

A MARINE EARLY CRETACEOUS FAUNA FROM STANWELL (ROCKHAMPTON DISTRICT).

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(PLATE 1).

Summary.—A small molluscan fauna of early Cretaceous age is described from a bed at Stanwell that apparently is within the Stanwell Coal Measures. The fauna is typical of the Valanginian (?) *Trigonia* beds of the Indo-Pacific region and, with other evidence, makes the Lower Cretaceous history of Eastern Australia closely parallel with that of India and of East and South Africa. From this evidence it would appear that the Stanwell Coal Measures may be later than has been thought—equivalent to the Blythesdale (pre-Aptian Cretaceous) and not Walloon (mid to late Jurassic) Series. This is not at variance with the floral evidence.

Some years ago Mr. J. H. Reid, District Geologist for Central Queensland, discovered marine mollusca on Portions 128 and 129, Parish of Stanwell, a locality about 20 miles W.S.W. of Rockhampton. There were many fragments, but few good specimens, preserved in a hard, brownish, calcareous sandstone.

Quite apart from its local importance in being evidence of marine Cretaceous conditions in a region far removed from other such beds, the collection is of unusual general interest in being the first record in Australia of a fauna, widespread in Indo-Pacific regions, that has given rise in recent times to a considerable controversy. Three questions arise: What precisely is the age of the fauna; how are the beds related locally to other sedimentary series; and what are the general palaeogeographical and stratigraphical relations to the Indo-Pacific region at large?

THE AGE OF THE FAUNA.

The decisive elements of the fauna are *Iotrigonia limatula* and *Pisotrigonia* sp. These are members of a fauna rich in peculiar Trigonias, that occurs only in the Indo-Pacific region. The trigoniid genera have not been recognised in Europe. The *Pisotrigonia* at this locality, although it has been collected only in fragments, is quite typical. Trigonias with V-shaped ribbing, as is noted below, appear at several horizons in the Jurassic and Cretaceous; but the type of V-ribbing in *I. limatula* is not known in any group other than that of *Iotrigonia*. Other features of the test agree, so that this assemblage may be correlated confidently with the *Iotrigonia* and *Pisotrigonia* faunas of the Uitenhage and Oomia beds.

The other elements of the fauna, although giving no precise evidence of age, are of groups that are found or may be found in those faunas. *Pseudomonotis* and *Hibolites* begin well down in the Jurassic and last until the Aptian. *Panope* is essentially Cretaceous; but it is very similar to Jurassic and Cretaceous *Pleuromya* and details of the hinge that distinguish the two genera are not shown in these specimens. *Indotrigonia* is another element of the *Iotrigonia* faunas in Kachh and East

Africa. However there is no certainty that the imperfectly preserved form now figured as *I. (?) sp.* is a true member of the genus; so that the record, being indefinite, does not confirm the evidence of the two other *Trigonias* in the collection although it does not oppose it.

This fauna, then, may be regarded as equivalent to that of the Uitenhage and Oomia beds. It gives no new evidence about the age of those faunas; but the evidence that they give may be used in placing the Stanwell bed.

The previous palaeontological evidence has been presented in great detail by Kitchin, particularly in his last papers (1926 and 1929). In one region this fauna is known definitely to be of Valanginian age—the Uitenhage beds, with a decisive ammonite fauna. In Patagonia, elements of the fauna are found with Neocomian ammonites; though it has not been made clear at present to which division of the Neocomian they belong. At other localities they are known to be pre-Aptian or post-Upper Jurassic, or both. At Kachh, for instance (see Spath 1930, p. 137), the sequence is as follows:—

Ukra Hill beds (with Aptian ammonites).	
Sandstones—several hundred feet thick.	} Oomia beds.
<i>Trigonia</i> bed.	
Sandstones—several hundred feet thick.	
Dhosa Oolite (with Lower Tithonian ammonites).	

In Zululand the fauna occurs at some unstated distance below beds with Aptian ammonites. At Tendaguru, as Kitchin has shown, the beds with indigenous *Trigonias* are pre-Aptian and occur with apparently *derived* Kimmeridgian ammonites.

In the Malone formation of Texas, elements of this fauna occur. Kimmeridgian ammonites are present (like Tendaguru) but the lamelli-branches are of Cretaceous facies (Kitchin 1926). Kitchin has suggested that here, and in Tendaguru, there is an admixture of endemic and derived fossils.

These faunas are, at the earliest, late Jurassic (Kimmeridgian) and are pre-Aptian. With Kitchin, one may agree that they are so similar as to form a stratigraphical unit; and since they are known to be Valanginian in South Africa, a Valanginian or near-Valanginian age may be assumed provisionally for the fauna.

A marine Hauterivian horizon (with *Simbirskites*) is recorded with some doubt¹ from elsewhere in Queensland (near Morven) where, as at Stanwell, the bed would occur within a pre-Aptian lacustrine

¹ The history of this record is as follows:—In the collections of the Queensland Museum a group of five fossils, cemented with commercial cement, bears the locality label "Victoria Downs, Morven". The exhibit has been in the Museum for several decades, but there is no record of how acquired. The ammonites (see Whitehouse 1927, p. 111) are typically Hauterivian. The other shells are a species of *Leptomaria*. No further material has been brought in from this region.

Victoria Downs was a property of some 200 square miles in area on which richly fossiliferous Aptian beds with ammonites (Roma Series) are underlain conformably by lacustrine beds (Blythesdale Series). It is thus a likely locality.

In preservation the specimens are so like the *Simbirskites* from North Germany, and specific relations are so close with North Germany forms, as Etheridge (1909) noted, that a little uneasiness is felt about the locality record. No geologist yet has searched the property for pre-Aptian fossils.

series. If the record should prove correct, the possibility must be considered that these two faunas are equivalent—whereupon the *Iotrigonia* faunas might persist to the Hauterivian. But not only is the Morven record doubtful but no species or genera are common to the two very meagre collections. Thus for the present it is advisable to conclude that the *Iotrigonia* fauna is Valanginian (or near-Valanginian), but that at least one other Neocomian marine incursion may have taken place into the pre-Aptian lacustrine area of Queensland.

LOCAL ASPECTS.

Mr. Reid states that the bed with the fossils is apparently not more than one foot in thickness and is interbedded in sandstones that are presumed to be part of the Mesozoic sediments of the Stanwell coal basin; and that the locality is but 100 feet from the prominent east-west "Stanwell fault" where the Mesozoic beds to the south are vertical and in juxtaposition with andesites of the Lower Bowen (Permian) volcanics to the north.

The rocks of the Stanwell area have been described by Dunstan (1898). The major portions of the sediments, covering an area of approximately 70 square miles, are sandstones, shales and coals of the Stanwell Coal Measures. They have a minimum thickness of 700 feet and have yielded the following flora² which Walkom has determined to be of Jurassic age:

Equisetites cf. *rajmahalensis* O. and M.

Taeniopteris spatulata McClell.

T. spatulata var. *major* Seward.

T. crassinervis (Feist.) Walkom.

T. tenison-woodsii (Eth. fl.) Dun.

Phyllopteris feistmantelii Eth. fl.

Ptilophyllum pecten (Phillips) Seward.

Araucarites polycarpa (Ten.-Woods) Walkom.

Elatocladus planus (Feist.) Walkom.

Apart from the region beside the fault, the Mesozoic beds in this basin are horizontal or very slightly dipping, dips not exceeding 10°.

Dunstan also records horizontal "Desert Sandstone" beds lying unconformably on the Stanwell Coal Measures though none are shown in his map near the new fossil locality. The lithology of the Desert Sandstone was not discussed. A passing reference stated that it is ferruginous. Unfortunately, the term "Desert Sandstone" has been used in Queensland for a great variety of material, including, more commonly than anything else, remnant of old lateritic soils. The reference to the ferruginous nature of the "Desert Sandstone" suggests that these also may be lateritic remnants.

It is not likely that the fossiliferous bed is part of the "Desert Sandstone." The hard, highly calcareous, brown sandstone is very typical of Mesozoic series of sundry ages in Queensland and quite unlike anything that any worker has placed in the "Desert Sandstone." As Reid has indicated in an unpublished communication, it is probable that the sediments are part of the Stanwell Coal Measures.

² Determinations by Walkom in his papers of 1915 and 1917.

If that is so and the age of the bed be accepted as lower Cretaceous, what then is the age of these coal measures generally? It may be pointed out that of the nine species of fossil plants mentioned above, upon which Walkom based a Jurassic age for the Series, no less than six are long-ranged forms—occurring not only in definitely Jurassic beds but described also by Walkom (1918 and 1919) in beds of unquestionably Cretaceous age elsewhere in Queensland³. The three exceptions are *Taeniopteris spatulata* var. *major*, *Phyllopteris feistmantelii* and *Taeniopteris crassinervis*. Of these the first is merely a variety of a species that occurs both in the Stanwell flora and in the Cretaceous floras described by Walkom. Then it should be noted that Walkom (1919, p. 23), when describing *Phyllopteris lanceolata* from the Cretaceous rocks of the Burrum Series, stated that “it is possible that *P. lanceolata* is a later, modified form of *P. feistmantelii*.”

Thus there is nothing against either of these two species being of Lower Cretaceous age. There remains *Taeniopteris crassinervis*. *Taeniopteris* is of course a form-genus, but nevertheless, as such, ranges from Permian to Lower Cretaceous. Forms that are identified in Queensland as of this species belong to at least three natural genera (including *Yabeiella*). Apart from this one record all the macrotaeniopterids in Queensland are from beds of early Triassic age—the Esk Series and the early part of the Ipswich Series. They are not known locally in beds that are undoubtedly Jurassic.

Species, like the Stanwell species, with infrequent dichotomous branching of the veins, occur in both Jurassic and Cretaceous beds elsewhere (e.g., the lower Cretaceous beds of the Weald in England and of Maryland in North America). Only its size makes it unusual for a Cretaceous form—it reaches a diameter of five inches. I know of no other Cretaceous *Taeniopteris* more than two inches wide—larger forms that have been recorded in Cretaceous rocks as *Taeniopteris* (or *Macrotaeniopteris*) are usually *Nilssonina*.

In the nature of such evidence there is little against the flora being of Lower Cretaceous age; and accordingly it is suggested that these Coal Measures generally are early Cretaceous—of Valanginian or near-Valanginian age. That is, in the local record, they may be regarded as approximate equivalents of the upper part of the Tiaro Series and of the Blythesdale Series generally, both of which lie below beds with Aptian ammonites.

PALAEOGEOGRAPHICAL ASPECTS.

Lower Cretaceous marine beds now are known at two localities⁴ along the east coast of Queensland—in the Maryborough-Bundaberg region where Lower Aptian marine beds interrupt a succession of Coal Measures; and here at Stanwell where Valanginian (?) beds also apparently are within a coal measure sequence.

The general geological history of the Lower Cretaceous of Queensland now becomes markedly similar to that of South and East Africa and of India. In all these regions the earliest Cretaceous sediments are

³ The latter plants came from the Maryborough Series where they are interbedded in marine shales with Aptian ammonites (*Australiceras*); from the Burrum Series that overlies the Maryborough Series; and from the Styx River Series that has, in addition, dicotyledonous plants.

⁴ That is, excluding remnants in Cape York Peninsula in the far north of Queensland.

lacustrine beds, chiefly sandstones, in which Valanginian (?) beds with the *Iotrigonia* fauna are a transient marine phase. Then follow marine Aptian sediments and then, after an interval, marine Upper Albian. The possibility of a marine Hauterivian incursion in Queensland raises the question whether other transient Neocomian marine phases may be present.

Such is the similarity of succession. There is also a similarity of faunas. The faunal agreement throughout this province of the first marine phase has been noted. Although the relationships are most marked with India and Africa, representatives of this limited *Trigonia* assembly are known in the N.W. Himalayas, Kachh, Coconda (east coast of India), Madagascar, Tanganyika, Zululand, South Africa, as well as in Patagonia, Chile, Bolivia and Texas. The similarity continues. Little is known at present of the Aptian faunas of Africa and India; but records from Zululand by Rennie (1936) of *Toxoceratoides*, *Australiceras*, *Tropaeum arcticum*, etc., suggest that there may be a close comparison with the Aptian beds (Roma Series) of Queensland.

In the Upper Albian the faunal similarities between East Africa and Eastern Australia are particularly marked, as Spath (1925) and I (Whitehouse, 1926) have shown. Several of the ammonite genera are common to those regions and are known nowhere else.

As a further link, reference may be made again to the belemnite family Dimitobelidae (Whitehouse, 1924) which is restricted to the Indo-Pacific region (India, Australia and New Zealand), and to the genus *Maccoyella* (chiefly Aptian), restricted, so far as is known, to India, Australia, New Zealand and Patagonia.

Pacific relationships remain intimate in the Upper Cretaceous, as Wilckens frequently has stressed (see, e.g., 1922, p. 31), but now they are more evident in the eastern Pacific region. No Upper Cretaceous marine beds occur in Queensland.

In these things this zone differs from the East Indies province. There, for instance, Valanginian beds are known (in Borneo and Sumatra) but they are of foraminiferal facies and have not yielded the *Iotrigonia* fauna. Later Cretaceous faunas of the Indies also are markedly different in facies—e.g., Albian deposits have pseudoceratitic ammonites.

FOSSIL PLANTS.

This is not the occasion to review in detail the palaeobotanical evidence of the Lower Cretaceous of Queensland; but a few aspects should be noted.

The typical early Mesozoic gymnosperm flora, with *Taeniopteris*, *Ginkgoites*, *Cladophlebis*, *Thinnfeldia*, etc., begins in Gondwanaland in the Permian. These four "genera," for instance, occur in the Permian of Queensland. Throughout the whole of the Triassic period the flora flourished and reached its local acme. It declined markedly in the Jurassic of Queensland where only occasionally is there a flora rich in species.

This flora was not well established in Europe until late in the Triassic—which accounts for so many of the Queensland Triassic floras having been placed erroneously as Rhaetic from European comparisons.

Typical Cretaceous gymnosperms, like *Nathorstia*, are spasmodically present in the Queensland floras. In the very far north, at Plutoville (see Walkom 1928), they are abundant in pre-Aptian beds but are rare in the south. They are not present in the Aptian flora of the Maryborough Series and are very sparingly present in the post-Aptian Burrum Series. Some of the typical, abundant plants of the Northern Hemisphere, notably the Cycadeoidea, did not reach Australia. This suggests that the early Mesozoic-type flora (*Thinnfeldia* Flora) evolved in the Permian of Gondwanaland and spread late in the Triassic to Europe; while in contrast the later (Cretaceous) gymnosperm flora arose in the northern regions and spread south.

Generally, in the Lower Cretaceous floras of the southern areas of Queensland, gymnosperms of types that dominated the Jurassic are still overwhelmingly the dominant forms. Thus, if the Stanwell Series, on the evidence of the mollusca, is very early Cretaceous, it is not altogether surprising that all the forms so far found are of the early gymnosperm types.

DESCRIPTION OF SPECIES.

(From material in the collections of the Geological Survey of Queensland.)

Genus *IOTRIGONIA* van Hoepen 1929B.

(Genotype by original designation: *Iotrigonia crassitesta* van Hoepen, p. 7, pl. II, figs. 4, 5; pl. III, figs. 1, 2. Lower Cretaceous Ndabana beds, Umsinene River, Zululand.)

Trigonias with V-shaped ribbing on the disc have appeared on several occasions. A middle Jurassic group was separated as *Vaugonia* by Crickmay in 1932 (Type: *V. veronica* Crickmay), and another of Lower Cretaceous age was named *Iotrigonia* by van Hoepen in 1929. No other groups have been given generic recognition. These two are but partial homoeomorphs, the ornament on disc and area differing considerably in the two groups. V-shaped ribbing arises in each group by a marked angularity developing between the anterior and posterior parts of the ribbing on the disc in the late nepionic or neanic stage, and this becomes exaggerated quickly into an acute angle forming a V. It may be regarded as the limiting stage of a tendency which in other groups of Trigonias (e.g., *Trigonia diversicostata* Whiteaves, 1876, p. 68, pl. X, fig. 1) is halted when the angularity does not exceed a right angle. In *Iotrigonia* the tendency is more developed than in *Vaugonia*, the angularity of the ribs being markedly more acute, reaching its acme in *I. limatula*. It may even be, as Kitchin has suggested in dealing with *I. van* and *I. v-scripta*, that the genus is not strictly monophyletic.

Dietrich (1933, p. 33) has dealt briefly with the similarities of the two genera, and Rennie (1936, p. 338) has discussed at length the genus *Iotrigonia*. Reference should be made to two papers by Kitchin (1903, p. 70 and 1908, p. 110) written long before the generic name was given, in which the relationships and affinities of the group of species now separated as *Iotrigonia* were discussed in admirable detail.

Hitherto *Iotrigonia* has been recognised with complete certainty only in India and South Africa. The valid species of the genus⁵ include *I. vau* (Sharpe) and *I. stowi* (Kitchin) from the Uitenhage beds of South Africa; *I. crassitesta* van Hoepen, *I. inconstans* van Hoepen and *I. haughtoni* Rennie from Zululand; and *I. v-scripta* (Kitchin) and, doubtfully, *I. dubia* (Kitchin) from the Oomia beds of Kachh in India. Kitchin refers to *Trigonia kühni* Müller from Neocomian beds in Tanganyika as possibly related. I have not seen Müller's work.

Of the American early Cretaceous species to which attention was drawn by Kitchin, *Trigonia diversicostata* Whiteaves, from Queen Charlotte Islands, and *Trigonia heterosculpta* Stanton from Patagonia are, I think, generically distinct. They and certain forms from the Malone Formation in Texas (Cragin, 1905, pl. LX, figs. 4-6) give more the appearance that V-ribbing developed as a sudden late acquisition, and it never assumes the perfect V of the Indian and African species. Chilean forms described by Phillipi (*T. arsinoe* P. and *T. foveata* P.) and an Alaskan species (*T. doroschini* Eichwald) also are mentioned by Kitchin, though he does not stress close relationships. I have not seen these two works.

The vertical ranges of *Iotrigonia*, from the African and Indian records, is a little difficult to assess. Spath's monograph on the ammonites (1930) establishes definitely that the age of the Uitenhage species is Valanginian. Of the Zululand forms *I. crassitesta* and *I. inconstans* occur in the Ndabana beds which lie below the ammonite-rich Umsinene beds of Albian age. Van Hoepen (1929A, p. 10) refers them to the Aptian, but the evidence for this is not yet published—the only ammonite in his list is *Douvilleiceras* sp., presumably *Douvilleiceras* in a comprehensive sense. As Rennie points out, all the Ndabana *Trigonia*s are closely akin to Uitenhage species. *I. haughtoni* from Northern Zululand was found below a horizon with an Aptian ammonite (*Tropaeum* sp.); but whether it is Aptian or pre-Aptian remains to be proved.

Similarly in Kachh, in India, the evidence is not precise. The species of *Iotrigonia* are from the Oomia group, the *Trigonia* bed occurring above the zone with Tithonian ammonites and below the beds with Aptian ammonites (see Spath's analysis of the succession—1933, pp. 736-757). Thus there the genus may be of late Tithonian or some pre-Aptian Cretaceous age. Once again the resemblance of associated *Trigonia*s to Uitenhage species has been noted by Kitchin and others.

Thus at present all that can be stated without question about the range of *Iotrigonia* is that it is not known earlier than Kimmeridgian or later than lower Aptian. But there is reason to believe that it may be confined to beds of Valanginian or near-Valanginian age. It is

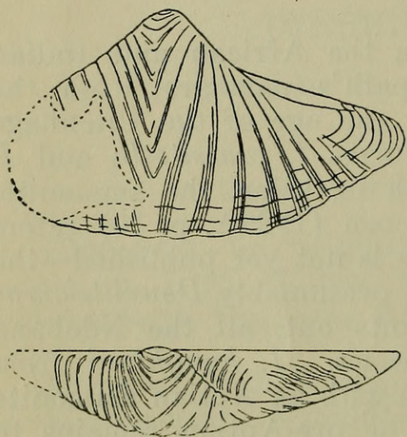
⁵ Bibliographic references to these and other species mentioned are as follows:—*I. vau*: Sharpe 1856, p. 194, pl. XXII, fig. 5, redescribed by Kitchin 1908, p. 110, pl. VI, figs. 1-3. *I. stowi*: Kitchin 1908, p. 115, pls. VI, figs. 4, 5; VII, fig. 1. *I. crassitesta*: van Hoepen 1929B, p. 7, pls. II, figs. 4, 5; III, figs. 1, 2. *I. inconstans*: van Hoepen 1929B, p. 8, pls. III, figs. 3, 4.; IV, figs. 1, 2. *I. haughtoni*: Rennie 1936, p. 340, pl. XLI, figs. 1-4. *I. v-scripta*: Kitchin 1903, p. 70, pls. VII, figs. 6-8; VIII, figs. 1-3. *I. dubia*: Kitchin 1903, p. 67, pl. VII, figs. 3-5. *Trigonia diversicostata*: Whiteaves 1876, p. 68, pl. IX, fig. 1. *Trigonia heterosculpta*: Stanton 1901, p. 20, pl. IV, figs. 16-18.

pertinent to remark that the marine Aptian beds (Roma Series) of Queensland contain an assembly of Trigonias, mostly undescribed, but none of the genera of this faunule.

I. crassitesta, *I. inconstans* and *I. v-scripta* all have a gerontic stage in which the V-ribbing ceases and purely concentric rugae succeed. This, of course, is not peculiar to *Iotrigonia*. Also, as in other Trigonias, in the gerontic stage, the marginal carina and the area tend to smoothen. In the nepionic stage the ribbing is concentric; and an intensification of gerontic tendencies with progressive limitation of the normal adult V-ribbing would lead to simple, concentrically ornamented forms. Such purely concentrically marked genera as *Indotrigonia*, *Sphenotrigonia* and *Rutitrigonia* are no doubt end-points of such a tendency in more than one lineage of Trigonias.

IOTRIGONIA LIMATULA sp. nov. Pl. I, figs. 1a, b.

Diagnosis: Sharply triangular *Iotrigonia* with very regular V-shaped ribs meeting at an acute angle along a straight axis and with a sharp marginal carina and narrow cardinal area.



Description: Shell thin, evenly but only slightly inflated, considerably longer than high. Outline sharply triangular, modified by a well rounded antero-ventral angle and a slight rounding of the acute postero-ventral corner. The umbo, which is very sharply defined and incurved, is slightly anterior to the median line (at almost one-third of the transverse diameter). Marginal carina very sharp in the earlier growth stages (to 16 mm.), abruptly bounding a very narrow lunate and slightly concave cardinal area.

On the disc the first few costae are concentric, gradually assuming a V-shape. Then they become V-shaped, the two branches forming a rib converging at a very acute angle. Occasionally an anterior rib ceases at the V-axis and is not paired on the posterior side.

The axis of the V's is remarkably straight and at right angles to the major axis of the shell. Costae are broadly rounded and spaced with narrower sulci. The posterior region being somewhat wider than the anterior, the costae become wider in that direction and cease just before the posterior angle. In the first 16 mm. of the marginal carina, where it is very sharp, each costa of the disc reappears as a costa of the area, extending slightly obliquely to the cardinal margin. Then, when the marginal carina broadens, the area becomes smooth and develops a faint longitudinal sulcus. The escutcheon is so narrow as to be obsolescent. Both disc and area are marked also with faint growth striae.

Internal structures not known.

Dimensions of holotype: Length: 36 mm. Height: 24 mm. Thickness: 7 mm. (Single valve.)

Along the main axis the relationship of the region in front of the V-axis to that of the region behind it is precisely 1 : 2.

Remarks: Only one specimen, the holotype, has been collected. It is a relatively small form for the genus and thereby possibly is immature.

In comparing it with other species, particularly the younger stages of other species, attention is drawn to the thinness of the shell in this form; to its sharply triangular outline and very sharp marginal carina in its early stage; to the very acute V-ribbing and the straightness of the V-axis. In such features it is in sharp contrast with such forms as *I. crassitesta* van Hoepen and *I. inconstans* van Hoepen with thick tests and less incisive details of form. It is to *I. v-scripta* that it shows most resemblances. Some smaller specimens of that species figured by Kitchin (1903, pl. VIII, figs. 1, 2) are very comparable, being similarly compressed and having also a more strictly scalene outline and a sharp marginal carina, while the ornament of the cardinal area also generally agrees. The two, although close, are not con-specific; for in *T. v-scripta* the V-axis is slightly curved and there is a median carina also on the area. The development of the costae in the early stages of these two species is rather similar. *T. haughtoni*, although thicker and more inflated, also may be compared for its relatively incisive details in the early stages and in the development of the early costae. But there the V-ribs although more acute than the genotype are developed along an axis with a very marked curvature.

The holotype of *I. limatula* has no suggestion of gerontic characters. Indeed in the preciseness of shape, details of ribbing and the sharpness of carina, it has a particularly youthful appearance. Whether larger specimens will show a cessation of the V-ribs in the very last stage remains to be proved. It is not to be concluded, of course, that apparently youthful characters indicate an early species of the genus. Spath (1935, p. 185) rightly has pointed out that arguments about age based purely on the apparent stage of evolutionary development within a group of Trigonias are apt to be misleading and in most instances are valueless.

Genus PISOTRIGONIA van Hoepen, 1929B.

(Genotype by original designation: *P. salebrosa* van Hoepen p. 20, pl. V, figs. 1-6 from the Ndabana beds of Zululand.)

(Synonym: *Rinetrigonia* van Hoepen 1929B, genotype *Trigonia ventricosa* Krauss. *Salebrosa* and *ventricosa* probably are identical, in which case *ventricosa* has precedence.)

Kitchin, who did such admirable work on the Trigonias of the Oomia beds in Kachh and of the Uitenhage beds of South Africa, was not able to separate forms from these two regions that he referred to *T. ventricosa* Krauss. Van Hoepen not only has made them specifically distinct but placed them in different genera. Rennie (1936, p. 330) has protested against this as wrong and unnatural, and I agree with him in recognising one genus only for the group and probably a common species in these two regions. Of the two names *Pisotrigonia* has precedence, since *Rinetrigonia* was proposed merely in the last sentence of the description of *Pisotrigonia*.

Pisotrigonia occurs in the same beds as *Iotrigonia*—that is, in the Uitenhage beds of South Africa, the Ndabana beds of Zululand and the Oomia beds of Kachh; so that the same reasoning that was used above in determining the age of *Iotrigonia* applies to *Pisotrigonia*.

The genus (part of the group of the section *Scabrae* of the *Trigonias*) is lunate in outline with very concave dorsal margin and even more curved, convex, ventral margin. The anterior portion is very inflated. The costae run diagonally. Posterior costae are plain or papillate. Anterior costae are coarsely tuberculate, with a median group that are tuberculate only towards the ventral ends.

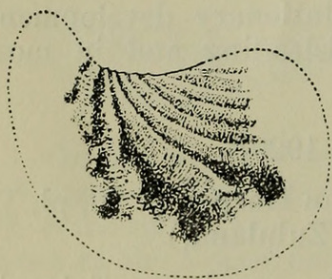
Pisotrigonia is very similar to *Pterotrigonia* van Hoepen and *Ptilotrigonia* van Hoepen, in each of which, however, all costae are tuberculate.

Species of the genus include *P. ventricosa* (Krauss)⁶ which occurs in the Uitenhage beds of South Africa, in the "*Trigonia smeei* beds" of Tendaguru (East Africa) and the Oomia beds of Kachh. *P. salebrosa*, the genotype, is regarded by Rennie as a synonym of *P. ventricosa*, and I agree. The forms recorded by van Hoepen as *salebrosa* are from the Ndabana beds of Zululand. *Trigonia subventricosa* Stanton from Neocomian beds in South Patagonia probably is correctly placed in *Pisotrigonia* although the tubercles on the anterior costae are small. This species is recorded but not figured by Piroutet from New Caledonia (1917, p. 128).

It is doubtful if any other described species rightly can be placed in *Pisotrigonia*. Most other forms that have been compared with the *ventricosa* group belong to *Ptilotrigonia*.

PISOTRIGONIA sp. Pl. 1, figs. 2, 3.

Several fragments of external moulds and several internal moulds are present of a species of *Pisotrigonia*. It has the typical form of the *Scabrae* (strongly lunate outline and very inflated anterior) and has also the characteristic ornament and wide smooth marginal carina of this genus. Two squeezes from external moulds are figured, the smaller of which shows the usual strong ventral curvature; and both show a sharp change from strongly tuberculate, oblique, anterior ribs to simple, sharp posterior ribs. Both have concentric growth striae that do not show well in the figures.



Sufficient is shown in these fragments to indicate that the species is distinct from the three forms that have been described for the genus. It is most similar to *P. kraussi*. Both forms have five posterior ribs with an abrupt change to coarse anterior ribs that bear very strong clavate tubercles. A study of the growth lines on the several fragments of this species suggests that the changing shape of the individual, from youth to maturity, is not unlike that of *P. kraussi*.

The available material is not sufficiently good to justify the introduction of a new specific name.

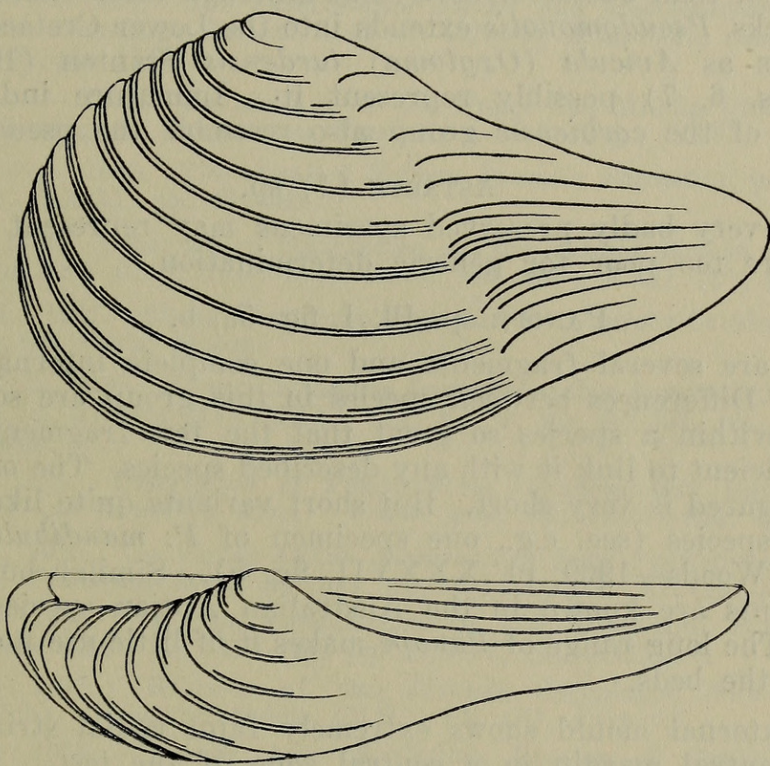
⁶ The bibliographic references to these species are as follows:—*P. ventricosa* Krauss sp. 1842, p. 30, redescribed and figured by Kitchen from the Uitenhage beds (1908, p. 91, pl. III, fig. 1) and from the Oomia beds (1903, p. 104, pl. X, figs. 4-8); *P. kraussi* Kitchin sp. 1908, p. 95, pl. III, fig. 2; *P. salebrosa* van Hoepen 1929 B, p. 20, pl. V, figs. 1-6; *P. subventricosa* Stanton sp., 1901, p. 18, pl. IV, figs. 19, 20.

Genus *INDOTRIGONIA* Dietrich 1933.

(Genotype, by original designation: *Trigonia smeei* J. de C. Sowerby from the Oomia beds of Kachh.)

INDOTRIGONIA (?) sp. Pl. I, figs. 4a, b; 6.

One external mould with the ornament abraded (pl. 1, fig. 4) is of a shell with straight ventral and dorsal margin and uniformly rounded anterior margin, with the umbones well towards the anterior end. The ornament is of strong concentric ribbing. There is a wide, shallow postero-ventral sulcus, a broad carina and a shallow trough-like posterior cardinal area. In and posterior to the sulcus the ribbing apparently ceases and the surface is marked only with growth striae. One other external mould (fig. 6) apparently of the same species shows the strength and simplicity of the concentric anterior ribbing.



Restoration.

This apparently is one of the purely concentrically ornamented *Trigonia* groups that, as suggested above in the section on *Iotrigonia*, are probably end-points of several lineages. Four such genera have been erected so far for Cretaceous forms—*Rutitrigonia* and *Pleurotrigonia* van Hoepen, *Indotrigonia* Dietrich and *Sphenotrigonia* Rennie. Although it is not definite that it belongs to *Indotrigonia*, the species is perhaps more comparable to members of that genus than any other. Forms belonging to it have very strong concentric costae, although there may be rudiments of other ornament in the umbonal regions (the umbo of this specimen is too abraded to register the early ornament). From the two species known in the genus (both from the Oomia beds of Kachh, with the genotype occurring also in Tanganyika) this form is distinct. The genotype, *T. smeei* (see particularly Kitchin, 1903, pls. III, fig. 9; IV, figs. 1-3) has a very narrow sulcus and a wide triangular area. *T. crassa* Kitchin (1903, p. 44, pls. IV, figs. 4-6; V, figs. 1-3) is

more triangular, has no sulcus and a less defined area. Both those species, which differ from this form in those features, also differ in being strongly ribbed on the area.

Forms of the *Indotrigonia* type occur later in the Cretaceous (*Trigonia meridiana* Woods, 1917, p. 6, pl. I, figs. 2-7, from the Albian of New Zealand is one example). Whether these indicate an extended range of the genus or a parallel development is problematical.

PSEUDOMONOTIS sp. Pl. I, figs. 7, 8.

A small pterioid lamellibranch is present with the following features: The left valve is inflated, ornamented with fine radial costae arranged as primary and secondary ribs, and with a small posterior ear. The right valve is flat and circular and its ornament is unknown. It is best placed in *Pseudomonotis*.

The related genus *Oxytoma* with longer posterior ears is rather more common than *Pseudomonotis*; but although more characteristic of Jurassic rocks, *Pseudomonotis* extends into the Lower Cretaceous, where such species as *Avicula (Oxytoma) tardensis* Stanton (1901, p. 14, pl. IV, figs. 6, 7) possibly represent it. Immature individuals of *Maccoyella* of the *corbiensis* group also resemble the pseudomonotids.

ASTARTE (?) sp.

A few very badly preserved specimens may represent this genus, but they are too poor for generic determination.

PANOPE sp. Pl. I, fig. 5a, b.

There are several fragments and one complete internal mould of a *Panope*. Differences between species in this group are so small and variations within a species so great that the few fragments available are not sufficient to link it with any described species. The one complete specimen figured is very short. But short variants quite like this occur in several species (see, e.g., one specimen of *P. mandibula* Sow. sp., figured by Woods—1909, pl. XXXVII, fig. 5). Similar but unfigured short variants are known in the Australian Aptian species *P. rugosa* (Moore). The long range of *Panope* makes it of little use for delimiting the age of the beds.

One external mould shows extremely faint radial striations from umbo to ventral margin in a central zone of the test. Fine radial striations or papillations, although rare, are not unknown on the genus.

Genus HIBOLITES (Mountfort) Mayer-Eymar 1863.

HIBOLITES sp. Pl. I, fig. 9.

There are several impressions of a belemnite but only one (here figured) shows the external groove. It is a member of the *Hibolites* group, most possibly *Hibolites* itself; but the material is not sufficient to determine the species (the one form with a groove showing is the youngest individual in the collection; and the few other fragments are not sufficient to determine the variation in shape of the species). Also, it is not sufficient to determine whether it may not be a member of the closely related genera *Mesohibolites* Stolley and *Neohibolites* Stolley. Stolley (1919, p. 48) gives the range of these genera as: *Hibolites* (Dogger to Aptian), *Mesohibolites* (Neocomian and Aptian), *Neohibolites* (Aptian to Upper Cenomanian).

Note.—This paper was written during a period of military leave.

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EXPLANATION OF PLATE I.

(All figures natural size.)

- Fig. 1a, b.—*Trigonia limatula* sp. nov. Lateral and cardinal views of a left valve (holotype).
- Fig. 2, 3.—*Pisotrigonia* sp. Plasticine squeeze of two fragments showing change in ornament from anterior tuberculate ribs to posterior plain costae.
- Fig. 4a, b.—*Indotrigonia* (?) sp. Lateral and cardinal view of a plasticine squeeze of a left valve.
- Fig. 5a, b.—*Panope* sp. The internal mould of a complete specimen. (a) right valve, (b) cardinal view.
- Fig. 6.— *Indotrigonia* (?) sp. Plasticine squeeze of a fragment showing regular, prominent, concentric ribs that appears to belong to the same species as figs. 4a, b.
- Fig. 7, 8.—*Pseudomonotis* sp. Plasticine squeezes of two left valves; fig. 8, showing the small posterior ear.
- Fig. 9.— *Hibolites* sp. Plasticine squeeze of a small individual.

(Material from the collections of the Geological Survey of Queensland.)



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