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ANNALS
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2. LAYOUT should be as follows:

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FISCHER, P.-H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archs Zool. exp. gén.* 74: 627–634.
KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Ann. Mag. nat. Hist.* (13) **2**: 309–320.
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(*continued inside back cover*)

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SEMPER ALIQUID NOVI AFRICA AFFERT

UPPER CRETACEOUS SEDIMENTS FROM THE IGODA RIVER MOUTH, EAST LONDON, SOUTH AFRICA

By

HERBERT CHRISTIAN KLINGER
&
BRIAN E. LOCK

Cape Town Kaapstad

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HERBERT CHRISTIAN KLINGER

South African Museum, Cape Town

&

BRIAN E. LOCK,

The University of Southwestern Louisiana, Lafayette

(With 7 figures)

[*MS. accepted 20 September 1978*]

ABSTRACT

The name Igoda Formation is proposed for a sedimentary sequence consisting mainly of calcareous sandstones and arenaceous limestones exposed on the bluffs overlooking the Igoda River Mouth near East London, South Africa. The invertebrate fauna indicates a Late Cretaceous age, probably Late Campanian to Early Maastrichtian. Faunal paucity precludes detailed comparison with other areas in southern Africa, but common faunal elements occur at Lower Needs Camp (here regarded as a lateral facies equivalent of the Igoda Formation), Pondoland, Zululand, Madagascar and Angola. Affinities with Madagascar are strongest.

CONTENTS

INTRODUCTION

Late Cretaceous fossiliferous limestones have long been known from the eastern Cape from one of the small quarries on the farm Needs Camp (the East or Lower Quarry) near East London (Lang 1908; Woods 1908; Chapman 1916). McGowran & Moore (1971) established a probable Upper Senonian (Campanian to Maastrichtian) age for this deposit on the basis of the micro-faunal content. Contrary to a report by King (1972), the second quarry at Needs Camp (the West or Upper Quarry) is excavated in limestones of Tertiary age (Lock 1973 and in preparation). Microfaunal investigations confirm this

Ann. S. Afr. Mus. 77 (5), 1978: 71–83, 7 figs.

(W. G. Siesser pers. comm.), although reworked Cretaceous material occurs in the limestones.

Until 1974 no other outcrops of Late Cretaceous marine sediments had been reported from south of the Umzamba Estuary (Pondoland, Transkei).

Mountain (1974: 19) briefly described a new fossiliferous locality less than 15 km from Needs Camp as follows: The rock occurs in a 'tiny exposure on the East London–Kidd's Beach road just west of the Goda River valley as the road climbs up on to the coastal plain. It can be seen in the present road cutting and consists of a friable limestone with abundant echinoid spines, *Ostrea* shells and gastropod casts. It is possibly Cretaceous but no one has examined the microfossils.'

Following landslides during the last few years, an extension of this occurrence became exposed in the bluffs overlooking the western shore of the lagoon at Igoda Mouth, less than a kilometre from the roadside section mentioned by Mountain (Fig. 1).

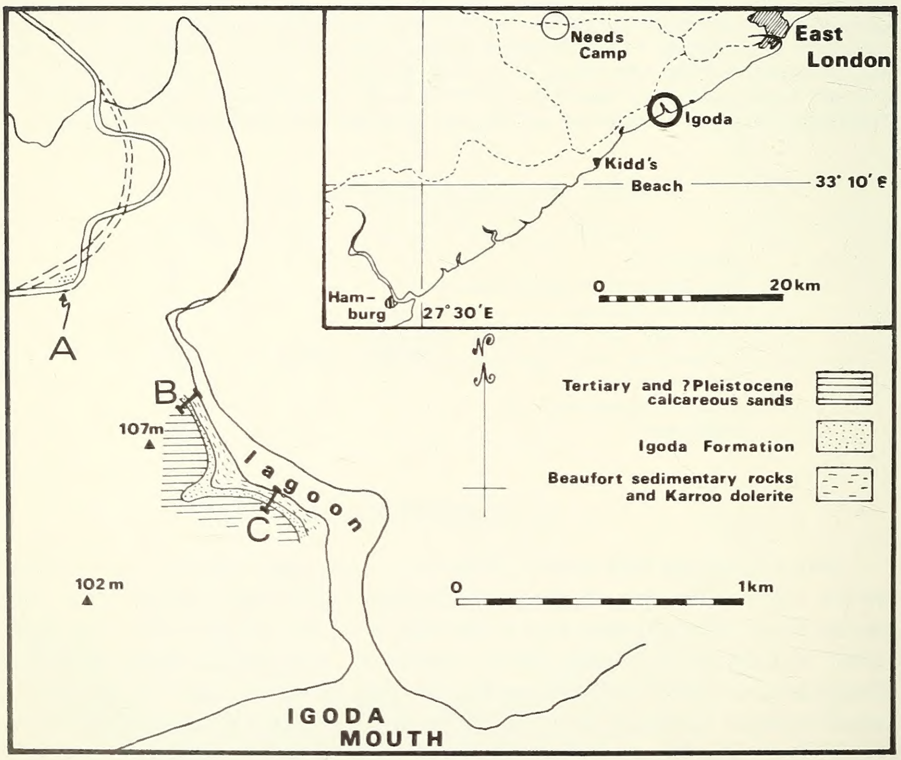

Fig. 1. Locality map, Igoda Formation. A. Roadside exposure reported by Mountain (1974); note the new road under construction. B. Type section of the Igoda Formation. C. Reference section. (See also Fig. 2.)

THE IGODA MOUTH SECTION

The succession in the new exposures is summarized in Figure 2.

The Cretaceous sequence, here named the Igoda Formation, rests unconformably on sandstones and mudstones of the Permian/Triassic Beaufort Group, which have been intruded by dolerites of later Karoo age. The contact is one of some relief. The type section (sections B1, B2) is a composite one (see Fig. 1 for location and Fig. 2 for sections), and has at its base up to 50 cm of matrix-supported small-pebble conglomerate, comprising well-rounded and well-sorted brown-stained pebbles with a mean diameter of about 2 cm but with individual pebbles up to about 5 cm long. Pebble lithologies consist of vein-quartz and quartz arenites for the most part, although one pebble was a single, well-rounded crystal of orthoclase 1,2 cm long.

The matrix is an arenaceous limestone with abundant glauconite. Some shell fragments are present in this limestone matrix. The basal conglomerate passes up into a sequence of arenaceous limestones and calcareous sandstones, all with a high content of glauconite. As this section is followed up the slope, exposures become very poor, and only a few of the more resistant calcareous beds form ledges. At an altitude some 20 m above the small-pebble conglomerate, a second unconformity, at the base of the overlying Alexandria Formation (of probable Tertiary age), is reached.

The middle portion of the Igoda Formation is better exposed some 30 m to the south. In this second section a brown, small-pebble conglomerate, indistinguishable from that just described, lies at the base of a similar sequence of well-exposed glauconitic arenaceous limestones and calcareous sandstones. As in the first section, these strata are fossiliferous, yielding a shelly fauna dominated by ostreids which litter the surface. At this point, however, the calcareous sequence has a much reduced thickness of just over 7 m, and the small-pebble conglomerate overlies a 3-metre-thick sequence of white, poorly consolidated, unfossiliferous sandstone and white, small-pebble conglomerates which are in all other respects identical to the brown ones already described.

These three lithological associations are regarded as informal members, and are known as the 'white member', 'brown, small-pebble conglomerate member' and 'calcareous member' respectively.

The base of the Alexandria Formation is marked by another conglomerate consisting of much larger pebbles (up to 30 cm in diameter) mostly of Beaufort Group sandstone and siltstone. These pebbles are generally less resistant than those found in the conglomerates of the Igoda Formation. The matrix of the Alexandria Formation basal conglomerate is a coarse bioclastic limestone containing fossil gastropods, especially *Patella* sp. and *Conus* sp., usually as moulds. Glauconite is absent to rare. This unit is about 1,5 m thick and is overlain by 10 m of cross-bedded, well-indurated, coarse bioclastic limestones. Characteristically, the cross-bedding comprises a single tabular set, with seaward dips of about 25°. Above this scarp-forming unit is a considerable thickness (at least 30 m) of poorly consolidated calcareous aeolian sands.

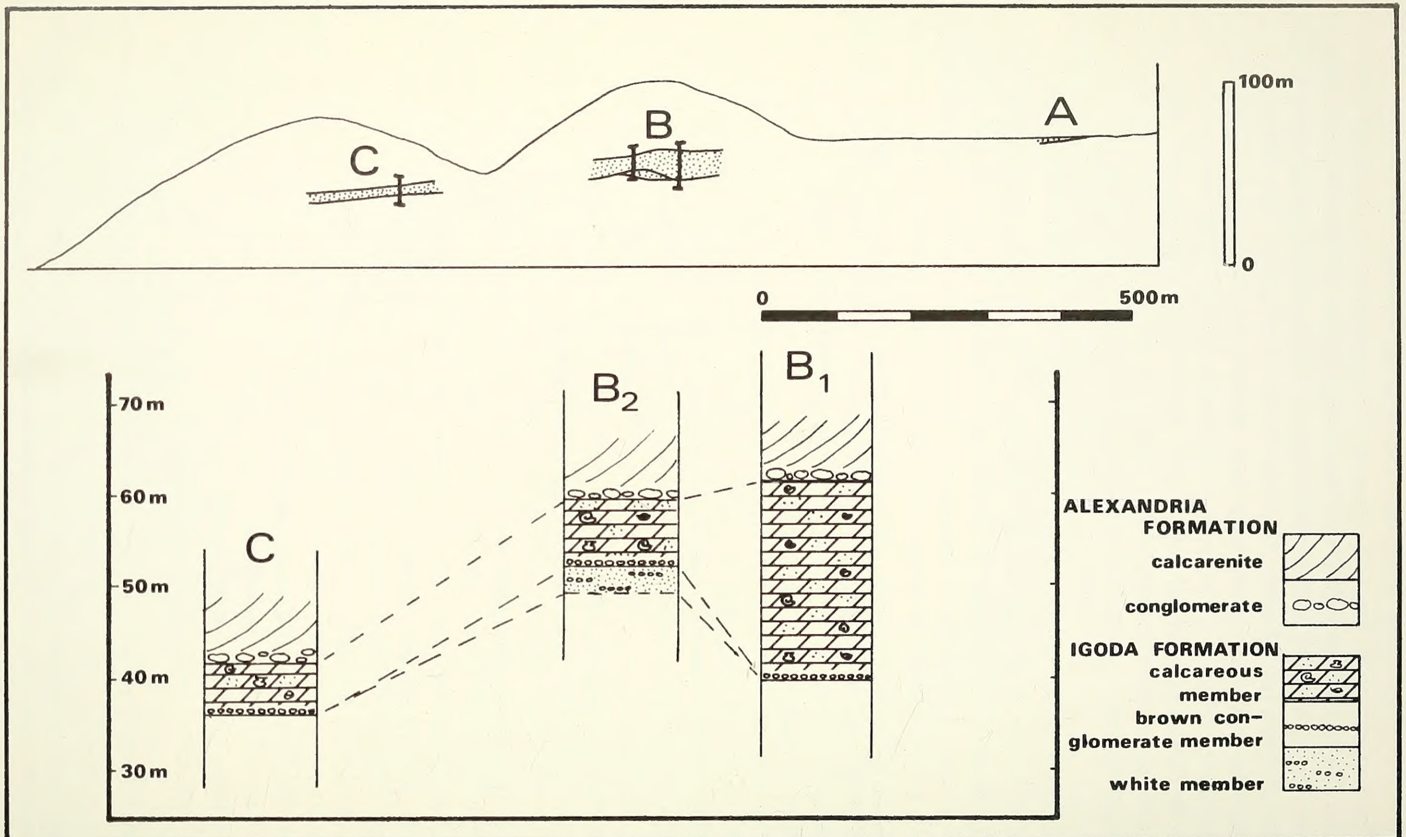

Fig. 2. Western bank of Igoda lagoon, showing distribution of outcrops described in text (above) and stratigraphic sections (below). Altitudes are in metres above lagoon water level, approximately high water mark. (See also Fig. 1.)

A second section was measured, 500 m closer to the sea (section C). Here the white member is no longer present, and the calcareous member is even further reduced in thickness (5,5 m). In other respects the sequence is similar (see Fig. 2).

THE ROAD SECTION

The original outcrop described by Mountain (1974, see above) was identified, and the adjective 'tiny' found to be very appropriate. Only a few tens of centimetres of very weathered glauconitic arenaceous limestone can be seen overlying Beaufort Group sandstones and merging upwards into soil and surface debris in the bank at the inland side of the road. The outcrop is very overgrown and easily overlooked. Broken specimens of *Rhynchostreon decussata* and *Lopha* spp., common forms in the main outcrop area, establish a correlation with the lagoon-side exposures.

At the time of the most recent visit (May 1977), roadwork was in progress for the straightening and improving of the main coastal road. Where this new road reaches the approximate altitude of Mountain's outcrop, it runs about 100 m inland of the latter, and cuts through a mass of dolerite. At the top of the cutting at this point, a few rounded pebbles of Beaufort Group sandstone in a calcareous cement were found. The size of these pebbles (20–30 cm) suggests that they are remnants of the conglomerate from the base of the Alexandria Formation. This would imply that the Igoda Formation pinches out at this point (area A on map, Fig. 1).

FAUNA AND AGE OF THE IGODA FORMATION

In comparison with the Cretaceous sediments of Zululand and Transkei (Kennedy & Klinger 1975 onwards), the invertebrate fauna of the Igoda Formation is meagre and poorly preserved. Bivalves are the commonest group, especially the ostreid forms, which have been preserved by virtue of their unique shell mineralogy, followed by brachiopods, baculitid ammonites, echinoids, and rare, normally coiled, ammonites, in that order of abundance.

At present, the material in the authors' collections is too scant to merit formal description and discussion, but a preliminary examination of the fauna has revealed the presence of the following faunal elements:

FORAMINIFERA
Textularia sp.

COELENTERATA
'*Caryophyllia*' cf. *arcotensis* Forbes (Fig. 3)

ECHINODERMATA
Unidentifiable cidarid with uniserial pore pairs (Fig. 4B)
Crinoid stem ossicles of *Pentacrinus* type (Fig. 4A)

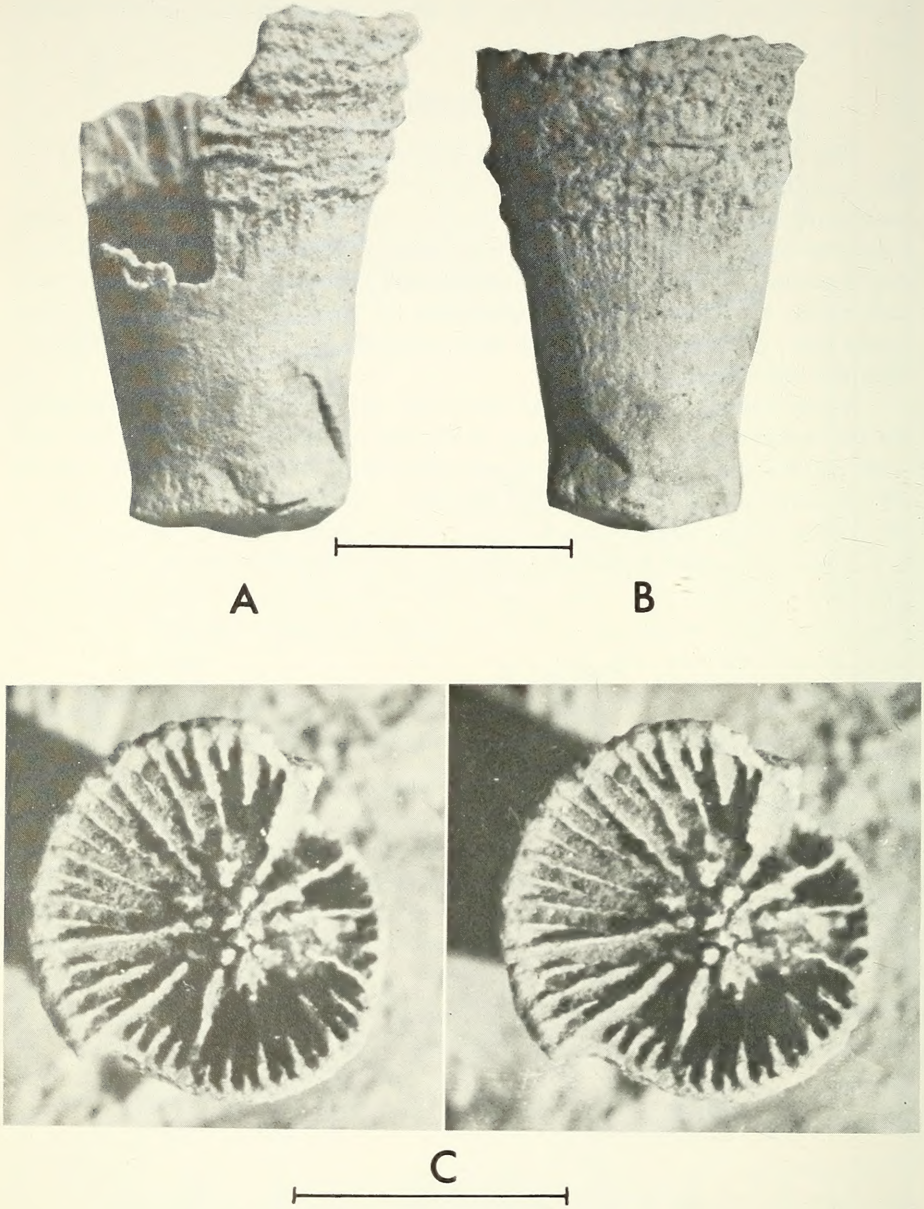

Fig. 3. '*Caryophyllia*' *arcotensis* Forbes (Geology Department, Rhodes University.) A–B. Lateral view. Scale bar 0,5 cm long. C. Dorsal view, stereopair. Scale bar 0,5 cm long.

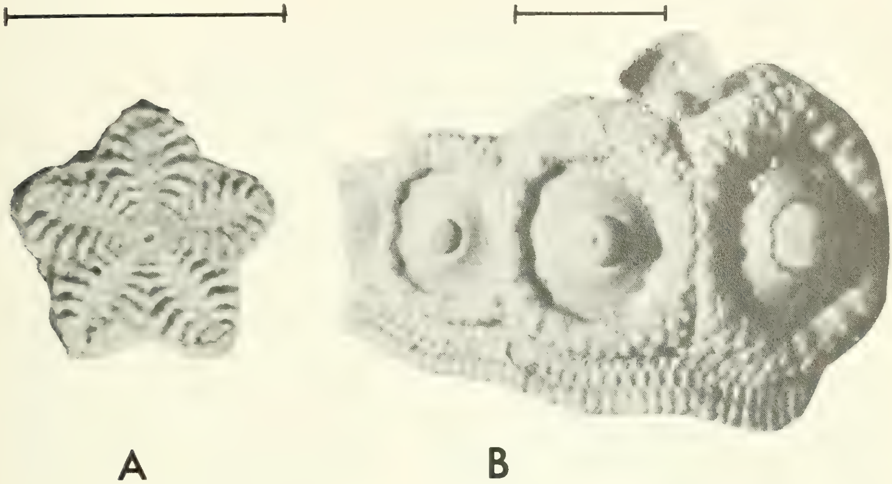

Fig. 4. A. Crinoid stem ossicle of the *Isocrinus* type. B. *Cidaris* sp. indet. Scale bars 0,5 cm long.

MOLLUSCA–CEPHALOPODA
Baculites subanceps Haughton (Fig. 5)
Eupachydiscus? sp. (Fig. 6)
Pachydiscid sp. indet (compressed)
Saghalinites sp. cf. *S. cala* (Forbes) (Fig. 7A–B)

MOLLUSCA–GASTROPODA
Turritella (*Zaria*) cf. *T.* (*Z.*) *besairiei* Basse

MOLLUSCA–BIVALVIA
Rhynchostreon decussata (*Goldfuss*)
Lopha (*Actinostreon*) *schnaebelei* Basse (Fig. 7C–H)
'*Trigonia*' sp.
Spondylus douvillei Basse
Panopea cf. *orientalis* (Forbes)
'*Inoceramus*' spp.

BRYOZOA
cf. *Ceriopora micropora* Goldfuss
'*Membranipora*' cf. *plebicola* Brydone

BRACHIOPODA
cf. *Terebratulina relicta* Stoliczka
cf. *Terebratula manuaensis* Muir-Wood
cf. *Rhynchonella natuans* Stoliczka
Eolacazella affine (Bosquet)

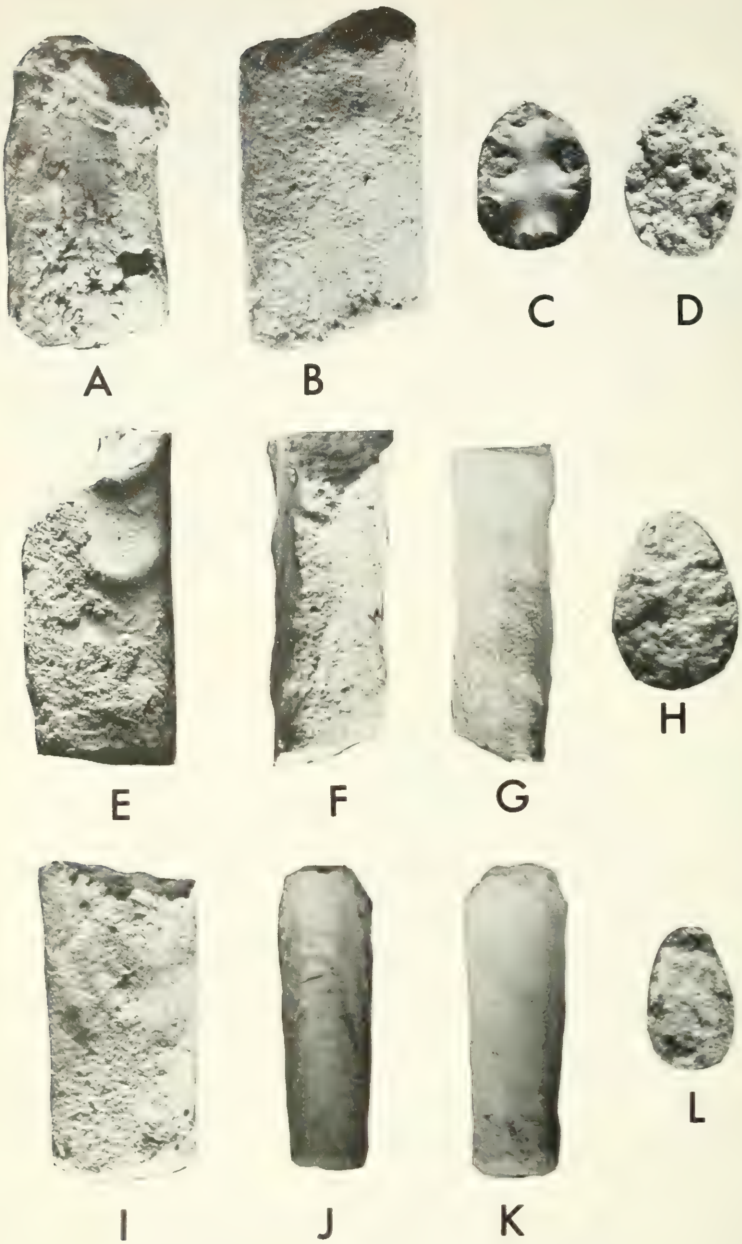

Fig. 5. *Baculites subanceps* Haughton. A, C. SAM–PCI5721. × 1,2. B. SAM–PCI5723. × 1,0. D. SAM–PCI5728. × 1,0. E–H. SAM–PCI5906. × 1,0. I–L. SAM–PCI5720. × 1,0.

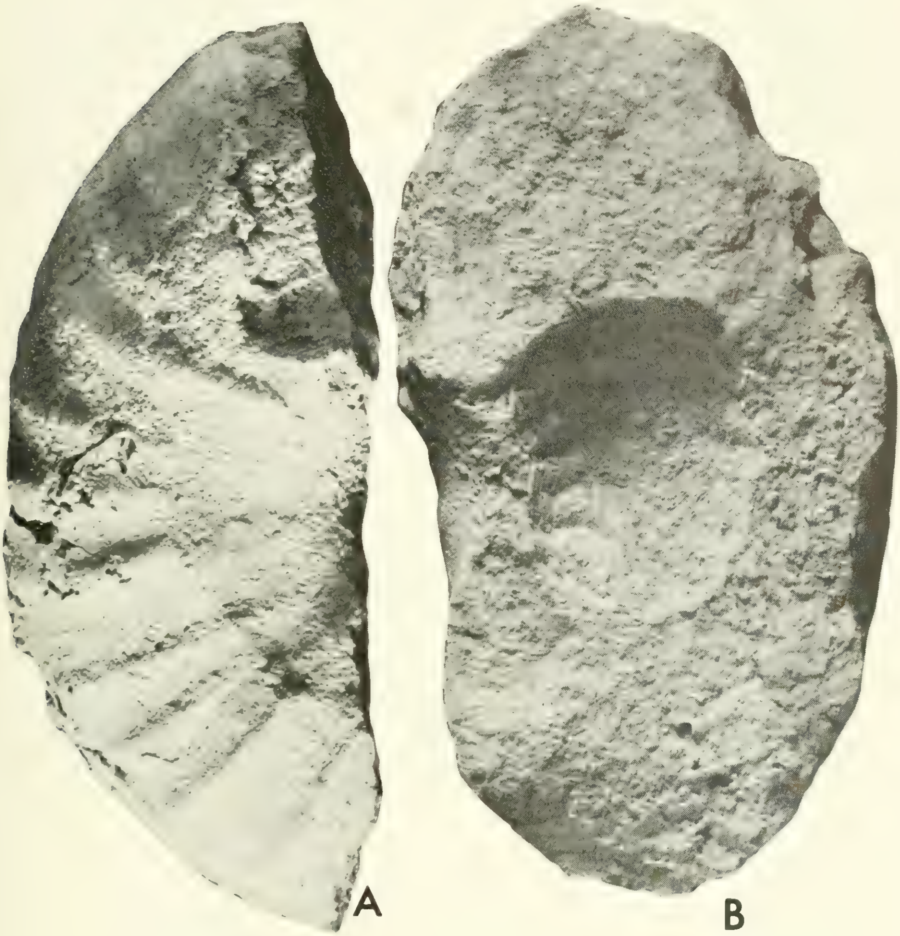

Fig. 6. *Eupachydiscus?* sp. indet. SAM–PCI5719. × 1,0.

Of the species identified, only a few can be used for accurate dating of the Igoda Formation.

Baculites subanceps s.s. has been firmly dated as Late Campanian in Angola (Howarth 1965), whilst the Pacific subspecies *B. anceps pacificus* occurs in the Late Campanian of Japan and California. *Saghalinites* ranges from the Santonian to Maastrichtian stages of the Late Cretaceous (Kennedy & Klinger 1977). *S. cala*, which the Igoda specimen resembles most, ranges from Campanian IV to Maastrichtian II (*sensu* Kennedy & Klinger 1975) in Zululand but is also known to occur in slightly older sediments in Pondoland (Transkei)

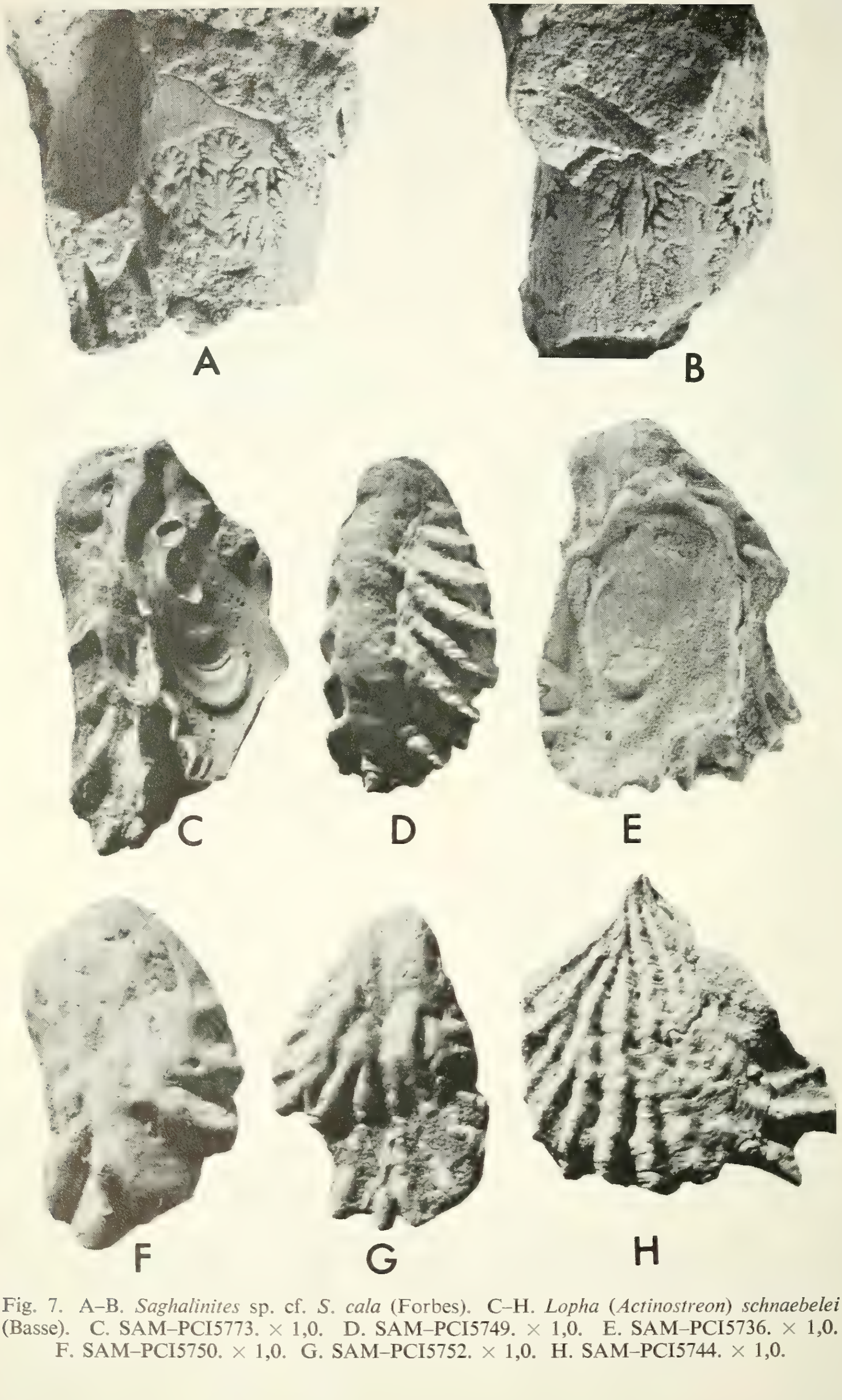

Fig. 7. A–B. *Saghalinites* sp. cf. *S. cala* (Forbes). C–H. *Lopha* (*Actinostreon*) *schnaebelei* (Basse). C. SAM–PCI5773. × 1,0. D. SAM–PCI5749. × 1,0. E. SAM–PCI5736. × 1,0. F. SAM–PCI5750. × 1,0. G. SAM–PCI5752. × 1,0. H. SAM–PCI5744. × 1,0.

(Middle Santonian–Lower Campanian) and southern India (Santonian or Campanian). The ammonite genus *Eupachydiscus* is typically Late Cretaceous, ranging from Coniacian to Maastrichtian, but the Igoda material is too poorly preserved for specific identification.

Ceriopora micropora Goldfuss has been described from the type locality of the Maastrichtian stage, but is also common in the Santonian and Campanian. *M. plebicola* is from the Maastrichtian.

Eolacazella affine (Bosquet) occurs in the Maastrichtian of Western Europe, and was also found at the Lower Needs Camp Quarry now dated as Upper Campanian/Lower Maastrichtian by McGowran & Moore (1971).

These data all seem to suggest an age of Campanian/Maastrichtian for the Igoda Formation with only a slight possibility of Santonian elements present.

COMPARISON WITH OTHER AREAS IN SOUTHERN AFRICA

The nearest onshore sediments of similar age occur at the Lower or Eastern Quarry at Needs Camp. *Eolacazella affine* occurs at both the Igoda River Mouth and at Lower Needs Camp, thus suggesting the two outcrops to be temporal equivalents, though of different lithologies. In places, the outcrops at Lower Needs Camp consist virtually of bryozoan limestone only. Exposures of similar lithologies have since been found by one of the authors (H. C. K.) in roadside excavations approximately half-way between the Upper and Lower Quarries, illustrating that the Lower Needs Camp lithology has a much greater aerial extent than previously suspected, and may yet prove to be a mapable unit to conform with the requisites for formal recognition as a separate Formation by the South African Committee for Stratigraphy.

The Lower Needs Camp sediments probably grade laterally into the slightly deeper water facies of the Igoda Formation, but outcrops connecting the two areas are, as yet, unknown.

Along the east coast of southern Africa, the closest Senonian sediments occur at the Umzamba Estuary (Transkei), which have been firmly dated as Mid-Santonian to Lower Campanian (Klinger & Kennedy 1977). Rare *Saghalinites cala* in the Umzamba Formation are comparable with *Saghalinites* sp. in the Igoda Formation.

The closest, and thus far only known, onshore Upper Campanian/Lower Maastrichtian sediments on the east coast of southern Africa occur in the False Bay/St Lucia region of Zululand (Kennedy & Klinger 1975). Here *Saghalinites cala* occurs quite frequently with *Nostoceras* sp. and *Eubaculites* sp. in the Upper Campanian and Lower Maastrichtian respectively. *S. cala* appears to be the only identifiable faunal element in common between the two areas. Lower Maastrichtian sediments are known from Cheringoma further north in Mozambique, but to date only poorly-preserved *Eubaculites* species are known (Crick 1923).

Much further north, the Campanian and Maastrichtian faunas of Maintirano, Madagascar, as described by Basse (1931), strongly resemble those from

Igoda especially as far as the thick-shelled ostreid forms are concerned, and to a lesser extent with the Late Senonian fauna of the east coast Province of Vatomandry described by Cottreau (1922), which is characterized by the paucity of ammonites, similar to the Igoda Formation.

Towards the southern and western coast, the closest sediments of comparable age are found in the off-shore Alphard Group between Cape St Francis and Cape Recife (Klinger *et al.* in prep.). Here, however, the dominant faunal element is *Eubaculites latecarinatus* indicative of Early Maastrichtian age. No macrofossils are common to both outcrops.

From here westwards, the first known Cretaceous on-shore sediments occur near Bogenfels (South West Africa) (Klinger 1977), but these have been dated definitely as Cenomanian, although some doubt still exists as to whether Senonian strata are present on-shore or not.

The closest comparable deposits occur at Carimba in Angola, the type area of *Baculites subanceps*, the latter being the only faunal element in common between Igoda and Angola. The Cretaceous sediments at Carimba have been firmly dated as Late Campanian by Howarth (1965).

SUMMARY

The name Igoda Formation is proposed for a sedimentary sequence consisting mainly of calcareous sandstones and arenaceous limestones exposed on the bluffs overlooking the Igoda River Mouth. The Formation is informally divided into 'white member', 'brown, small-pebble conglomerate member' and 'calcareous member'.

In comparison with the Cretaceous sediments of Natal and Transkei, the Igoda fauna is meagre, consisting mainly of thick-shelled ostreid bivalves, followed by brachiopods, baculitid ammonites, echinoids, and rare, normally coiled ammonites, in that order of abundance.

These faunas point to an age of Late Campanian to Early Maastrichtian.

Due to the paucity of the faunas, comparisons with other temporally equivalent areas are tenuous. The Lower Needs Camp Quarry deposits are of similar age, and probably represent a shallower water and more restricted lateral facies equivalent of the Igoda Formation. *Saghalinites* sp. cf. *cala* connects the Igoda Formation to the Cretaceous deposits on the east coast of southern Africa at the Umzamba Estuary and in the False Bay/Lake St Lucia region of Zululand.

As far as the abundance of thick-shelled ostreids and relative scarcity of ammonites is concerned, the Cretaceous deposits of Maintirano and Vatomandry in Madagascar show greatest affinity, but this should probably be ascribed to the depositional environment rather than to more favourable migration routes.

On the west coast of southern Africa, comparable deposits occur at Carimba in Angola which provide a definite date for *Baculites subanceps*, i.e. Late Campanian.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype
SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .'; '. . . in *C. namacolus* (Fig. 10) . . .'

(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene

(c) Scientific names, but not their vernacular derivatives
e.g. Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively.

Name of new genus or species is not to be included in the title: it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

HERBERT CHRISTIAN KLINGER
&
BRIAN E. LOCK

UPPER CRETACEOUS SEDIMENTS FROM THE IGODA RIVER MOUTH, EAST LONDON, SOUTH AFRICA