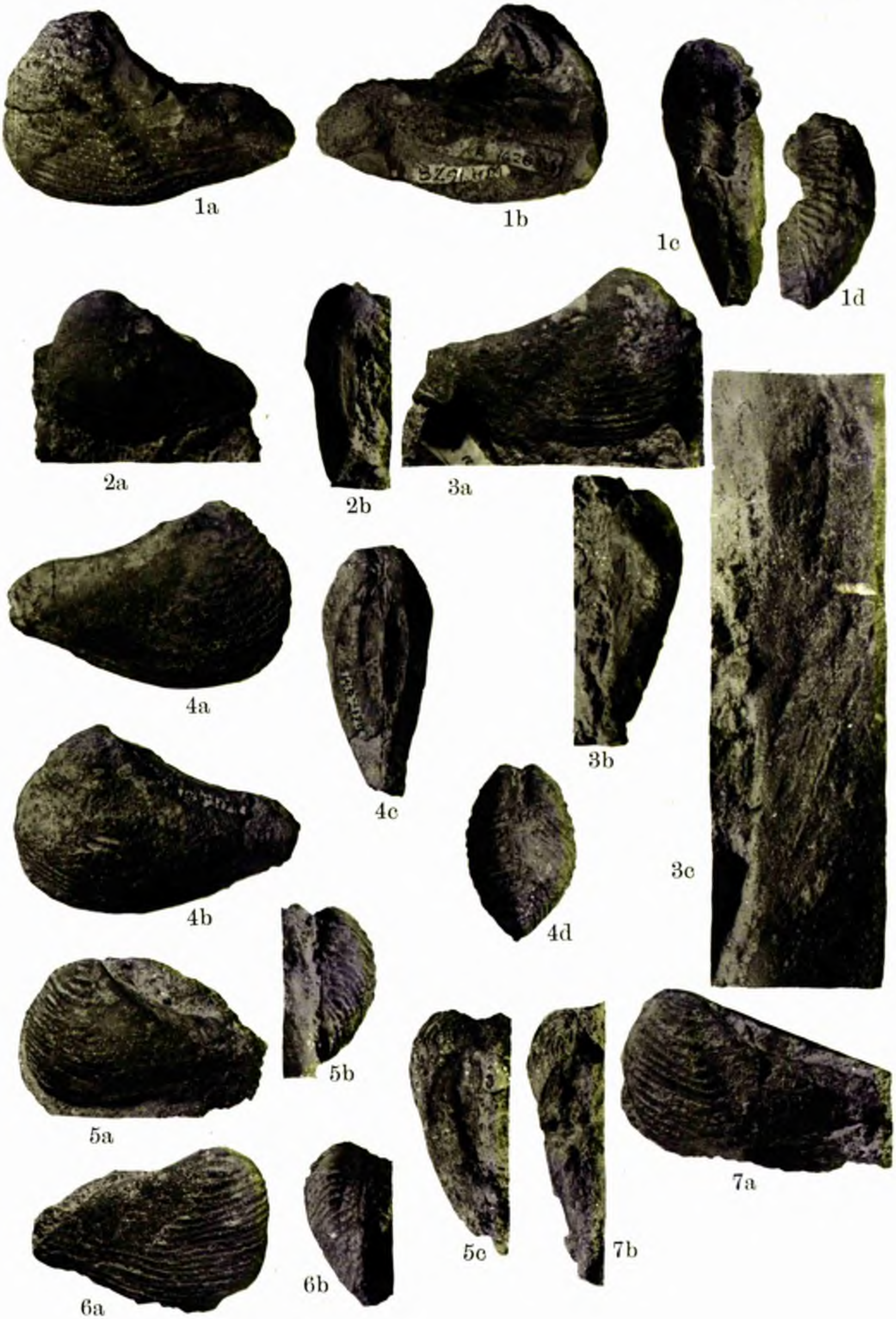


PLATE XLI.

"Trigonia" s. lato

(All figures are of natural size).

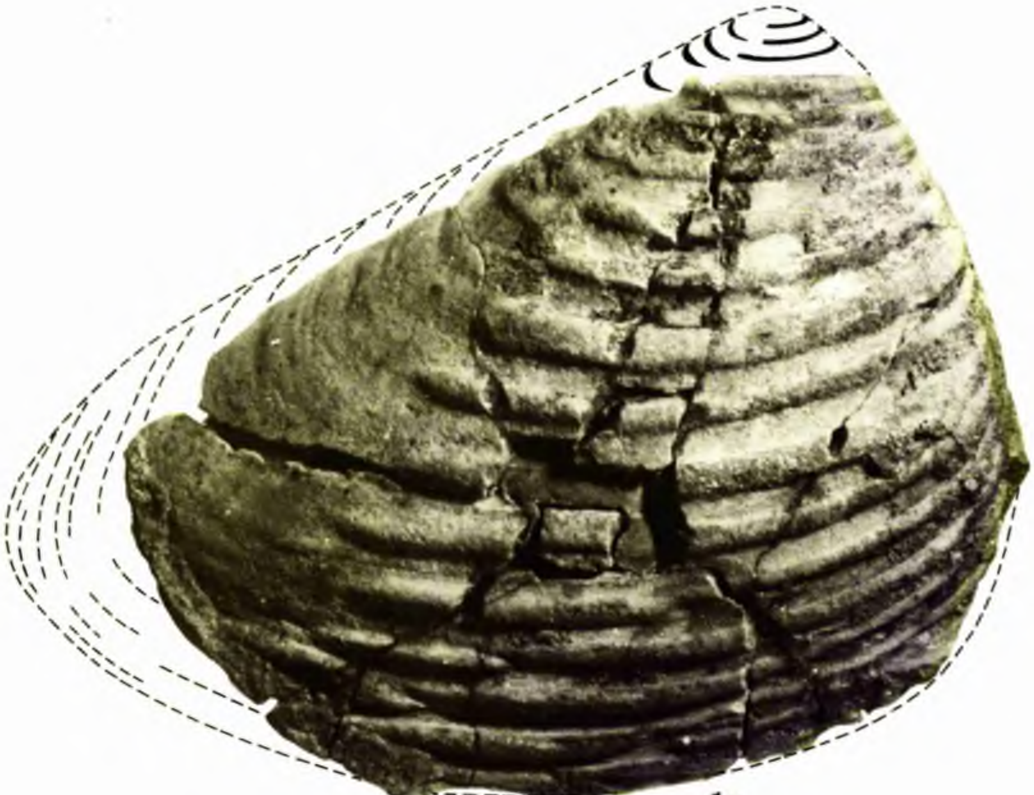
FIG.1. Trigoniid gen. et sp. indet.; (Hunt. Mus. No. S.12120). Locality WA.2316, Nandenga Stream; Tithonian. Page 223.

(a) Lateral view of the incomplete specimen showing the strong rounded concentric costae separated by flat-bottomed inter-spaces about equal in width to the costae. The area is smooth for the most part, and not differentiated from the surface of the flank from which the costae rise. There are costellae in the proximal part of the area but these degenerate into growth rugae lower down.

(b) Anterior view showing the slight development of a frontal face and the costae continuing parallel to the growth lines to the anterior margin.

(c) "Escutcheon" view showing costellae on the proximal part of the area but only growth rugae lower down. The uppermost part of the area is not preserved and the escutcheon and inner part of the area are missing.

(d) Interior view showing the remnants of trigoniid dentition. There is a wide shallow groove starting a little below the end of the tooth 3b and extending horizontally, presumably corresponding to the position of the siphons.



1a

1b

1d

1c