JURASSIC AND BASAL CRETACEOUS AMMONITES

FROM

THE KEMABOE VALLEY, WEST IRIAN (WEST NEW GUINEA)

By

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SCOPE & CONTENTS: An unlocalised collection of ammonites from West New Guinea is described and identified. These identifications afford the basis for determining the stratigraphic position of the fauna, which extends from the Sowerbyi Zone of the Middle Jurassic to the Upper Valanginian. The relations of the fauna to other ammonite faunas are described and indicate the ammonites in the present collection to be most closely related to the faunas of the Pacific Realm and Ethiopian province of the Tethyan Realm. A new genus, Sulaites is described and possible sexual dimorphism is detected therein.

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I. INTRODUCTION

This thesis is concerned with the description of a collection of ammonites from the central part of the former Netherlands New Guinea (now known as West New Guinea or West Irian). This collection was made by Dr. C.C.F.M. Le Roux during 1939 and 1940, in the course of an ethnological expedition to the region of the Kemaboe Valley.

A small part of this area was mapped by the Nederland Nieuw Guinea Petroleum Maatschappij (referred to hereafter as the N.N.G.P.M.), before relinquishing their concession in 1960, but by far the greatest part of the region has never been investigated (Map 2,3). A geologist had originally accompanied Le Roux's party, but returned to Europe at the outbreak of the war, in September 1939, when the expedition had just entered the Kemaboe Valley.

None of the material collected by Le Roux is known to have been found *in situ*, but is, nevertheless, of interest, since it includes several genera not previously known from New Guinea, which amplify the rather meagre records from this poorly known area. Situated between the Pacific realm and the Indian part of the Tethyan Realm, the ammonites of this region are of more than local interest.

General description of the ammonite collection made by Le Roux

Le Roux entered the Kemaboe Valley by way of the Izaboe and travelled upriver for about twenty kilometres to the village of Zanepa, before leaving the valley and striking due east (Map 3). After the departure of the geologist, Le Roux himself determined to collect pebbles and fossils from the rivers, but he mentions only one locality, the bed of the Iwaboe, which was said to be very rich in ammonites. This river is a tributary of the Kemaboe, entering the left side of the main valley about four kilometres below Zanepa and just outside the area mapped by the N.N.G.P.M. Whether this is the only locality from which he collected is not known.

Altogether the collection comprises more than two hundred ammonites, many of which are fragmentary, all preserved in exactly the same way, that is, in black, calcareous mudstone, containing variable amounts of free calcite and disseminated pyrite, together with some silica. The ammonites occur within concretions of the same material. This mode of preservation was noted by Boehm (1913) in ammonites from Windesi, northern Lenggeroe area, but with the difference that there silica played a much larger part in the constitution of the concretions. Boehm's remarks on the difficulty of preparing such material could, however, be repeated here.

The state of preservation of the material in the present collection is good, although in some cases the inner whorls have been laterally compressed (but usually with the ornament on one side preserved in full relief), or more rarely, completely destroyed, either before or during lithification. Local crushing occurs on the outer whorls of some specimens, while a small number have been compressed dorso-ventrally. Insofar as the determination of the collection is concerned, these diagenetic effects are less critical than the erosion suffered by the specimens, which is evident in almost every case and often considerable. Since this phenomenon is so prevalent and since the N.N.G.P.M. found only one ammonitiferous concretion in situ (but reported that many similar forms occurred in the river bed), it would seem probable that most of, if not all, the material was collected by Le Roux ex situ. All other collections from West New Guinea have been made entirely from the concentrations of concretions found as river pebbles.

The specimens described in this thesis are all deposited in the Rijksmuseum van Geologie en Mineralogie of Leiden and have been provisionally numbered. These numbers are prefixed by "L" in the following descriptions.

II. STRATIGRAPHY OF THE KEMABOE VALLEY, A REVIEW

Although forming one of the major east-west valleys in central New Guinea, the Kemaboe has remained poorly known, largely because of the surrounding rugged terrain and dense forests. It is not shown on the geological map of Indonesia prepared by the Direktorat Geologi Indonesia and published by the United States Geological Survey (1965), but it is shown on the maps published by the N.N.G.P.M. (Visser & Hermes, 1962).

The Kemaboe rises on the northern flanks of the Nassau Range of the Schneegebirge in the Central Ranges, about twenty kilometres east of Carstenztops (5030 M.), the highest peak in New Guinea, and flows slightly north of west for some one hundred and fifty kilometres, before turning to the north-west and then to the north, where it passes through the Minimitara Mountains. Beyond this point its course is not known, but it is presumed to enter one of the tributaries of the Wai Poga, which empties into the eastern side of Geelvink Bay (Map 2).

The rocks exposed in the upper part of the valley visited by Le Roux range in age from the Jurassic to the Tertiary and comprise a variety of lithologies. The following account is based largely on the reports of the N.N.G.P.M. published by Visser & Hermes (1962), and the maps of the region are from the same source.

1) Jurassic-Cretaceous

During this interval were deposited the coarse and fine clastics with minor carbonates, which make up the Kembelangan formation. This formation, so far as is known, is most fully developed in the region between the Bintoeni, Argoeni, Etna and Geelvink Bays (the Lenggeroe area (Map 4)). Here it comprises four members, designated 'A', 'B', 'C' and 'D', by the N.N.G.P.M. of which 'B', 'C' and 'D' form a sequence in upward succession with which 'A' is, at least partly, the lateral equivalent. Both the 'A' and 'C' are predominantly argillaceous, whereas the 'B' and 'D' members are predominantly arenaceous.

The type locality of the 'A' member is in the Nanggoebi Valley in the Wandaman Ranges, where it consists of about 1200 m. of shales and mudstones, with intercalated limestone bands and with massive limestones at the base. Towards the east thes beds become progressively metamorphosed and pass into schists and phyllites. Fossils are not common at the type locality, only indeterminate belemnites having been found, but along the strike, both to the north and south, concretions derived from this member have yielded numerous ammonites indicating Bajocian, Bathonian, Callovian and Tithonian (Boehm, 1913; Visser & Hermes, 1962).

The 'B', 'C' and 'D' members have their type locality in Well Kembelangan #1, on the north shore of Etna Bay, where the lowest part of the succession is a sandstone resting conformably on the non-marine Tipoema formation below, into which it grades, and becoming more shaley towards the top. From the lower part of this sandstone was obtained *Grammatodon* (*Indogrammatodon*) *virgatus* (Sowerby), indicative of Upper

Bajocian to Lower Oxfordian. This part of the sequence is, therefore, contemporaneous with at least the Nanggoebi River sequence and has been allocated to the 'A' member of the N.N.G.P.M., although it is of arenaceous, 'B' member, facies. The upper part of this same sandstone contains Lower Cretaceous foraminifera and constitutes the 'B' member proper of the N.N.G.P.M. The whole of this sandstone unit is c.600 m. thick.

Overlying the 'B' member are c.700 m. of grey shales and silty shales, with thin sandstones, which make up the 'C' member. In the lower part, the foraminifera characteristic of the 'B' member persist, but give way in the upper part to Upper Cretaceous forms, which continue into the 'D' member, another sandstone unit c.150 m. thick, which is conformably overlain by limestones of Tertiary age. Locally the 'D' member includes foraminifera of early Tertiary age, so that, although thinner here than in the Nanngoebi River, the formation spans a greater interval of time (Fig. 2,3).

Since the 'A' member is found only in the eastern part of the Lenggeroe area, while the 'B', 'C' and 'D' members occur only in the west, the Jakarti Fault Zone lying approximately along the boundary, and since the lower part of the sandstone sequence of the region about Etna Bay is equivalent to some part of the shale sequence of the Nanngoebi River, Visser & Hermes (1962) concluded that the 'A' member is the lateral equivalent of the other members. However, the latest horizon recognised within the 'A' member in this region is Tithonian, whereas the others all largely Cretaceous. In addition, in the Imskim Ranges, north of Lenggeroe, the 'A' member is overlain, apparently disconformably, by the pelagic limestones of the Upper Cretaceous Imskim formation. This apparent disconformity was interpreted by Visser & Hermes as being due to differences in competence between the Imskim formation and the Kembelangan formation when folded, leading to the formation of local thrust planes, which have cut out the Lower Cretaceous. The discovery of Lower Cretaceous ammonites in the 'A' member in the Central Ranges (Gerth, 1965) supports this hypothesis. The diagram figured by Visser & Hermes (1 9 6 2, fig. II-2) to illustrate the relationship between the members of the Kembelangan formation on the west side of Geelvink Bay is reproduced here (Fig. 4).

Outside the Lenggeroe area the fourfold subdivision of the Kembelangan formation is no longer possible, but a distinction between a largely argillaceous facies and a largely arenaceous facies can be made. The former was assigned to the 'A' member by the N.N.G.P.M., while the latter, which may, however, include up to 50% argillaceous beds, was assigned to the "undifferentiated 'BCD' members". In all cases the arenaceous beds are situated to the south of the argillaceous, suggesting that the source of the clastics lay in this direction. The lateral equivalence of the two facies is shown by the discovery of Jurassic fossils in the more shaley parts of the arenaceous beds and of Jurassic ammonites in the argillaceous beds.

Both facies of the Kembelangan formation are devloped in the Kemaboe Valley and its vicinity. Here the 'A' member consists of a thick (more than 1,000 m.) of intensely folded soft black slates and phyllitic slates, with intercalations of black marly limestones, silty sandstones and orthoquartzites. The base has not been observed. The beds show a progressive increase in metamorphism to the north and north-west, while to the south they are partly faulted against and partly overlain, apparently disconcordantly, by the sandstones and sandy shales of the "undifferentiated 'BCD' members". South-west of the Kemaboe Valley, near the Wissel Lakes, these sandy beds contain Upper Cretaceous foraminifera and this is the only evidence of their age in this region. As in the Imskim Ranges, the apparent disconcordance between the 'A' member and the overlying beds may be a result of differences in competence. Another parallel with the Lenggeroe area is that a fault zone (the North Paniai Fault Zone) lies more or less along the boundary between the two facies and that the more argillaceous beds to the north and east are thicker than the sandier beds to the south and west (Fig. 3). There would seem to be a possibility that the depositional environment of the Kembelangan formation was tectonically controlled during Jurassic and Cretaceous times.

2) Undifferentiated Mesozoic

Below the crest of the Schneegebirge lies a series of beds, which the N.N.G.P.M. referred to the Mesozoic, without further distinction. Where they have been investigated in greater detail, near Idenbergtop, they have been divided between the Tipoema formation and the 'undifferentiated 'BCD' members" of the Kembelangan formation. In the vicinity of Carstenztops it would appear from the risings of the rivers that these beds are south of the main watershed, but farther west, near Tafelberg, they seem to occur partly within the drainage basin of the Wissel Lakes and partly within that of the Kemaboe and its tributaries (Visser & Hermes, 1962).

3) Tertiary

An unmapped interval of about forty kilometres separates the arenaceous beds of the "undifferentiated 'BCD' members" from the overlying New Guinea Limestone Group. This group consists of massive limestones of Paleocene to Miocene age, which outcrop throughout the upper reaches of the Kemaboe Valley and form the northern flanks and the crest of the Schneegebirge and the other prominent peaks of the Central Ranges. They have been folded into a series of north-west trending anticlines and synclines and, within the Kemaboe Valley, have been pierced by several small intrusions near Carstenztops and the village of Wandai (Visser & Hermes, 1962).

4) Pleistocene

Near its headwaters the Kemaboe crosses quite extensive deposits of glacial debris, both ground moraine and terminal moraine, which indicate the former extent of the glaciers still persisting in these mountains. Similar morainic material also occurs near Carstenztops (Visser & Hermes, 1962).

III. PALAEONTOLOGY

1) Previous literature on ammonites from New Guinea

Jurassic ammonites have been figured from a number of localities in the western and central part of New Guinea (Map 5) and the literature up to 1954 has been reviewed by Arkell (1956), who included, besides his own comments, taxonomic revisions made by Spath (1928) in the course of his work on the ammonites of Kutchh. Since 1954, the Australasian Petroleum Company Proprietry (1961) has mentioned, but not described, further discoveries of ammonites in Papua, and Visser & Hermes (1962), in addition to reviewing the earlier literature on ammonites from the former Netherlands New Guinea, figured previously unpublished material identified for the N.N.G.P.M. By Arkell and Donovan.

i) The first ammonites to be described from New Guinea were figured by Etheridge (1890) and were collected as pebbles from Observatory Bend on the Strickland River (Map 5, loc. 10). Etheridge compared them with Bajocian and Callovian forms and later revisions have confirmed this diagnosis, although Arkell (1956) suspected that the Kimeridgian was also represented. As subsequently revised, the collection comprises:

?Kossmatia (Arkell, 1956; p. 447; for Etheridge pl. 29, fig. 4).

Macrocephalites (Kamptokephalites) etheridgei Spath (1928, pl. 32, fig. 3; for Etheridge, pl. 29, fig. 1).

Boehm's varieties. The following forms seem to have been represented in the material from New Guinea:

Macrocephalites (*Dolikephalites*) *keeuwensis* Boehm (for *M*. *keeuwensis* *α* Boehm 1913, p. 14).

(?)*Macrocephalites* s.s. (for *M*. *keeuwensis* *δ* Boehm 1913, p. 16, which was compared with Boehm 1912, pl. 43, fig. 3).

Eucycloceras *intermedium* Spath 1928 (for *M*. *keeuwensis* *β* Boehm 1913, p. 14, which was compared with Boehm 1912, pl. 38, fig. 3, which was designated lectotype by Spath).

Idiocycloceras *bifurcatum* (Boehm) (Spath 1928, for *M*. *keeuwensis* *β* var. *bifurcata* Boehm 1913, p. 14, compared with Boehm 1912, pl. 39, fig. 1 and 2, of which fig. 1 was designated as lectotype by Spath).

Subkossmatia *beta*-*gamma* (Boehm) (Spath 1928, p. 212 for Boehm 1913, pl. 5, fig. 2).

The rest of the fauna comprised *Phylloceras* *mamapiricum* Boehm, which was associated with the macrocephalitids and:

Tulites (?) (*Rugiferites*(?)) *godohense* (Boehm) (Boehm 1913, p. 10; Arkell 1952, p. 87; Arkell 1956, p. 448).

Chondroceras(?) cf. *C*. *submicrostoma* (Gottsche) (Boehm 1913, pl. 2, fig. 3; Arkell 1956, p. 448).

Chondroceras (*Defonticeras*(?)) *boehmi* Westermann (1956b, pl. 4, fig. 1; for Boehm 1913, pl. 2, fig. 4).

Cadomites *daubenyi* (Gemellaro) (Boehm 1913, pl. 3, fig. 1).

Stephanoceras aff. S. crassicosta (Quenstedt) (Boehm 1913, pl. 3, fig. 2, which Arkell (1956, p. 448) compared with S. caamoni Mc-Learn 1930, pl. 2, fig. 2 and S. (Stemmatoceras) palliseri Warren 1947, pl. 3 from the Humphriesianum Zone of Western Canada).

The holotype of "Sphaeroceras" godohense Boehm (1912, pl. 35, fig. 2) does not have the aperturel region preserved, so that its generic position is doubtful. Arkell (1952, p. 87) considered it to be a Tulites (Rugiferites), but Kruizinga (1926, p. 52; pl. 14, fig. 2,3) had figured under this name an entire and typical Chondroceras. Westermann (1956a, p. 257; 1956b, p. 109, pl. 13) considered the species figured by Boehm and Kruizinga to be distinct and made the latter the holotype of Chondroceras (?) (Praetulites) kruizingai Westermann.

Chondroceras and Stephanoceras indicate Middle Bajocian, while Cadomites may be Upper Bajocian, although this genus extends into the Bathonian and probably into the Lower Callovian. If the "Sphaeroceras" godohense is a tulitid, the Bathonian is also represented.

v) Gerth (1927) described a collection, which was said to have been made from the Wairori and Weriangi Rivers in the Onin Peninsula, but rivers with these names are not known in that area and the oldest rocks exposed there are Paleocene, so that this location must be an error. It is more probable that the material was found in the north-west part of the Vogelkopf Peninsula (Map 5, loc. 1), where there is a Weriangi River and where Jurassic slates and shales are known (Visser & Hermes, 1962, p. 54). The collection determined by Gerth comprised:

(?)Peltoceratoides sp. (Gerth 1927, p. 227; compared with specimens figured by Boehm (1907) from the Sula Islands.

"Macrocephalites keeuwensis" Boehm (Gerth 1927, p. 225; referred to Boehm's varieties without giving specific references or figuring the material, so that the species present cannot be determined).

Bullatimorphites cf. bullatus (d'Orbigny) (Gerth 1927, p. 226; Arkell 1956, p. 448).

Stephanoceras (Stemmatoceras) etheridgei Gerth (1927, p. 226; pl. 36, fig. 1. Holotype, placed in the subgenus Stemmatoceras by Westermann, 1964, pers. comm. to the Rijksmuseum, Leiden; and referred to as "Normannites etheridgei (Gerth)" by Arkell 1956, p. 448).

Normannites (Itinsaites) sp. (Gerth 1927, p. 227; pl. 36, fig. 2; Westermann 1964, pers. comm. to the Rijksmuseum, Leiden. Compared by Gerth with Boehm 1908, pl. 12, fig. 3, which Arkell 1956, p. 440, considered to be a Normannites close to N. orbignyi).

In this collection, as in the previous ones, the Bajocian, Callovian and, possibly, the Bathonian are represented, and in addition there is an indication of the Oxfordian.

vi) Oxfordian is also represented in material from the Sepik River (Map 5, loc. 7) described by Schlüter (1929), together with Tithonian, Kimeridgian and Callovian.

Haplophylloceras strigile (Blanford) Schlüter 1929, p. 58).

Blanfordiceras wallichi (Gray) (Schlüter 1929, p. 59; pl. 11, fig. 4).

Kossmatia desmidoptycha Uhlig (Schlüter 1929, p. 57; pl. 10, fig. 3).

Idoceras cf. *I. mihanum* Boehm (Schlüter 1929, p. 57).

"*Perisphinctes* (*Kranaosphinctes*) *burui*" Boehm (Schlüter 1929, p. 56; pl. 10, fig. 2).

P. (*Kranaosphinctes*(?)) cf. *moluccanum* Boehm (Schlüter 1929, p. 56).

"*Macrocephalites keeuwensis* γ" Boehm (Schlüter 1929, p. 56; pl. 10, fig. 1).

"*Peltoceras*" sp. (Schlüter 1929, p. 55).

"*Oppelia*" sp. (Schlüter 1929, p. 55).

Although Schlüter followed Hummel (1923) in uniting *Perisphinctes burui* Boehm 1908, *P. taliabuticus* Boehm 1907 and *P. galoi* Boehm 1907 under the (invalid) name of *P. burui* (see Arkell 1934-1947, p. lx), it is apparent that the Oxfordian is present here.

The Tithonian is indicated by *Haplophylloceras* and *Blanfordiceras* and the Kimeridgian by *Kossmatia* and *Idoceras*, while the *Macrocephalites* is Lower Callovian. Schlüter, in placing his specimen in *M. keeuwensis* γ, realised that Boehm's varieties were probably separate species. The "*Peltoceras*" and "*Oppelia*" were not figured or described and their precise affinities are uncertain.

vii) Kimeridgian and Tithonian genera were recorded by Glaessner (1947, 1957) from a series of black shales in the Kereru Range of Papua (Map 5, loc. 11), known as the Tubu Shales. They included Streblites sp. and Haplophylloceras strigile (Blanford), associated with berriasellids and neocomitids, of Lower Cretaceous age.

viii) No further Jurassic material was published until the Australasian Petroleum Company released the details of the exploration for oil in eastern New Guinea (Australasian Petroleum Company Prorpietry (A.P.C.P.) 1961).

In the Strickland Gorge (Map 5, loc. 9) black shales, resting unconformably on granite, yielded (un-named) harpoceratid ammonites, which were said to be characteristic of the topmost Lower Jurassic or basal Middle Jurassic, while similar black shales at Telefomin in the Territory of New Guinea (Map 5, loc. 8) yielded "Macrocephalites keeuwensis" Boehm and Paraboliceras cf. P. haugi Uhlig, indicating Callovian and Tithonian. Almost nothing is known about this important section, which seems to extend over the whole Upper Jurassic, partly because of the difficult terrain and poor access and partly because of tribal unrest in the area. It is possible that the material described by Schlüter was derived from these beds.

From these scattered observations it would appear that the Mesozoic rocks of the region of the Sepik and Strickland headwaters (Map 6) include ammonite bearing rocks of a facies similar to that of the 'A' member of the Kembelangan formation as well as the pelecypod bearing sandstones and shales described by Osborne (1945) and Rinkwood (1955).

ix) Upon relinquishing their concessions in the former Netherlands New Guinea, the N.N.G.P.M. published a detailed account of their findings (Visser & Hermes, 1962) with descriptions of Jurassic ammonites by Arkell and Donovan. The material identified by Arkell came from the island of Roemberpon (Map 5, loc. 2) and consisted of:

Macrocephalites (Dolikephalites) keeuwensis Boehm (Visser & Hermes, encl. 17, fig. 33,34). Lower Callovian.

Pseudotoites (Latotoites) cf. P. antipodus (Arkell) 1954 (Visser & Hermes, encl. 17, fig. 17; ? = P. (L) woodwardi (Crick) 1894; Westermann, 1964b,p. 54). Middle Bajocian.

Pseudotoites (Pseudotoites ?) cf. P. spitiformis Arkell 1954 (Visser & Hermes, encl. 17, fig. 18; ? = P. (P?) semiornatus (Crick) 1894; Westermann, 1964b,p. 53). Middle Bajocian.

M. keeuwensis is the common Lower Callovian species in Indonesia, but the other two are of rather more interest, since Pseudotoites is known only from the Pacific region: West Australia, Argentina, South Alaska and also the Sula Island (Kruizinga 1926, pl. 6, fig. 1; pl. 12, fig. 3). The forms from British Columbia identified as Pseudotoites are placed in Zemistephanus (Westermann, 1964b, p. 62).

The collection identified by Donovan occurred as claystone conceretions in rivers between Geelvink Bay and Etna Bay (Map 5, loc. 4) and comprised, according to Donovan:

Haplophylloceras strigile (Blanford) (Visser & Hermes, 1962, encl. 17, fig. 32). Tithonian.

Idiocycloceras aff. I. bifurcatum (Boehm) loc. cit. fig. 30). Lower Callovian.

Macrocephalites (Dolikephalites) keeuwensis Boehm (loc. cit. fig. 28). Lower Callovian.

M. (D.) aff. M. subcompressus (Waagen) (loc. cit. fig. 27). Lower Callovian.

M. (Kamptokephalites) terebratus (Phillips) (loc. cit., fig. 26). Lower Callovian.

M. (K.) beta-gamma Boehm (op. cit. p. 55) Lower Callovian.

M. (K.) sp. (op. cit. p.55).

M. (Pleurocephalites ?) sp. juv. (op. cit., encl. 17, fig. 31). Lower Callovian.

Garantiana sp. (loc. cit. fig. 23). Upper Bajocian.

Normannites (?) moermanni (Kruizinga) (loc. cit., fig. 24). ("Coeloceras" moermanni Kruizinga, 1926, pl. 13, fig. 2; "Coeloderoceras" moermanni Arkell (1956, p. 441) (see below, p. 83). ?Middle Bajocian.

x) More recently Gerth (1965) described a fauna from the northern flanks of the Central Ranges near Van Arkel Top (Map 5, loc. 6), in an area mapped by the Bureau of Mines of Netherlands New Guinea (van der Wegen, 1966). The material was found in pyritic concretions derived from black shales of the 'A' member of the Kembelangan formation and consisted of:

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Spiticeras (Kilianiceras) sp. (Gerth 1965, p. 216).

Berriasella sp. (Gerth 1965, p. 212).

Blanfordiceras novaguinense Gerth 1965 (pl. 18, fig. 2. Holotype).

Pseudoparaboliceras aramaraii Gerth 1965 (Holotype and type species, pl. 18, fig. 1).

Mayaites cf. M. maya (Sowerby) (Gerth 1965, pl. 18, fig. 4).

Perisphinctes (Kranaosphinctes (?)) novaguinensis Gerth 1965 (Holotype pl. 18, fig. 3).

"Macrocephalites keeuwensis" Boehm (Gerth 1965, p. 209).

Concerning the age of this fauna, Gerth considered that Spiticeras indicated Valanginian, while the Berriasella and Blanfordiceras indicated Berriasian. According to the "Treatise", however, Spiticeras ranges from Upper Tithonian to Berriasian, Berriasella is Tithonian to Berriasian and Blanfordiceras is Upper Tithonian to Berriasian. It would appear that the age of this fauna is slightly older than that envisaged by Gerth, but still, possibly, Lower Cretaceous.

Pseudoparaboliceras is similar to such Himalayan forms as Paraboliceras jubar (Uhlig 1904-1910), except that the parabolae are lost, and may be Tithonian, although Paraboliceras and its allies belong to the typically Kimeridgian family Ataxioceratidae ("Treatise").

Probable Kranaosphinctes was recorded by Gerth under the name of Pachyplanulites, which is referred to as a synonym of Kranaosphinctes in the "Treatise". Gerth himself remarked that this specimen resembled the forms figured by Boehm (1912) from the Sula Islands, which Arkell

(1934-1947, p. lx) thought were Kranaosphinctes. If this is so, this specimen indicates Oxfordian and not Tithonian, as Gerth thought. Pachyplanulites was based by Spath (1930) on Oxfordian perisphinctids from Kutchh.

The main interest of this collection, besides showing a close relationship with that of the Spiti Shales, is that it indicates possibly higher horizons in the 'A' member of the Kembelangan formation than were recorded earlier.

Conclusions

The 'A' member of the Kembelangan formation extends from the Middle Bajocian to the Tithonian or Berriasian, although there are apparently some lacunae. These are probably due to collection failure, however, rather than to incompleteness of the fossil record, since the island has been poorly explored and the geological investigations have been mostly reconnaissance surveys. In addition, fossils retrieved from river detritus may not be a fully representative sample of the material occurring within the drainage basin.

2) Comparisons of the faunas of West New Guinea with those of the Sula Islands

The Sula Islands lie between New Guinea and Celebes (Map 7) and form the westward continuation of the belt of black shales with concretions, which make up the 'A' member of the Kembalangan formation in West New Guinea and the similar beds in Papua and the Territory of New Guinea. Together with the island of Obi, the Sula Islands and New Guinea form a single unit, distinct from the rest of Indonesia, both in facies and fauna, characterised by abundant Middle and Upper Jurassic ammonites. For this reason, the faunas of the Sula Islands may most conveniently be discussed with those of New Guinea.

The oldest material from the Sula Islands occurs in sandstones resting on a basement of igneous and metamorphic rocks and overlain by the main shale succession. These sandstones have yielded *Coeloceras*, *Fuciniceras* and *Hammatoceras* from the Toarcian, which are older than anything recorded from New Guinea. In addition, *Hammatoceras molukkanum* Cloos occurs in the overlying shales, in which the rest of the fauna is found. All genera known from New Guinea are represented here, together with "*Oppelia fallax* (Guéranger)" (= *O. aspidoides* (Oppel)) (Bathonian), *Hecticoceras* (*Putealiceras*) and *H.* (*Sublunuloceras*) (Middle ? - Upper Callovian), *Bochianites* and *Himalayites* (Upper Tithonian) and numerous mayaitids (Oxfordian) (see Arkell, 1956, p. 440).

These faunas are clearly related to those of India (Kutchh and Spiti), and Madagascar, as well as to those of the Pacific region. This question of faunal relations will be dealt with later (Chapter IV).

3) Taxonomic Description of the Present Fauna

Introduction

The absence of any information concerning the stratigraphic position of the specimens or of their mutual stratigraphic relations does not allow the detection of any local anomalies in the faunal succession, nor differences in the ranges of the constituent genera, nor does it take into account the possible occurrence of "heterochronous homoemorphs" (Buckman, 1895). Moreover, since the determination of the collection is based on the identification of morphotypes, it involves an essentially "vertical classification". Partly for this reason and partly because the material at hand is, in general, either insufficient in numbers or not well enough preserved, the designation of new species has been avoided as far as possible and the specimens have been identified by comparison with published species with the minimum of revision. For example, the *Fontannesia* have been compared with several of Buckman's species, although there is a possibility that all these, the holotypes of which came from a single bed, are members of one "chronodeme", as Westermann (1966) showed to be the case with Buckman's *Sonninia* from the same bed.

The basis of the classification used here is the "Treatise on Invertebrate Palaeontology (L.) Mollusca 4, Cephalopoda, Ammonoidea" Arkell, Kummel & Wright, 1957, referred to hereinafter as the "Treatise". Together with Arkell (1956), it is the source of most of the stratigraphic information also, although some emendations in the light of more recent work have been effected.

The parameters measured on the specimens are illustrated in Text-fig. 1. "D" is the diameter at which the parameters were measured. "H" is the whorl height at this point, "W" the whorl width and "U" the umbilical width. Only these four were used, as they are those most commonly employed. For each specimen measured the values of each value are given (all measurements are in millimetres) and (in parentheses) the fraction of the diameter.

In the lists of synonymy, the use of "?" follows that given by Schenk and McMasters (Procedures in Taxonomy, 1956, p. 18), that is:

"?" after the genus, or between the genus and species indicates that the genus is doubtful.

"?" after the species indicates that the species is doubtful.

"?" before the whole citation indicates that the whole citation is doubtful.

Systematic Descriptions

Superfamily	PERISPHINCTACEAE Steinmann, 1890.
Family	OLCOSTEPHANIDAE Haug, 1910.
Genus	*Olcostephanus* Neumayr, 1875.
(Type species:	*Am. asterianus* d'Orbigny, 1840).
Subgenus	*O.* (*Rogersites*) Spath, 1924.
(Type species:	*Holcostephanus modderensis* Kitchin, 1908).

Olcostephanus (*Rogersites*) sp. indet.

Plate 1, fig. 1a, b.

Material: One specimen (L81) with the inner whorls poorly preserved, due to recrystallised calcite.

Description:

The specimen is involute with a deep umbilicus, bordered by steep walls. On the innermost whorls the ornament is not preserved, but on the ante-penultimate whorl it consists of blunt, rectiradiate primaries, which arise a little distance from the umbilical seam and divide at a prominent bulla on the umbilical edge into three or four secondaries. These secondaries swing forwards on the flanks and, on the outer whorl, are seen to curve slightly backwards before passing straight over the rounded venter without interruption. This ornament persists up to the end of the phragmacone and for nearly half of the body-chamber, which occupies almost one whorl, with oblique constrictions at intervals. After the last constriction, the umbilical seam unwinds and the body-chamber contracts laterally, so that the whorl section changes from depressed to sub-circular. At the same time the ribs become much coarser and the projection of the secondaries more pronounced.

Remarks:

Olcostephanus is characterised by moderately involute whorls, with a rounded venter, which arise on the umbilical wall and give rise to bundled secondaries at bullae near the umbilical edge and with oblique constructions persisting on to the outer whorls. This last feature distinguishes it from members of the Polyptychitinae, in which the constructions are confined to the inner whorls.

Of the two subgenera, O. (Olcostephanus) has sharp, dense ribs and a rounded umbilical edge, while O. (Rogersites) has coarser, less dense ribs and a more angular umbilical edge. The inner whorls resemble some species of Subastieria.

The affinities of the present specimen would appear to be closer to the (Rogersites) than to Olcostephanus S.S. because the ribs are neither as sharp, nor as dense as in the type species of the latter and the umbilical edge is not rounded. The coarsening of the ribs, however, occurs abruptly on the last part of the outer whorl, accompanied by loss of the prominent umbilical edge. Up to the point where this modification takes place the specimen resembles the type species of O. schenki (Oppel) refigured by Uhlig (1904-1910;pl.18,fig.2), except that Oppel's species is more evolute. Uhlig (op. cit) considered O. schenki to be closely related to O. atherstoni Sharpe from South Africa, which species Roman (1938) included in O. (Rogersites). The specimen differs from O. (Rogersites) schenki figured by Spath (1939; pl.17,fig.9,10) in being more finely ribbed on the phragmacone. On the other hand, none of the more finely ribbed species figured by Spath have such an abrupt umbilical edge and do not show a coarsening of the ribs on the body-chamber.

Age:

The forms described by Spath (1939) were from the Belemnite Beds of the Salt Ranges, cited variously as Valanginian or Neocomian. According to the "Treatise", Olcostephanus s.s. and O. (Rogersites) are Upper Valanginian.

Dimensions:

	D	H	W	U	H/W
End phragm.	(36)	19(.53)	25(.69)	6.5(.18)	(.76)
Near end body-ch.	55	21.5(.39)	28.5(.52)	15(.27)	(.75)

Family BERRIASELLIDAE Spath, 1922.

Subfamily BERRIASELLINAE Spath, 1922.

Genus Blanfordiceras Cossman, 1907.

(Type species: Am. wallichi Gray, 1830-32).

"Blanfordiceras wallichi(Gray)1830-32;?var. "b" Uhlig 1905"

Plate I, fig.2a-c.

1830-32 Am. wallichi T.E.Gray, "Illustrations of Indian Zoology", vol.1, pl.100, fig.3.

1865 Am. wallichi H.F.Blanford & Salter, "Palaeontology of Niti", p.84; pl.15, fig.1.

1904 Am. wallichi Gray sp. G.C.Crick, "The Cephalopoda of the Strachey Collection from the Himalayas", p.13.

1905 Hoplites (Blanfordia) wallichi Gray sp. V. Uhlig,"The fauna of the Spiti Shales", p.186; pl.29,fig.1-3; pl.30,fig.1; pl.31,fig.1,2.

1907 Blanfordiceras wallichi (Gray) M.M.Cossman [fide W.J.Arkell, 1957, "Treatise on Invertebrate Palaeontology, Part L"].

1925 Blanfordiceras wallichi (Gray).L.F.Spath, "Ammonites and Aptychi", vol.1, p. 145.

1965 Blanfordiceras novaguinense H.Gerth, "Ammoniten des mittleren und oberen Jura und der ältesten Kreide vom Nordabhang des Schneegebirges in Neu Guinea", p.213; pl.18, fig.2.

Material:

One almost complete adult specimen (the last sutures are approximated), one half-whorl preserved body-chamber, aperture missing. (L73).

Description:

At the end of the phragmacone the whorl is sub-elliptical in cross-section, higher than wide, with the greatest width just below the centre of the flank. The umbilical wall is steep and the venter is tabulate with a median sulcus. The ornament at this stage consists of prorsiradiate, slightly falcoid ribs, which rise on the outer part of the umbilical wall and increase in strength before being projected on to the flank. Just above the centre of the flank, the primaries divide into two equally strong secondaries, which swing forward on to the venter, where they are interrupted by the sulcus, their terminations becoming swollen into small tubercles. Altogether there are 35 primaries on the last whorl of the phragmacone.

On the body-chamber the ribs become modified. They are more distant and sinuous than on the phragmacone and occasional secondaries are intercalated, together with rare single ribs. The ribs pass over the venter without interruption, the only indication of a sulcus being a slight weakening of the ribs in the mid-line. The small tubercles on the edge of the tabulate area persist. Since the venter has been broken away at the beginning of the body-chamber, it is not known whether the loss of the sulcus is gradual or abrupt.

The whorl-section of the body-chamber is also modified, becoming more inflated, but remaining rather higher than wide, with the greatest width now at the umbilical edge (Fig. 5). The umbilical wall becomes almost vertical and the umbilicus relatively wider.

Only the external part of the suture is visible (Fig. 6). E and L are of the same length, E being slender and with a narrow prong between the Median Saddle and the E/L saddle. This saddle is divided asymmetrically by a secondary lobe on the dorsal side and the U_2/L saddle shows a more symmetrical major indentation. Both these saddles, together with U_2/U_3, are broad based. U_2 is slightly oblique and U_3 is weakly retracted and oblique.

Remarks:

Blanfordiceras resembles Berriasella except for the ribbing, which is less dense and more sigmoidal, inconspicuous on the umbilical wall and becoming stronger on the flank. On the body-chamber the ribs become more widely spaced and intercalataries appear. In addition the whorls are stouter and the ventral sulcus more prominent, at least in the earlier stages. All species of Blanfordiceras pass through a stage where the ornament closely resembles that of Berriasella callisto (d'Orbigny) and in most this persists into the adult, with the differences mentioned above, but in a few becomes strongly modified in the middle stages. Berriasella is smaller than Blanfordiceras and possesses lappets, suggesting that these two supposed genera are dimorphs, Blanfordiceras being the macroconch, of subgeneric difference only.

Of the species figured by Uhlig (1904-1910) from the Spiti Shales, the specimen at hand belongs to the group of *B. wallichi* (including *B. rotundidoma* Uhlig, *B. applanata* Uhlig and *B. subquadrata* Uhlig), in which the ribbing is berriasellid throughout and the ventral sulcus persists as far as the neighbourhood of the body-chamber. The distinction between these species is based mainly on the whorl section, *B. applanata* being compressed with flattened flanks, *B. subquadrata* being, as the name suggests, subquadrate and *B. rotundidoma* being more inflated with a rounder whorl section and also more evolute, the bifurcation of the primaries being visible on the inner whorls.

None of the material examined by Uhlig agreed exactly with the holotype of *B. wallichi* (Gray), which has a broadly elliptical whorl section, with the greatest width just below the centre of the flank, and a more inflated body-chamber. Uhlig recognised three varieties of *B. wallichi* from Spiti and the specimen at hand would seem to be closest to the 'b' variety (Uhlig, op. cit.; pl. 29, Fig. 1,2; pl. 31, Fig. 2) (see Fig. 5).

B. novaguinensis Gerth was said to differ from *B. wallichi* in having flatter flanks and from *B. applanata* in the form of the ribbing. It was, however, also said to be closer to the specimen figured by Boehm from the Sula Islands (1904; pl. 5, Fig. 1) than to those figured by Uhlig from Spiti. Uhlig, however, considered Boehm's form to be closer to the holotype of *B. wallichi* than any of the Spiti material, so that for this reason Gerth's species is here regarded as a synonym of *B. wallichi*. The specimen at hand differs from that figured by Gerth not only in having rounder flanks, but also in being less densely ribbed.

Age:

Blanfordiceras is known from the Hollandi Zone at the top of the

Upper Tithonian in Madagascar, where it is associated with Himalayites and abundant Aulacosphinctes spp. (Collignon, 1960).

Outside Madagascar the only other locality where the horizon of this genus has been determined is Neuquen in Argentina. Here B. australis (Burckhardt) (the genotype of Pseudoblanfordia Spath, 1925) occurs together with Cuyaniceras, Spiticeras, Thurmanniceras and Neocomites in the Zone of Spiticeras damesi, which Leanza (1945, 1947) correlated with the Boisseri Zone (Berriasian) of Europe.

Blanfordiceras, therefore, is of topmost Jurassic or lowermost Cretaceous age.

Dimensions:

	D	H	W	U	H/W
End phrag.	48	19(.40)	17(.35)	16.7(.35)	(1.12)
Near end body-ch.	72	25.5(.35)	24(.33)	27(.38)	(1.06)

Blanfordiceras sp. indet.

Material:

Three small fragments (L16, L169, L284) and one poorly preserved juvenile form (L271).

Description:

The largest fragment (L16) is wholly septate and is part of an individual of at least 95 mm. diameter. Its maximum height is 35 mm. and its maximum width 32 mm. It has been severely worn. Part of the penultimate whorl is preserved and shows an elliptical cross-section. The ornament consists of strong rectiradiate ribs, which fade out on the umbilical wall and are not seen to bifurcate. On the outer whorl the ribs are falcoid and bifurcate at about the centre of the flank. The secondaries are interrupted on the venter by a median sulcus and develope small tubercles at the ends.

A second fragment (L169) is also wholly septate and corresponds to a specimen about 50 mm. in diameter. It differs from the specimen of B. wallichi described above (L73) at a similar diameter in having rounder and wider whorls, with a less steep umbilical wall and finer ribs, which bifurcate lower down on the flank, but are of about the same density.

The last fragment (L284) is part of a body-chamber, more than 34 mm. high and 36 mm. wide, of which a length of only 4 cm. is preserved. The umbilical wall is not preserved and the specimen has been badly worn.

The juvenile specimen is preserved in a very hard pyritic matrix, which could not be prepared. The exposed portion is badly worn, but the ribs can be seen to be sigmoidal, and the secondaries interrupted on the venter by a median sulcus. The whorl is compressed with slightly flattened flanks.

Remarks:

This material is too poor for specific identification, but shows an affinity with the B. wallichi described above (L73). L16 seems to be closest to B. wallichi judging from the whorl-section and ribbing, and L169 seems to belong to this group also. The third fragment and the juvenile are completely indeterminable.

Age:

See above under Blanfordiceras wallichi (Gray)

Subfamily HIMALAYITINAE Spath, 1925.

Genus *Himalayites* Uhlig in Boehm, 1904.

(Type species: *Himalayites treubi* Boehm, 1904).

Himalayites sp. nov. aff. *H. nederburghi* Boehm, 1904.

Plate I, Fig. 3a-c.

? 1904 *Himalayites nederburghi* Boehm, "Grenzschichten zwischen Jura und Kreide", p.41; pl.7, fig.3; Text-fig. 15.

Material:

One specimen (L50) with about one-half whorl preserved body-chamber. The externside and one flank near the end of the phragmacone have been crushed, but otherwise the preservation is good.

Description:

The inner whorls are slightly compressed oval, with flat sides and a shallowly sloping umbilical wall. The ornament consists of fine, sharp, rather strongly falcoid ribs, which rise on the umbilical wall and are forwardly inclined on the flanks. On the penultimate whorl the ribs divide below the umbilical seam of the following whorl, no tubercles are present and the connection between the primaries and secondaries is weak. At the beginning of the outer whorl the cross-section is still compressed, but the whorl soon becomes wider and rounder, while the umbilical wall steepens and the inner part becomes smooth. The ribs remain dense, but become more rectiradiate and, while continuing to divide at about the centre of the flank, intercalaries become frequent and single ribs occur. The secondaries pass over the venter without interruption, but are slightly weakened in the mid-line and swell into weak bullae. Near the end of the body-chamber, as preserved, occasional primaries develope prominent bullae at the point of division and become flared. Trifurcating secondaries make an appearance at this point.

Remarks:

Himalayites comprises those Berriasellidae with rounded whorls and sharp ribs, occasionally bearing strong lateral spines. In Himalayites (Himalayites) the inner whorls tend to be compressed, becoming rounded and finally depressed. The spiniferous ribs are flared, while the others remain simple. H. (Micracathoceras) on the other hand has rounded whorls at all stages, the tubercles are smaller and more frequent and the tuberculate ribs are not flared.

The present specimen is, therefore, more closely related to H. (Himalayites), although it is much more densely ribbed than any of the species figured by Uhlig from Spiti or by Boehm from the Sula Islands. It is closes to H. nederburghi Boehm, but is not only more densely ribbed, but also slightly more involute and less wide. H. treubi Boehm differs from this specimen in being larger, it is still compressed at a diameter where the present specimen has become rounded and developed tuberculate ribs.

H. hyphasis (Blanford) and H. ventricosus Uhlig are more involute and more depressed, as well as less densely ribbed.

Age:

Himalayites s.s. occurs in the Upper Tithonian of Stramberg, where it is associated with H. (Micracanthoceras), and both are also found in the Upper Tithonian of Southern Spain and Sicily. In Madagascar Himalayites s.s. occurs together with Blanfordiceras in the Hollandi Zone at the top of the Upper Tithonian. The precise horizon of the species from the Spiti Shales is not known, since the Lochambel Beds (Upper Spiti Shales) from which they were collected span the interval from Upper Tithonian to Valanginian. It would appear that Himalayites s.s. is typically Upper Tithonian, but the possibility that it may extend into the Lower Cretaceous cannot be excluded.

Family PERISPHINCTIDAE Steinmann, 1890.

Subfamily(?)ZIGZAGICERATINAE Buckman, 1920.

Genus (?)Cobbanites Imlay, 1962.

(Type species: Cobbanites talkeetnanus Imlay, 1962).

(?)Cobbanites aff. C. engleri (Frebold),1957

Plate II, Fig.1a,b

? 1957 Procerites engleri Frebold, "Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills", p.65; pl.39, fig.1; pl.40,fig.1a,b.

? 1962 Cobbanites engleri (Frebold). Imlay, "Jurassic (Bathonian or Early Callovian) Ammonites from Alaska and Montana", p. 26.

Material:

One specimen (L37) in a good state of preservation, except that the body-chamber has been slightly crushed laterally. The body-chamber occupies almost one whorl and the final sutures are approximated, suggesting that this is an adult individual, but the aperture is not preserved.

Description:

The specimen is evolute with a shallow umbilicus and slightly compressed whorls, the flanks of which are very nearly flat and are bounded on the inner side by a steep umbilical wall. On the innermost whorls the ribs first appear as low corrugations at a diameter of c. 2 mm. and soon become strong and prorsiradiate. Initially they rise at the umbilical seam and are rather weak on the umbilical wall, but gain in strength as they pass on to the flanks. Just below the umbilical seam of the next whorl they develope a small tubercle and swing forward noticeably. The primaries are not seen to divide on the inner whorls.

This style of ribbing persists throughout the phragmacone, the only modification being that the ribs become weaker on the umbilical wall, so that a smooth band developes near the umbilical seam, and swell slightly at the umbilical edge. The ribs are interrupted at intervals by oblique constructions. On the last part of the phragmacone the primaries are seen to bifurcate at, or immediately above, the small ventro-lateral tubercle into slightly weaker secondaries, which swing forward on to the venter, where they are interrupted by a narrow, but distinct, siphonal smooth band, their ventral terminations swelling into tiny bullae.

After a deep constriction just after the final suture the ribs are modified. The primaries gradually fade, all signs of tubercles or swellings are lost, those at the ventral ends of the secondaries at once, those at point of bifurcation of the ribs persisting a little longer, so that the secondaries merge into a rather wider and less well defined smooth band on the venter. Two further constrictions occur on the body-chamber, not apparently associated with any additional modification of the ribs.

During the modification of the ribbing on the body-chamber, there does not seem to be any significant change in the whorl section, but since the whorl shows signs of lateral compression, this cannot be certain.

Of the suture, only the external portion at the end of the phragmacone is visible and here it has been pyritised so that the detail is difficult to make out. The depth of the incisions may be greater than shown in the figure (Fig. 7). The first lateral saddle (E/L) is broad based and asymmetrically divided by a secondary lobe, the external branch being the larger. L/U_2 is also bifid, with the larger branch near the umbilicus. L is asymmetrical and U_2 is oblique, as is U_3, which is weakly retracted.

Remarks:

The specimen resembles certain Leptosphinctinae, such as L. (Vermisphinctes), but its inner whorls enclose a shallower umbilicus and are not coronate. In addition its whorl section is compressed throughout and the ribbing less dense and more prorsiradiate than in Leptosphinctes. On the other hand the ribbing and dimensions of the specimen are similar to those of the paratype of "Procerites" engleri Frebold, a plaster cast of which is at hand. Both possess strong, well-spaced, prorsiradiate ribs on the inner whorls, interrupted by constrictions and each bearing a small tubercle near the umbilical seam of the succeeding whorl. At a diameter comparable with the present specimen, the paratype shows a similar weakening of the primaries.

"P". engleri is more compressed at comparable diameters, however, by virtue of a greater whorl height and possesses a narrower ventral smooth band. Its suture is more complexly incised and similar to that of Procerites (cf. P. schloenbachi(de Grossouvre), Arkell, 1951-57; ext.-fig. 62). The suture of the specimen shows a closer similarity to that of Leptosphinctes leptus Buckman (1920, pl. 160, fig. 3), with its bifid E/L, saddle, oblique U_2 and weakly retracted U_3.

Cobbanites talkeetnanus Imlay differs from the specimen in being more strongly ribbed to larger diameters, with more rectiradiate ribs, and in having higher whorls at comparable diameters.

Age:

The type material was collected by Imlay from the basal part of the Chinitna formation of Southern Alaska, associated with Cadoceras, Pseudocadoceras, Gowericeras and Lilloetia, characteristic of the Calloviense Zone (Lower Callovian). The holotype itself, however, came from an un-named unit at the top of the underlying Tuxedni formation, of uncertain age. It may be either Upper Bathonian or Lower Callovian (Imlay, 1962, p. 27).

In the Fernie Group of Alberta Cobbanites is associated with a fauna of Lower Callovian age (Frebold, 1957) and in Montana it occurs in the Rierdon formation (Lower Callovian) and in the top of the underlying Sawtooth formation, which extends from the Upper Bajocian to the Bathonian (Imlay, 1962; text-fig. 7). From this it would appear that Cobbanites is typically Lower Callovian, but may be Upper Bathonian.

Dimensions:

	D	H	W	U	H/W
End phrag.	(37.5)	20(.53)	21(.56)	18.5(.49)	(.95)
End body-ch.	54.5	15.2(.37)	15.7(.39)	12(.34)	(.97)

Superfamily STEPHANOCERATACEAE Neumayr, 1875.

Family OTOITIDAE Mascke, 1907.

Genus *Docidoceras* Buckman, 1919.

(Type species: *Docidoceras* cylindroides Buckman, 1919).

Docidoceras aff. *D*. *longalvum* (Vacek), 1886.

Plate II, Fig. 2a-d.

? 1886 *Coeloceras longalvum* Vacek, "Über die Fauna der Oolithe von Cap San Vigilio, verbunden mit einer Studie über die obere Liasgrenze", p.99; pl.17, fig.1,2.

? 1897 *Coeloceras limatum* Pompeckj, "Palaontologische und stratigraphische Notizen aus Anatolien", p.745; pl.31, fig.5.

? 1922 *Docidoceras perfectum* Buckman, "Type Ammonites", vol. ; pl.314. Bremer, 1966, p.163.

? 1925 *Coeloceras longalvum* Vacek var. *trapanicum* Renz, "Beiträge zur Cephalopoden des älteren Doggers am Monte San Giuliano (Monte Erice) bei Trapani in Westsizilien", p.30; pl.1, fig.6.

? 1964 *Docidoceras longalvum* (Vacek) Westermann, "Sexual Dimorphismus bei Ammoniten und seiner Bedeutung fur Taxonomie der Otoitidae", p.48; pl.6, Fig.1,2. (Holotype refigured.)

Material:

One specimen (L360) complete and fully grown, with the aperture preserved. The inner whorls have been laterally compressed, but the ornament on one side has been preserved in full relief without apparent distortion. The body-chamber occupies nearly 1-1/4 whorls.

Description:

The inner whorls are depressed, ovate and ornamented with strong rectiradiate primaries, which swell into small tubercles and divide just below the seam of the succeeding whorl. This whorl section and ornament persist throughout the phragmacone, becoming modified only on the body-chamber. At all stages the widest point is at half whorl height, where the ribs divide. The secondaries are usually in threes, one of which is often unattached to a primary, but is on the other. They are slightly projected on the venter. The primaries are blunt and show a very slight tendency to become bullate on the later part of the phragmacone and early part of the body-chamber, but thereafter become considerably weakened. At the same time the secondaries also weaken, but to a lesser degree, and the whorl section is also modified at this point. The umbilical seam unwinds as the body-chamber contracts, while the hitherto distinct lateral edge is lost. Although the whorl remains depressed, there is an increase in the height relative to the width.

A little way before the aperture the whorl widens and then just before the aperture it constricts. This constriction is obvious only on the internal mould, being filled with a thick calcite deposit, which is continuous with a strip of secondary calcite running along the lower edge of the flank, next to the umbilical seam of the body-chamber, obscuring the ribbing. The aperture itself is collared and lipped.

One septum is visible near the end of the phragmacone (Fig. 8; Pl. II, fig. 2d). It is typically bullate with U_1 apparently undivided.

Remarks:

Westermann (1964b) recognised three species of Docidoceras s.s., with the other previously named forms as probable synonyms or subspecies. More recently Bremer (1966) has described a variety from Turkey, which he placed in D. longalvum.

The three species recognised by Westermann are D. cylindroides Buckman, 1919, D, longalvum (Vacek) 1886 (syn. D. perfectum Buckman, 1922; subspp.? D. longalvum var. limatum (Pompeckj) 1897, D. longalvum var. trapanicum (Renz) 1925) and D. planulatum Buckman, 1921 (syn.(?) D. biforme Buckman, 1922 and D. liebi Maubeuge, 1955).

Of the alleged subspecies of D. longalvum, "var. trapanicum" was said to be distinguishable because the body-chamber was more weakly ribbed than the holotype of D. longalvum, while Bremer (1966) distinguished "var. limatum" by its longer primaries, which were said to extend to the shoulder rather than ending at mid-flank. However, the holotype of D. longalvum does show weakening of the ribbing on the body-chamber, as the photographic figure given by Westermann (1964) shows and the greater length of the primaries in "var. limatum" is not conspicuous and probably insignificant.

The present specimen corresponds most closely to D. longalvum, but there are some differences. D. longalvum is rather more depressed throughout and, in the middle stages, a little less involute. The primaries in both the specimen and D. longalvum are rectiradiate and end in the centre of the flank, but the projection of the secondaries in the specimen can be matched only in *D. liebi* Maubeuge, and in an undescribed new subgenus from South Alaska (to be described by Westermann). In the latter, however, the primaries are prorsiradiate and develop into bullae on the body-chamber, rather than fading as in *Docidoceras* s.s.

D. planulatum (including *D. liebi*) is a much smaller species, in which the ribs remain strong to the end.

D. cylindroides is more depressed and broader at all stages and more involute. The primaries are longer and less dense.

Age:

The species of *Docidoceras* described by Buckman were all collected from the Discites Subzone at the base of the Sowerbyi Zone, but *D. liebi* was found by Maubeuge (1950, 1955) in the "Sowerbyi Zone" of the Bernese Jura. *Docidoceras* would appear, therefore, to be characteristic of the lower one or two subzones of the Sowerbyi Zone, but the full extent of its range is not known and it is usually referred to the Sowerbyi Zone of the Bajocian.

Dimensions:

	D	H	W	U	H/W
End phrag.	(49)	13(.27)	26(.53)	26(.53)	(.50)
	65	20(.31)	29.7(.46)	32.5(.50)	(.67)
End body-ch.	93	22.5(.24)	32(.34)	48(.52)	(.70)

Family STEPHANOCERATIDAE Neumayr, 1875.

Genus *Stephanoceras* Waagen, 1869.

Subgenus *S.* (*Stephanoceras*) Waagen, 1869.

(Type species: *Am.* *humphriesianus* J. de C. Sowerby, 1825).

Stephanoceras (*Stephanoceras*) aff. *S.* *skidegatense* (Whiteaves), 1876.

Plate III, fig. 1a,b.

? 1876 *Ammonites* *skidegatense* Whiteaves, "On some invertebrates from the coal-bearing rocks of the Queen Charlotte Islands", p. 34; pl.7, fig.1.

? 1932 *Stephanoceras* *skidegatense* (Whiteaves), McLearn, "Contributions to the Stratigraphy and Palaeontology of Skidegate Inlet, Queen Charlotte Islands, B.C.", p.54; pl.1, fig.2; pl.2, fig.3; pl.3, fig.8,9.

Material:

One fragmentary specimen (L245) comprising the beginning of the body-chamber and end of the phragmacone, part of the penultimate whorl and remnants of the ante-penultimate whorl. One side of the outer whorl has been damaged.

Description:

The outer whorl is rounded ovoid in cross-section, with rounded flanks, gentle umbilical shape and a slightly flattened venter. There is very little overlap with the preceding whorl, which is more depressed and not as inflated. Both whorls are widest at about one-third whorl height.

The ornament on the ante-penultimate whorl consists of sharp, rectiradiate primaries, which develop tubercles just below the point where the whorl is overlapped by the next. They continue to be sharp on the penultimate whorl, but are more rursiradiate and slightly curved anteriorly. Here, owing to the unwinding of the umbilical seam, the secondaries are exposed, arising, usually, in groups of three, from the tubercles at the end of the primaries, which are situated at the greatest width of the whorl. These secondaries are not as strong as the primaries. On the outer whorl the primaries are still sharp and rursiradiate near the umbilical seam, but are more curved anteriorly than on the preceding whorl. The secondaries are blunter and curve backwards so that they pass straight over the venter. The primaries themselves become blunter on the body-chamber and the secondaries begin to fade.

The septal suture (Fig.9a) is complex. E and L are of the same length and the intervening saddle is asymmetrically divided by a deep secondary lobe, the larger, more external branch being tripartite. L is asymmetrical and is separated from U_2 by a bipartite saddle. U_2 is strongly oblique and reaches almost to the base of L, while U_3 is also oblique and probably weakly retracted, although the sutural elements nearest the umbilical seam has been destroyed. The internal part of the suture is dominated by a single saddle, called in the figure (U_n ?), being much less deep than U_3 and oblique.

Remarks:

The specimen is similar to S. (S.) humphriesianum (Sowerby), but the holotype of the latter does not show the inflated whorl and relatively long, curved primaries of the present form. These features can, however, be matched in material of the S. humphriesianum group from British Columbia (McLearn, 1932), and especially in S. skidegatense, which differs, only in being less densely ribbed. The ribbing is most similar to that of S. caamonoi McLearn, but this species differs in that its outer whorl is not inflated. S. yakounense McLearn is more coarsely ribbed and less inflated.

"Kreterostephanus" kreter Buckman, 1927 (pl. 755) appears to have similar curved primaries, but it also has a steep unbilical slope and the outer whorl does not seem to be inflated. In the "Treatise", Kreterostephanus is regarded as a synonym of Stephanoceras.

The relatively long primaries on the inner whorls, together with the dense secondaries and expanded outer whorl suggest a relationship with Cadomites, but the short primaries on the outer whorl and the form of the suture argue against this. The suture of Cadomites (Fig.9b) possesses an almost straight U_2, with a slightly incised L/U_2 saddle. Moreover, in the internal part of the suture, Cadomites has two saddles developed almost equally, while in Stephanoceras there is a major development of the U_n/I saddle, the U_n/U_3 saddle being reduced. As the internal suture of the present specimen shows the pattern found in Stephanoceras, it is accordingly placed in that genus. It differs from S. (Stemmatoceras) in the absence of a lateral edge and in having shorter, less pronounced primaries.

Age:

According to the "Treatise", S. (Stephanoceras) is of Middle Bajocian age, but in North-West Europe it would seem to be confined to the Humphriesianum Zone and in N.E. Spain and North Africa it occurs in condensed deposits (if correctly identified) and probably does not extend into the Subfurcatum Zone (Upper Bajocian) (Arkell, 1956). Records of *Stephanoceras* from the Sauzei Zone usually refer to *S.* (*Skirroceras*), but in the Swabian and Franconian Alb, Arkell (1956) suspected that "*humphriesianus*-like forms" from this zone were, in fact, earlier forms, possibly *Docidoceras*, or *S.* (*Kumatostephanus*). Imlay (1964) considered *S.* (*Stephanoceras*) to range from the Sowerbyi Zone to the Subfurcatum Zone, following Arkell (1956), but none of the page references he cites give evidence of a Sowerbyi Zone age.

In North America, *S.* (*Stephanoceras*) *skidegatense* occurs in the Yakoun formation of the Queen Charlotte Islands (Stratum Typicum), which is correlated with the Fitz Creek formation (Humphriesianum Zone) of South Alaska (Imlay, 1964), and in the Twin Creek Limestone of Utah and Wyoming (probably Subfurcatum Zone) (Imlay, 1967). In addition, Frebold (1957) records "*S.* cf. *skidegatense*" from the Fernie Group of Alberta, where among its associates is *S.* (*Kumatostephanus*), which is apparently restricted to the Sauzei Zone (Westermann, 1964a). Since *Stephanoceras* s.s. is also recorded by Imlay (1964) from the Red Glacier formation (Lower Bajocian and Sauzei Zone recognised) of South Alaska, it would appear that, while this subgenus is typical of the Humphriesianum Zone, it may also extend down into the zone below.

Accordingly the specimen at hand could be from the Saucei Zone or the Humphriesianum Zone.

Stephanoceras sp. indet.

Plate III, fig. 2a,b.

Material:

One specimen (L131) consisting of half a whorl of body-chamber, the umbilicus enclosed in a pyritic matrix, which could not be prepared.

Description:

The whorl is depressed throughout, with the greatest width at about one-third whorl height. The venter is rounded, giving the whorl an oval cross-section. The umbilical wall is vertical and the lateral edge is rounded and not prominent. The primaries are blunt and slightly prorsiradiate, rising near the umbilical seam and swelling into bullae on the lateral edge, where they divide into, usually three, secondaries, but with frequent intercalaries present. Near the end of the whorl there is a conspicuous irregularity in the secondaries, perhaps the result of a slight injury. The secondaries are weakly projected on the venter. On the penultimate whorl the primaries, although obscured by matrix, are seen to be strong, almost bullate, and are forwardly inclined.

Neither sutures nor septae are visible at any stage.

Remarks:

The depressed oval whorls of this specimen, without a prominent lateral edge and ornamented by fairly strong ribs suggest it is related to the group of S. rectecostatum Weisert, S. mutabile (Quenstedt) and S. umbilicum (Quenstedt). The whorl section of the specimen is most similar to that of S. umbilicum figured by Weisert (1932, Text-fig. 18), but this species is rather more involute, with longer, more dense primaries. These differences apply to the other members of this group.

The ribbing of the specimen is closest to S. plicatum (Quenstedt), but the whorl section is not figured by Weisert; it is said to be oval (Weisert, op. cit., p. 142).

Stemmatoceras differs in having a more inflated whorl, with a well developed lateral edge and ornamented with strong, high primaries.

Age:

(?) Upper Sauzei Zone or Humphriesianum Zone.

Dimensions:

	D	H	W	U	H/W
End of whorl	(70)	22(.31)	31.5(.45)	29.5(.42)	(.70)

Subgenus S. (Stemmatoceras) Mascke, 1907.

(Type-species: Am. humphriesianus coronatus Quenstedt, 1886 = Stemmatoceras frechi Renz, 1913.

Stephanoceras (Stemmatoceras) aff. S. etheridgei Gerth, 1927

Plate III, fig. 3a,b.

? 1890 Stephanoceras aff. S. blagdeni (Sowerby), R. Etheridge, "Our present knowledge of the Palaeontology of New Guinea", p. 175; pl. 29, fig. 2.

? 1927 Stephanoceras etheridgei Gerth, "Ein neues vorkommen der bathyalen cephalopoden-facies des mittleren Jura in niederlandischen Neu-Guinea", p.226; pl.36, Fig.1.

? 1954 Normannites etheridgei (Gerth), W.J. Arkell, "The Bajocian Ammonites of Western Australia", p.583.

Material:

One specimen (L41), incomplete and with a considerably worn outer whorl. It was sawn in half to expose the cross-section of the inner whorls, but they had been laterally compressed. They are, however, preserved in full relief on one side.

Description:

The inner whorls are more or less evolute, with rounded flanks and a steep umbilical wall, enclosing a deep umbilicus. The umbilical edge is rounded and the greatest width of the whorl occurs at mid-flank. On the penultimate whorl the cross-section is depressed and a prominent lateral edge develops at mid-flank, from which the flanks slope steeply to the umbilical seam.

The venter is flattened at the beginning of the outer whorl, but later becomes rounder, giving the whorl a more inflated appearance, although the H/W ratio remains the same, and the lateral edge also becomes rounder at the same time.

On the inner whorls the ornament consists of strong rectiradiate ribs, rising near the umbilical seam and becoming sharp on the flank, but on the outer whorl rising a little higher, leaving a smooth band next to the umbilical seam. As far as the first half of the penultimate whorl the primaries well into a tubercle adjacent to the subsequent umbilical seam. Part of the whorl has been destroyed and on the final part of the penultimate whorl tubercles are absent or hidden by the outer whorl. The absence of tubercles on the outer whorl is probably the result of wear in transit. Here the primary ribs are blunter and divide at the lateral edge into two or three secondaries, which are projected on the venter.

The suture is not visible at any stage.

Remarks:

Up to about 44 mm. diameter the specimen is similar to the inner whorls of Teloceras. At about the same diameter S. (Stemmatoceras) has longer primaries and a less pronounced lateral edge. The inflation of the outer whorl, together with the rounding of the lateral edge and arching of the venter, however, show that the specimen is not a Teloceras and suggests that it does belong to S. (Stemmatoceras). All these taxa are closely related and connected by intermediate species.

Of the species of S. (Stemmatoceras) previously described from New Guinea, S. brodiaei (Sowerby) identified by Donovan is too worn for comparison, while S. cf. coronatum (Quenstedt) (= ? frechi Renz) is less densely ribbed and has a flatter venter. S. aff. indicum (Kruizinga) is more depressed with stronger, more widely spaced ribs and more evolute. Arkell (1954, 1956) considered "Coeloceras indicum" Kruizinga, 1926, to be a Teloceras, and "Stephanoceras humphriesianum forma indica" to be a Cadomites. It is the former which Donovan appears to have regarded as conspecific with his material, but the specimen figured by Donovan (in Visser & Hermes, 1962) has much shorter and more widely spaced primaries and coarser secondaries.

Stephanoceras etheridgei Gerth is closest to the present specimen, but has a less wide outer whorl and a less rounded venter. The inner whorls and the ribs, however, appear to be the same. This species is similar to Stemmatoceras frechi Renz (figured by Weisert, 1932; pl.18, fig.4 under the name of S. coronatum (Quenstedt)). As a cross-section of the latter is not given, it is not certain how close these two species are. The inner whorls of the holotype of S. etheridgei are poorly preserved.

Arkell (1954) tentatively assigned S. etheridgei to Normannites, but Westermann placed it in Stemmatoceras (1964, in lit., identified for the Rijksmuseum, Leiden).

Age:

In western Europe S. (Stemmatoceras) appears to be more or less contemporaneous with Stephanoceras s.s., although, according to Kumm (1952) and Weisert (1932), it appears earlier in the Sauzei Zone and dies out earlier in the Humphriesianum Zone, not being found in the Blagdeni Subzone.

This appears to be the case in North America also. Imlay (1964) records it from the Red Glacier formation (probable Sauzei Zone) and the Fitz Creek formation (Humphriesianum Zone) in South Alaska, while Westermann (1964) records it from the Fernie Group (together with Stephanoceras cf. skidegatense S. (Kumatostephanus) and Arkelloceras indicating Sauzei Zone (see above, p. 45). However, Imlay (1967) also records Stemmatoceras from the Twin Creek Limestone which he considers to be Subfurcatum Zone, remarking that Stemmatoceras indicates a position near the Middle Bajocian-Upper Bajocian boundary. It would appear from the European evidence, on the other hand that this subgenus does not extend above the Humphriesianum Zone. It is, therefore, regarded here as being of Sauzei Zone and Humphriesianum Zone age.

Dimensions:

D	H	W	U	H/W
(42)	13(.31)	22(.52)	(17)(.41)	(.59)
(60)	21.5(.36)	36(.60)	(22.5)(.38)	(.60)

(?) S. (Stemmatoceras) sp. indet.
Plate III, fig. 4a,b

Material:

One specimen (L343), slightly worn.

Description:

This specimen is almost identical with the previous one (L41) at a corresponding diameter, except that it is slightly more depressed, with straighter primaries and the secondaries are not projected on the venter. It is also similar to some species of Teloceras at the same diameter, but the primaries appear to be rather longer in the latter.

Remarks:

Since this specimen is at the stage where the distinction between Teloceras and Stemmatoceras is not clear, it is referred to the latter only with uncertainty and largely because it is associated with the specimen just described.

Age:

(?) Sauzei Zone or Humphriesianum Zone.

Family	TULITIDAE Buckman, 1921.
Genus	Bullatimorphites Buckman, 1921.
Subgenus	B. (Bullatimorphites) Buckman, 1921.
(Type species:	Bullatimorphites bullatimorphus Buckman, 1921)

Bullatimorphites (Bullatimorphites) sp. indet. 'a'
Plate 4 , fig. 1a,b

Material:

One specimen (L274), one-half whorl of body-chamber, with a remnant of the phragmacone and external mould of inner whorls.

Description:

The external mould shows that the inner whorls were highly involute and that the outer whorl is 'elliptically" coiled. The preserved part of the outer whorl reaches its greatest width at the beginning of the body-chamber, after which it contracts. The ornament is not preserved on the phragmacone: on the body-chamber it consists of more or less rectiradiate and rather blunt primaries, which rise near the rounded umbilical edge and divide high on the flank into two secondaries, although some single ribs also occur. The secondaries pass straight over the venter.

The last septal suture has a slender U_2 lobe.

Remarks:

The rounded umbilical edge and involute coiling of the inner whorls indicate that this specimen is not Tulites s.l., while it is larger than the described species of Bomburites. It is, therefore, assigned to Bullatimorphites s.s. although it is more densely ribbed than the species figured by Arkell (1952,1954b). In this respect it is similar to Bullatimorphites sofanum (Boehm) (1912, p. 150; pl. 35, fig. 2), which also has a slender U_2 (Arkell, 1952, p. 87). However, the ribs of B. sofanum are stronger than those of the specimen and the whorls less bullate. B. ymir (Oppel), with which Boehm compared his species, has more flexuous, less dense ribbing, more involute inner whorls and is more depressed. The present specimen is intermediate between B. sofanum and B. ymir in the degree of involution.

Age:

B. ymir (Oppel) is known from the Lower Bathonian of Provence (Arkell, 1954, p. 108) and is the earliest form known, although it also extends up through the Middle and Upper Bathonian, together with other species of the genus. In parts of north-west Europe, in Spain and in Sicily, Bullatimorphites is found in the Lower Callovian, usually in the Macrocephalus Zone, but, south-west of the Paris Basin, apparently in the Koenigi Zone (Arkell, 1956, p. 54). The specimen at hand could, therefore, range from the Zigzag Zone of the Lower Bathonian to the Koenigi Zone of the Lower Callovian.

B. (Bullatimorphites) sp. indet. 'b'

Plate 4, fig. 2 - 5

Material:

Six specimens in a fairly good state of preservation (L205, L211, L275, L276, L279, L315), together with about twenty specimens which are poorly preserved, either fragmentary or crushed.

Description:

The two best preserved forms are L275 and L279, which are almost identical. Only in the latter are the inner whorls visible, however; they are depressed and tightly coiled throughout the phragmacone. The body-chamber is elliptically coiled in both specimens and occupies about one whorl, but the aperture is not preserved. As the umbilical seam unwinds, the whorl becomes more compressed and the body-chamber contracts slightly. The umbilical edge is rounded. At the beginning of the outer whorl the umbilical wall is vertical, but becomes less steep as the seam unwinds.

In both specimens the ornament on the outer whorl consists of dense, sharp primaries, rising on the umbilical wall and swinging forward on the flanks. They divide at about mid-flank into two or three secondaries, which curve backwards and then pass straight over the venter. The connection between the primaries and secondaries is rather weak and the secondaries occasionally appear as intercalaries.

Part of the external septal suture of L275 is visible, but could not be developed because of pyritisation, so that the form of U_2 is unknown.

Of the other forms, L205 is very close to the two above specimens, but has been slightly crushed, while L315, although smaller is similarly ribbed, has a more markedly elliptical umbilicus and is slightly more compressed. L211 is less well preserved, but is similarly ribbed and has a similar small umbilicus.

L276 is rather more problematical. Only the body-chamber is preserved, the beginning of the preserved part being of about the same diameter as the first two specimens described here, but is slightly higher and wider. The umbilical edge is rounded and the umbilical wall steep. The ornament is identical with that of the other forms in this group and it is elliptically coiled.

It differs from the rest, however, not only in being larger, but also in possessing four broad, irregular constrictions, which do not interrupt the ornament. After each of which the whorl expands, creating a rather uneven appearance.

Remarks:

The specimens of this group differ from the previously described specimen (L274) in being more densely ribbed and with more rounded whorls. In addition, the ribs are more flexuous and sharper. They are placed in *Bullatimorphites* because they have a rounded umbilical edge and are larger than *Bomburites*. The ribbing, however, is similar to that of *B.* (*Treptoceras*) (see below, this page).

Dimensions:

		D	H	W	U	H/W
L275						
	End phrag.	(30)	15.5(.52)	23.7(.79)	-	(.65)
	End body-ch.	57.5	23(.40)	29(.50)	14(.24)	(.79)
L279						
	End phrag.	28.2	16.5(.59)	23.2(.82)	-	(.71)
	End body-ch.	59	22.3(.38)	30.5(.52)	16(.27)	(.73)

Subgenus *B.* (*Treptoceras*) Enay, 1959.

(Type species: *Treptoceras laurenti* Enay, 1959).

B. (*Treptoceras*) aff. *B.* (*T.*) *microstoma* (d'Orbigny) (1846)

Plate V, Fig. 1a-c.

? 1846 *Ammonites microstoma* d'Orbigny, "Paléontologie francaise. Terrains jurassiques, t.l. Céphalopodes", pl. 129, fig. 3,4.

non 1886 *Am. microstoma* Quenstedt, "Die Ammoniten des schwabischen Jura, Bd. 2, Braun Jura", pl. 78, fig. 4.

? 1888 Am. microstoma d'Orbigny, de Grossouvre, "Etudes sur l'étage bathonien", p. 387.

? 1932 S. microstoma (d'Orbigny) Corroy, "Le Callovien de la bordure occidentale du Bassin de Paris", p. 100; pl.3, fig.11,12.

? 1958 Bullatimorphites (Bomburites) microstoma microstoma (d'Orbigny) Westermann," Ammoniten Fauna und Stratigraphie des Bathonien NW Deutschlands", p.67; pl.22, fig.3.

non 1915 S. microstoma Loczy, "Monographie der Villanyer Callovien-Ammoniten", p.95; pl.14, fig.7.

non 1921 S. microstoma Riche & Roman, "La Montagne de Crussol", p.152; pl.7, fig.11. (= Treptoceras laurenti Enay, 1959, "Tulitidés [Ammonitina] du Bathonien", p.253; pl. 7b, fig. 4.)

non 1923 S. microstoma Lissajous, "Etude sur la faune du Bathonien des environs de Macon", pl. 16, fig.4; pl.17, fig.3. (= Bullatimorphites ex gr. suevicum Roemer, Enay, 1959, op. cit.).

non 1929 S. microstoma (d'Orbigny) Lanquine, "Le Lias et le Jurassique des Chaines provencales", p.316; pl.11, fig.5 (= Schwandorfia lanquinei Arkell, 1952, "Monograph of the English Bathonian Ammonites", p. 87,88).

Material:

One specimen (L277), entire and in a good state of preservation.

Description:

The inner whorls are not fully exposed, but it can be seen that at the beginning of the penultimate whorl there is a high degree of overlap, that the umbilical wall is steep and separated from the flank by a rounded umbilical edge and that the ribs are sharp and dense in this region. The umbilicus is small and apparently deep. Where the outer whorl has been broken away on one side, the primaries are slightly prorsicline and divide just below the centre of the flank into two secondaries. The greatest width of the whorl here is at about one-third whorl height, immediately above the umbilical edge.

On the outer whorl the ribs are still sharp and rectiradiate on the umbilical wall, but become stronger at the umbilical eege and curve forward slightly on the flanks until dividing at mid-flank into two secondaries, which curve backwards and pass straight over the venter. Occasional intercalaries occur.

The whorl section at the end of the phragmacone is more or less semicircular, with a flatly rounded venter, rounded flanks and a vertical umbilical wall. At the beginning of the body-chamber the umbilical seam starts to unwind and the umbilical wall becomes less steep. From this point the whorl increases only gradually in height, but widens and so becomes increasingly depressed. Immediately before the aperture the whorl contracts and a terminal constriction cuts the ribs obliquely. This constriction shows traces of calcite filling. On one side only a lappet has been preserved. It is situated ventro-laterally and is apparently of small size, although it is not complete. The body-chamber occupies almost one whorl.

The external septal suture is partly exposed at the end of the phragmacone, but is pyritised so that the detail is not clear. The first and second morphological lateral saddles are of the same size, the former being rather slender.

Remarks:

Treptoceras was proposed by Enay (1959) for those Tulitidae exhibiting a combination of the generic characters of *Bullatimorphites* with those of *Schwandorfia*. Such a combination is shown in the figure of *A. microstoma* d'Orbigny (1846, pl. 143, fig. 3,4), which Arkell (1954, p. 110) considered to be a synthetogram, since none of the material in d'Orbigny's collection possessed lappets. Lappets do occur, however, in '*A. microstoma*' Quenstedt, considered by Arkell (loc. cit.) to be, probably, a new genus. The material collected by Enay from Trept (Isère), Crussol and Ardèche confirms this.

According to Enay (op. cit.), the inner whorls of *Treptoceras* are identical with those of *Bullatimorphites*, while the apertural region is similar to that of *Schwandorfia*, except that the terminal constriction in the latter is parallel to the ribs and in *Treptoceras* it cuts the ribs obliquely.

The occurrence of a small form with lappets, the inner whorls of which are identical with the immature whorls of large *Bullatimorphites* with simple apertures, suggests strongly that the former is the microconchiate equivalent of the latter. For this reason, *Treptoceras* is regarded as a subgenus of Bullatimorphites in accordance with the convention regarding sexual dimorphs (Callomon, 1963; Westermann, 1964b).

The specimen differs from other species of Treptoceras in that the body-chamber becomes depressed in the course of the last whorl, while in the known species, including T. microstoma(d'Orbigny), become more compressed. It is also more regularly coiled than any of the material studied by Enay, more so even that T. microstoma (d'Orbigny). This species, however, is quite variable (de Grossouvre, 1888) and of the published material is closest to the specimen (Enay, pers. comm.).

T. laurenti Enay differs in having two prominent geniculations 180° apart, a prominent flare and in being more compressed. T. crimaciense Enay is similar in proportions to T. laurenti and is similarly flared, but the coiling is less elliptical, the first geniculation being the strongest.

B. microstoma microstoma (d'Orbigny) figured by Westermann (1958) does not have the typical ventral flare, but only a slight heightening of the venter, scarcely rising above the constriction ("delphinulate aperture" of Buckman), in which it resembles the form from the vendee figured by Enay (op. cit., pl. 7b, fig. 7), who considered it to be close to T. microstoma (d'Orbigny). The specimen described by Westermann is regarded by Enay as belonging to a new species of Treptoceras. It differs from the specimen at hand in having more tightly coiled inner whorls, fewer, blunter ribs and a "delphinulate aperture". From the plate it would appear to be more compressed also, but since only a lateral view is given, this is uncertain.

Age:

Treptoceras is not known from horizons below the Middle Bathonian (Couches ocreuses of Crussol) (Enay, op. cit.) and occurs in the Upper Bathonian (de Grossouvre, 1888) and Lower Callovian (Corroy, 1932) of the Paris Basin and the Lower Callovian of Kutchh (Spath, 1931). The material described by Enay from Trept is of uncertain stratigraphic position, but Elmi (1964) has described T. aff. microstoma from the Aspidoides Zone of the Ardèche. Enay (pers. comm.) considers the sub-genus to be characteristic of the Middle and Upper Bathonian.

Dimensions:

	D	H	W	U	H/W
End phrag.	26.5	13.5(.51)	19(.72)	6.3(.23)	(.71)
End body-ch.	43.7	13.7(.31)	24.5(.56)	13.3(.30)	(.56)

B. (Treptoceras) sp. nov.?

Plate V, fig.2a-c.
fig.3a-b.

Material:

Two specimens (L278, L291), the first of which is complete, but slightly damaged, the second with the aperture missing.

Description:

The inner whorls of the complete specimen are depressed and tightly coiled, with rounded umbilical edge and steep umbilical wall as in the previously described form (L277). The dense primaries are fine and sharp throughout, rising on the outer part of the umbilical wall and swinging forward on the flank.

At the beginning of the body-chamber the umbilical seam begins to unwind and the whorl section becomes more depressed. The primaries are still fine and dense on the outer whorl, where the shell remains, but on the internal mould they are blunter, strongly prorsiradiate on the inner part of the flank and dividing at mid-flank into two or three secondaries, which curve backwards and pass straight over the venter. Intercalaries are more numerous than in the preceding form and the secondaries are less strongly attached to the primaries.

The terminal constriction cuts obliquely across the ribs, but there is no conspicuous ventral flare. The lappets are small and situated ventro-laterally.

The final septum is exposed and is typically bullate. U_3 is not retracted.

The second specimen is almost identical with that just described. The coiling and ornament are the same, but the whorls of the former are slightly more depressed. Since the aperture is not preserved, it is not known whether it possessed lappets.

No sutures are visible.

Remarks:

The dimensions of the complete specimen are close to the forms described by Enay (1959) and to T. microstoma, but the ornament is quite different. Instead of the strong, rather well-spaced and regularly bifurcating ribs of these species, the specimen possesses numerous finer and more flexuous primaries, loosely connected with the secondaries and with frequent intercalaries present. The aperture is similar to that of L277, differing from the described species in the absence of a ventral flare. These differences suggest that a new species is present here, but until more is known about the range of variation of the Treptoceras species or more material is available it seems advisable not to supply a new name here.

The second specimen is almost identical with the first, but the aperture is missing. The ornament and coiling, however, also resemble some species of Labyrinthoceras, e.g. L. intricatum Buckman, but the latter is more widely coiled and the whorls are higher and wider (according to the explanation of Buckman, 1919, pl. 135A, at a diameter of 41.5 mm., H = .52, W = .76).

The ribbing of these two specimens is very similar to that described in B. (Bullatimorphites) sp. indet. 'b' (see above p. 53) and it may be suspected that the latter, which are larger and do not have modified apertures preserved, could be the macroconchiate equivalents of the present forms, although in the absence of any information about the stratigraphy or faunal associations this cannot be proposed with any certainty.

Age:

Middle Bathonian to Lower Callovian.

Dimensions:

	D	H	W	U	H/W
L278	20.5	10(.49)	14.2(.69)	5(.24)	(.70)
End phrag.	31.2	14(.45)	18(.58)	8(.26)	(.78)
Just before constriction	46.2	17(.37)	22.6(.49)	14(.30)	(.75)
L291					
End body-ch.	47	16(.34)	23.3(.50)	13.5(.29)	(.69)

(?) B. (Treptoceras) sp. indet.

Plate VI, fig. 1.

Material:

Three specimens, of which one (L150) is more or less complete, while the others (L303, L305) are fragments of the terminal part of the body-chamber.

Description:

The complete specimen has been slightly distorted so that the beginning of the outer whorl has been pushed laterally, covering the umbilicus on one side, and destroying the venter and flanks between this affected part and the apparently unaffected later part. The inner whorls are not exposed and most of the outer whorl is covered by poorly preserved shell material. At a diameter of c. 46 mm. this specimen is higher and wider than Treptoceras sp. nov.? and with a smaller umbilicus. The primaries are stronger and slightly more flexuous, but divide in the same way, giving rise to identical secondaries.

The specimen possesses a terminal constriction, which obliquely cuts the ribs and expands after this with a suggestion that lappets may originally have been present, although no longer preserved.

Of the two fragments, the larger (L305) is identical with the aperture of the specimen just described, while the other is almost identical with the aperture of Treptoceras sp. nov.?, but is rather more depressed (H/W = .70), with a smooth umbilical wall and blunter ribs. Part of one lappet is preserved.

Remarks:

The small umbilicus of the complete specimen, with elliptical coiling of the outer whorl and the numerous, flexuous ribs obliquely interrupted by the terminal constriction suggest Treptoceras sp. nov., but without lappets preserved this identification is not certain and the specimen could be Bullatimorphites s.s. This is true also of the larger of the fragments, but the other fragment does possess lappets and is clearly similar to Treptoceras described previously, although too poor for specific identification.

Age:

(?) Middle Bathonian to Lower Callovian.

Dimensions:

L150	D	H	W	U	H/W
Near beginning of body-ch.	(42)	19.5(.46)	28(.67)	(9)(.21)	(.70)
Just before constriction	61	21(.34)	27(.44)	(19.5)(.31)	(.78)

(?) B. (Treptoceras) sp. juv.

Plate VI, fig. 2-3.

Material:

Three specimens (L272, L289, L290), the first of which is compressed dorso-ventrally and the last is one-half internal mould and one-half imprint. The third appears to be complete.

Description:

The complete specimen (L289) has poorly preserved inner whorls, which enclose a small, deep umbilicus. They are finely ribbed. The outer whorl is elliptically coiled and depressed, with the greatest width at about one-third whorl height, where there is a lateral edge. The venter is flat and the umbilical wall rather steep.

The ornament consists of strong well-spaced primaries, which rise on the outer part of the umbilical slope and are forwardly inclined slightly on the flank. They divide at mid-flank into two secondaries, which are strongly connected and which pass straight over the venter.

In both the other specimens the ornament consists of fine, dense and prorsiradiate primaries, which divide high on the flanks, giving rise to two or three backwardly curved secondaries, which pass straight over the venter. The connection between primaries and secondaries is weak and single ribs are present as well as intercalaries. L272 has a false geniculation due to compression, but L290 is ellpitically coiled. Both have more inflated whorls than L289 with rounder lateral edges and a gently rounded venter.

Part of the last septum is exposed in L290, but is poorly preserved and does not show the features of the umbilical lobes and saddles. The body-chamber occupies about three-quarters of a whorl, mostly as an imprint, and is of about the same length in the others also.

Remarks:

The ribbing of L272 and L290 is of the same type that is seen in B. (Treptoceras) sp. nov.? and in (?) B. (B.) sp. indet. suggesting that the two specimens may be young examples of one or other of these.

L289, with its stronger ribs suggests a closer affinity with *B.* (*T.*) *microstoma* or *Bullatimorphites* s.s. Without more material collected *in situ* it is not possible to make any firm suggestions about the relationships of these forms, although the similarities indicate that they are, in fact, related.

Family MACROCEPHALITIDAE Buckman, 1922.

Genus (?) *Macrocephalites* Zittel, 1884.

(Type species: *Am.* *macrocephalus* Schlotheim, 1813).

(?) *Macrocephalites* sp. indet.

Plate VI, fig. 4a-c; fig. 5a-c.

Material:

Three specimens (L204, L317, L249), of which the first two are well preserved while the third is fragmentary.

Description:

L317 is fully septate. The inner whorls are concealed by a pyritic matrix and the beginning of the outer whorl is slightly crushed. The umbilicus is small and apparently deep and the umbilical wall of the outer whorl is vertical, separated from the flanks by a rounded umbilical edge. At the start of the outer whorl the whorl section is slightly depressed, with almost flat flanks and an arched venter, but about three-quarters of a whorl further on there is a noticeable increase in width relative to the height so that the whorl becomes depressed and the venter flatter.

The ornament at the beginning of the outer whorl consists of fine primaries, which curve forward on the flank and divide at about mid-flank into two or three secondaries, which are projected slightly on the venter. Where the widening of the whorl begins, the primaries become rather stronger and a little more widely spaced.

The other well preserved specimen, L204, is more compressed at all stages. It is septate almost up to the end of the preserved part, with a small portion of the body-chamber attached. The umbilical wall is steep and separated from the flatly curved flanks by a rounded umbilical edge. The venter is arched. On the outer whorl of the phragmacone the ornament consists of fine, sharp primaries, slightly curved forward on the flanks and dividing at mid-flank into two or more secondaries. Intercalaries are numerous. The secondaries are slightly projected on the venter.

At the beginning of the body-chamber the primaries are abruptly modified. They become blunt and distant, but no change seems to occur in the secondaries. Throughout the outer whorl the overlap is more than half whorl height, so that even at the beginning of the body-chamber this specimen is more compressed than the previous.

The third specimen is identical with L204.

Remarks:

The first specimen (L317) resemble macrocephalitids figured by Spath (1924) from Kutchh and Jeannet (1951) from Herznach, but it is still immature and a subgeneric determination is not possible. It could be a Mayaites, with which Macrocephalites is homeomorphic.

L204 is more problematical. The inner whorls are more compressed than those of Macrocephalites and the distant spacing of blunt primaries on the body-chamberis not the same as the modification of the ribs in Macrocephalites.

Drs. Callomon and Howarth (pers. comm.) would place it in Sphaeroceras, rather than in Macrocephalites, but Drs. Imlay and Westermann (pers. comm.) would place it in Macrocephalites, since the inner whorls are too compressed to be Sphaeroceras.

Age:

If the specimens are Macrocephalites, they indicate Lower Callovian.

Genus Subkossmatia Spath, 1924.

(Type species: Am. opis J. de C. Sowerby, 1840.

Subkossmatia beta-gamma (Boehm) 1913
Plate VII, fig. 1a-c.

1913 Macrocephalites keeuwensis - Boehm, "Unteres Callovien und Coronatenschichten zwischen Maccluer Gold und Geelvink Bai", p.16; pl.5, fig.2.

1928 Subkossmatia beta-gamma (Boehm), Spath, "Reivision of the Jurassic Cephalopod Fauna of Kachh (Cutch)", p.212.

Material:

Two specimens (L51, L163), neither of them complete. The former is slightly larger and consists of the inner whorls (except the last half-whorl of the phragmacone) and the body-chamber, including the aperture. The latter consists of part of the body-chamber only.

Description:

The better preserved specimen has involute whorls, with dense, fine ribs, projected on the flanks. The primaries divide at about mid-flank into two or three secondaries, which are slightly projected on the venter. The whorls are compressed, oval, with a steep umbilical slope. The beginning of the body-chamber is ovoid, the greatest width at the umbilical edge. The ribs are blunter and more distant than on the inner whorls and prorsiradiate, dividing at about one-third whorl height into two or three secondaries. Intercalaries are frequent. The secondaries are projected slightly on the venter. The umbilical slope is steep and the flanks flatly rounded, so that the whorl appears compressed although the height and width are almost equal. The venter is rounded. The body-chamber occupies half a whorl and is terminated by an oblique constriction, only the lower part of which is preserved.

Remarks:

Spath (1928) considered Subkossmatia beta-gamma (Boehm) to be close to S. obscura Spath, which differs from the genotype, S. opis (J. de C. Sowerby), in being less compressed, with less dense ribbing and a tabulate venter in the inner whorls. All these forms are very close, however, and may be doubtfully distinct specifically.

Both specimens in the collection here are similar to S. beta-gamma in having involute inner whorls, densely ribbed and with a rounded venter and a more evolute outer whorl with blunt more distant ribs. The species described by Spath (1928) are all more densely and sharply ribbed on the outer whorl.

Age:

In Kutchh, Subkossmatia occurs in the Rehmanni Zone and Lower Anceps Zone (Spath, 1928), which Callomon (1955) considered to be equivalent to the Jason Zone and Lower ? (Coronatum Zone (Middle Callovian) In Madagascar, Basse & Perrodon (1952) assigned Subkossmatia to the same horizons, by comparison with the situation in Kutchh.

Dimensions:

L51	D	H	W	U	H/W
End of body-ch.	84.5	34(.40)	34(.40)	23.3(.28)	(1.00)

Genus Eucycloceras Spath, 1924.

(Type species: Stephanoceras eucyclum Waagen, 1875).

(?) Eucycloceras sp. indet.

Plate VII, Fig. 2a-b

Material:

One specimen (L19), internal mould at the beginning of the body-chamber.

Description:

The whorl is compressed and flat sided with a vertical umbilical wall and a slightly flattened venter. The ribs are sharp, dense and slightly falcoid. They bifurcate at, or just below, the centre of the flank and the secondaries are slightly projected on the venter. The umbilicus seems to be involute, but only the part bounded by the preserved whorl fragment is preserved.

Remarks:

This specimen is doubtfully referred to Eucycloceras, rather than to Subkossmatia, because of the apparently involute umbilicus. The immature whorls of these two genera, however, are somewhat similar (Spath, 1928, p. 209), although Subkossmatia tends to show differentiation of the ribbing on the venter as well as being more evolute.

Age:

Eucycloceras occurs in the Rehmanni Zone of Kutchh and perhaps in the Diadematus Zone also (Spath, 1928). Callomon (1955) would correlate the former with the Jason Zone of Europe (Middle Callovian), the Diadematus Zone being equivalent to the upper part of the Calloviense Zone (Lower Callovian).

Superfamily HILDOCERATACEAE Hyatt, 1867.

Family SONNINIIDAE Buckman, 1902.

Genus Fontannesia Buckman, 1902.

(Type species: Dumortieria grammoceroides Haug, 1887).

Fontannesia aff. F. grammoceroides (Haug) 1887.

Plate VIII, Fig. 1

? 1887 Dumortieria grammoceroides Haug, "Polymorphidae", pl.5, fig.5; text-fig.6c.

? 1902 Fontannesia grammoceroides (Haug). Buckman "Emmendations of Ammonite Nomenclature", p.6.

? 1905 Fontannesia grammoceroides (Haug) "Inferior Oolite Ammonites", Suppl. p.clxxxvii.

Material:

One specimen (L186), septate up to 45 mm. diameter, the body-chamber extending for almost one further whorl.

Description:

The inner whorls are subquadrate, with rounded flanks and a flattened venter bearing a blunt keel. At a diameter of c.12 mm. a distinct, rounded umbilical edge develops and the umbilical slope becomes steep, remaining so up to a diameter of c.70 mm. and then decreasing. The ribs on the inner whorls are simple, blunt and rectiradiate, rather well spaced. On the outer whorl they become slightly falcoid and are strongly projected on the shoulder, separated from the keel by a smooth band. The umbilical slope and innermost part of the flank are also smooth. One or two ribs are seen to divide on the penultimate whorl and on the outer whorl there are five or six bifurcating ribs. The primaries divide near the centre of the flank and the secondaries are sharply reclined before being projected on to the shoulder.

The whorl section becomes compressed, oval at the beginning of the penultimate whorl, the flanks continuing to be rounded up to the later part of the outer whorl, where they become flatter, giving the whorl a compressed subquadrate section (Fig. 10).

The keel is blunt at all stages and appears to be unfloored throughout. The external suture is the same as that of the specimen described as F. luculenta below (p.75), The L lobe is slender and trifid, separated from U_2 by a bipartite saddle. U_2 is straight and U_3 is weakly retracted. The inner suture is not exposed.

Remarks:

The strong, backwardly biplicate ribs of this specimen can be matched in F. grammoceroides (Haug), which differs only in having denser, more rectiradiate ribbing particularly on the inner whorls. Similar ribbing also occurs in F. fairbridgei Arkell which, however, has coarser, less dense ribs, with a larger number of divided primaries than either F. grammoceroides or the present specimen and also possesses a gentle umbilical slope. While the present specimen seems to be intermediate between these two species in rib density, it would appear to be much closer to F. grammoceroides.

Fontannesia shows a resemblance to Grammoceras in most characters (Arkell 1954, pp.564, 567, 597), but the latter typically possesses denser and more falcoid ribbing, which in G. (Phlyseogrammoceras), some species of which Arkell (1954, p.564) compared with F. fairbridgei, tends to be fasciculate at the umbilical edge. The inner whorls of Grammoceras tend to be smoother and the external suture is simpler, with a more stocky L lobe and weakly divided umbilical lobes, which are not retracted.

Age:

The specimens of Fontannesia figured by Buckman (1892, 1905) were collected from the Discites Subzone (Sowerbyi Zone) of Dorset and Kumm (1952) records Fontannesia from the "Zone of L. discites" in north-west Germany. Outside Europe, Arkell (1954) records the genus from the Sowerbyi Zone in West Australia, probably the Discites Subzone (Arkell, 1954, pp. 568, 596). Although this genus occurs in the lowest subzone of the European Sowerbyi Zone, it does not follow that it is of precisely the same age in the Antipodes and a general Sowerbyi Zone age may be more probable.

Dimensions:

	D	H*	W	U	H/W
End body ch.	77	28.3(.37)	20.1(.26)	28.7(.37)	(1.41)
End phrag.	45	16.2(.36)	13.7(.30)	14.6(.32)	(1.18)
Measured between the ribs	(17)	7.5(.44)	7.6(.45)	7.5(.44)	(.99)

* Measured between the ribs

Fontannesia aff. F. luculenta Buckman, 1902

Plate VIII, fig. 2a,b

? 1895 Dumortieria grammoceroides Haug. Buckman, "Inferior Oolite Ammonites", p. 262; pl.46, fig.6,7.

? 1902 Fontannesia luculenta Buckman, "Emmendations of Ammonite Nomenclature", p.6.

? 1905 Fontannesia luculenta (Haug). Buckman "Inferior Oolite Ammonites", Suppl. p.clxxxviii, text-fig. 187.

Material:

One specimen (L165), wholly septate.

Description:

The inner whorls are subquadrate, but rather more compressed than in the previously described specimen, and possess rounded flanks and a blunt keel. The ribs are blunt slightly falcoid and fairly dense; slightly prorsicline on the flanks and projected on the shoulder.

In the later stages the whorl section becomes increasingly compressed, with rounded flanks and a smooth, gentle umbilical slope throughout. The venter remains keeled and is separated from the flanks by a marked ventro-lateral shoulder. The ribs become slightly more falcoid and more projected on the shoulder. A smooth band intervening between the shoulder and the keel. The latter is apparently unfloored at all stages.

The suture (Fig. 11) is rather simple at the beginning of the outer whorl, the E/L saddle is broad based and weakly divided while a bipartite saddle separates the slender trifid L lobe from the similarly trifid and straight U_2. U_3 is straight and weakly retracted. The internal suture has a dominant I/U_1 saddle and a reduced U_2/U_3 saddle, U_1 being small and oblique.

At larger diameters the lobes and saddles become more incised, but retain the same relative positions.

Remarks:

The more compressed whorls of this specimen and its simple less pronounced ribbing distinguish it from the preceding example. It resembles *Fontannesia explanata* Buckman and *F. luculenta* Buckman in coiling and ornament. These two species are very similar, the principal differences being that the former is more evolute, densely ribbed and does not possess a ventro-lateral edge. The present specimen is similarly ribbed to *F. explanata*, but is more evolute as well as a ventro-lateral edge, in these respects resembling *F. luculenta*.

F. clarkei (Crick) is almost identical with the specimen of F. luculenta of which Buckman (1892, pl.46, fig.8) figured only the suture, up to a diameter of c.70 mm., but at larger diameters the ribbing of F. [illegible] fades, while that of F. luculenta persists (Arkell, 1954; p.566). F. carinata Buckman is somewhat similar to the above species, but the ribs are rursiradiate and much coarser on the inner whorls and more sigmoidal on the outer. The section of the outer whorl is a compressed oval, without a ventro-lateral edge and with a prominent sharp keel.

The present specimen would seem to be most similar to F. luculenta in all its characters except rib density, in which it resembles F. explanata. For this reason it has been identified here with the former species.

The above forms are all very similar and may represent the range of variation of a single species. However, until a revision based on a re-assessment of the available material is made, it does not seem advisable to unite them yet.

Age:

Sowerbyi Zone (? Discites Subzone).

Dimensions:

	D	H	W	U	H/W
End of outer whorl	68	23.4(.34)	16.3(.24)	25.5(.38)	(1.44)
End of penult. whorl	34	12(.35)	10(.29)	12.5(.37)	(1.20)

<u>Fontannesia</u> <u>obruta</u> Buckman, 1905

Plate VIII, fig. 3a-c

1905 <u>Fontannesia</u> <u>obruta</u> Buckman, "Inferior Oolite Ammonites", Suppl. p. clxxxix, pl. 24, fig. 8-11.

<u>Material</u>:

One specimen (L167), complete, but with part of the outer whorl damaged. Half one whorl consists of body-chamber.

<u>Description</u>:

The inner whorls are subquadrate, with rounded flanks, a prominent ventro-lateral shoulder and a vertical umbilical slope. The ribs are strong and distant on the flanks and projected on the shoulder, separated from the blunt keel by a smooth band. The umbilical slope is smooth. The later whorls become increasingly compressed; the umbilical slope remains vertical and smooth, but the ventro-lateral edge is lost and the smooth band is restricted to the base of the keel. The flanks become flatter and the ribs weaken, particularly near the umbilical edge where they become obsolete. Where the test is preserved at the end of the outer whorl, striae are visible parallel to the very slightly falcoid ribs. The last septum is exposed and shows that the internal part has a single dominant saddle. Part of the external suture is visible near the end of the phragmacone; the L lofe is slender and trifid.

<u>Remarks</u>:

This specimen is almost identical with the holotype of <u>F</u>. <u>obruta</u> figured by Buckman (1905), the principal differences being that the present specimen is rather less densely ribbed and slightly less compressed at a corresponding diameter. The ribs are similarly rectiradiate and fade near the umbilicus, however, there is no prominent ventro-lateral edge present and the flanks are conspicuously flattened with a vertical umbilical slope, as in F. obruta.

The narrow venter, vertical umbilical slope and reduced ornament in the present specimen suggest a relationship with Dorsetensia, but the examples of the latter genus figured by Buckman (1892) show a greater reduction in ornament, the umbilical edge is much sharper and the external suture has a shorter, broader L lobe.

Age:

Sowerbyi Zone (? Discites Subzone).

Dimensions:

	D	H	W	U	H/W
End of preserved whorl	(85)	28.5(.34)	17.5(.21)	32(.38)	(1.63)

Fontannesia sp. indet.

Plate IX, fig. 1-3

Material:

Three specimens (L168, L312, L148), the first two almost entire, the last consisting of about half a septate whorl.

Description:

The specimens are involute and compressed fastigate, with flattened sides, except for L148, whose flanks are gently rounded. The inner whorls appear to be finely ribbed, while the ribs on the outer whorl are rectiradiate on the flanks and strongly projected on the shoulder, where they are separated from a keel by a smooth band. The umbilical slope is steep and smooth with a rounded umbilical edge. Several ribs on the outer whorl bifurcate, some near the centre of the flank, but a number tend to be fasciculate, especially in L312 and L148.

Sutures are visible only in L148, which has a slender trifid L lobe, and the septal surface shows a single internal saddle.

Remarks:

These specimens are apparently related to the others in this collection, which have been referred above to *Fontannesia*. They seem to be close to *F. luculenta*, but the fasciculation of the ribbing can not be matched in any previously described species.

Age:

(?) Sowerbyi Zone.

(?) *Fontannesia* sp. indet.

Plate IX, fig. 4-5.

Material:

Two specimens (L190, L316), almost complete.

Description:

Both specimens are moderately involute, with compressed, fastigate whorls. The ribs on the inner whorls are sharp and dense, becoming slightly falcoid in the middle stages and rectiradiate on the outer whorl, where they are strong and distant, fading close to the umbilical edge and strongly projected on the shoulder, separated from a blunt keel by a narrow smooth band. The umbilical slope is smooth and gentle throughout.

The external septal suture is visible on L190 and appears to have a broader, less slender L lobe than in the specimens described above. The septal surface is exposed in L316 and shows a single internal saddle.

Remarks:

Although these two specimens seem to belong to the same group as the specimens described above, being very similar in whorl shape, they differ markedly in the ribbing of the outer whorl, which is much stronger than in any previously described species of *Fontannesia*, from which it also differs in possessing a stockier L lobe in the external suture. Despite these differences, however, they would seem to be more closely allied to *Fontannesia* than to some other genus.

Age:

(?) Sowerbyi Zone.

INCERTI SEDIS

Genus *Sulaites* Getty, gen. nov.

Subgenus *S.* (*Sulaites*) Getty, subgen. nov.

Sulaites (*Sulaites*) *pinguis* Getty, sp. nov. - Type species

Plate X, fig. 1-2
Plate XI, fig. 1-4

Diagnosis:

Medium-sized ammonites, inner whorls planulate, with tabulate venter; becoming depressed at a diameter of c.55 mm. and developing almost coronate outer whorls with a flatly rounded venter. Ribs strong and rectiradiate throughout; primaries with prominent bullae at the umbilical edge and bifurcating at a strong lateral tubercle (bulli-tuberculate), secondaries becoming bullate on the shoulder and weakening on the venter. No modification of the ribbing occurs. Aperture not known.

Derivatio nominis: Latin 'pinguis' = fat.

Stratum typicum: Kembelangan formation, 'A' member.

Locus typicus: Kemaboe Valley, central West New Guinea.

Material:

The holotype (L363), ten well-preserved specimens and twenty one less well-preserved specimens, some of which are doubtfully referred to this species.

Description:

The inner whorls are evolute and subcircular, becoming tabulate in the middle growth stages, with gently curved flanks separated from the fairly steep umbilical wall by a rounded umbilical edge. The ribs are bullate on the umbilical edge and weaken before dividing at a lateral tubercle into two secondaries, with occasional intercalaries. The secondaries are bullate on the shoulder, and become weaker on the venter, producing a slight ventral furrow. Up to a diameter of about 55 mm. the lower part of the secondaries is visible on the inner whorls, but at this size the whorls become more involute and depressed, the umbilical slope less steep and the primaries relatively longer so that the secondaries are occluded by the following whorl.

The point at which the whorls become depressed is quite abrupt, but in only one specimen (L49) is the onset of depression marked by a constriction of the whorl (Plate XI, fig. 2a,b). The tabulation of the venter persists on to the depressed whorls and is lost only in the largest, most depressed specimens. As the whorls become increasingly depressed, a lateral edge is produced at about mid-flank, where the lateral tubercles are situated, and the umbilical edge becomes obsolete. The bullae persist, however, and move on to the lower part of the lateral edge. In the largest specimens (mostly fragments of the outer whorl, e.g. L357, pl. XI, fig. 4a-c) they are still distinguishable, but tend to be less prominent due to the curvature of the lateral edge. These changes produce an almost coronate whorl in the larger specimens (Fig. 12). The body-chamber occupies nearly one whorl in the larger specimens, but the aperture is not preserved in any.

The septal suture is visible in the holotype, but is better displayed in L20 (Fig. 13). L is very broad and separated from a straight U_2 by a broad, simple saddle. U_3 is oblique, but not completely preserved. The internal suture has a major $I/U_{1?}$ saddle and a more weakly developed $U_{1?}/U_3$ saddle. $U_{1?}$ is of the same depth as U_2. All the lobes and saddles are broad based and weakly incised.

Dimensions:

For the measurements see the Appendix. Whorl height (H) shows negative allometry with whorl width (W) (Fig. 14), while showing isometric growth compared to the diameter (D) (Fig. 15). Whorl width and diameter show positive allometric growth (Fig. 16). There is a weak positive correlation between U/D and H/W (Fig. 17), indicating that the more evolute specimens are also more compressed, a recognised trend in ammonites (see Westermann, 1966).

Remarks:

This subgenus, represented by a single species, cannot be identified with any genus previously described. The outer whorls resemble Teloceras, which, however, does not possess bullae near the umbilical edge or shoulder and the inner whorls are not planulate. Stephanoceras and Normannites have planulate whorls, but the ribs are simple and continuous and with mid-lateral tubercles. The septal suture of Sulaites s.s. is much simpler than in both.

Subgenus S. (Parasulaites) Getty, subgen. nov.

Sulaites (Parasulaites) serpentiformis Getty, sp.nov. - Type species.

Plate XII, fig. 1-3
Plate XIII, fig. 1-2

? 1926 Coeloceras moermanni Kruizinga, "Ammoniten en eenige andere fossielen uit de jurassische afzettingen der Soela Eilanden", p. 44; pl.13, fig.2 [nom. dub.?]

Diagnosis:

Sulaites in which the planulate stage persists without modification throughout the conch. Aperture with small lappets situated at midflank.

Derivatio nominis: from the planulate ("serpenticone") whorls.

Stratum typicum: Kembelangan formation, 'A' member.

Locus typicus: Kemaboe Valley, central West New Guinea.

Material:

The holotype (L162), twelve well-preserved specimens and six less well preserved.

Description:

The inner whorls of this subgenus appear to be identical with those of S. (Sulaites) pinguis described above. The whorls are subcircular with a tabulate venter and flatly rounded flanks. The ornament comprises strong bulli-tuberculate primaries and the secondaries are bullate on the shoulder and weaken on the venter.

The subcircular whorl section persists throughout all growth stages and in some specimens tends to become more subquadrate (Fig. 18). In the holotype, however, it remains subcircular and towards the end of the body-chamber the tabulation of the venter is reduced.. The tubercles on the last two or three ribs are also reduced and the bases of the small lappets occur near mid-flank. One other specimen (L132) also possesses lappets, but is slightly more quadrate, smaller and more densely ribbed.

A single specimen (L88) almost as large as the holotype (which is the largest specimen) shows a pronounced tabulation of the venter and is ornamented by very sharp, dense ribs. The inner whorls are preserved only as an imprint, but a squeeze showed that the strong, bulli-tuberculate primaries are prorsiradiate, a feature not encountered in the others. This specimen seems to be a divergence from the norm in the direction of increased ornament.

The development of the septal suture in the later growth stages has been followed by combining information from several specimens (Fig. 19).

The earliest stage for which there is any information is at a whorl height of 1.5 mm., where the umbilical lobes are all equally developed, so that the sequence of insertion of new elements into the suture is unknown. The lobe on the umbilical side of the internal saddle, however, seems to be a minor element and perhaps part of a split U_1. It remains a minor element throughout the elaboration of the suture. The adjacent lobe, which abuts on to one side of the umbilical seam, is probably U_1 and, like the lobe ($U_{3?}$) on the other side of the seam, is not retracted. The internal saddles are slim, but those of the external suture are very broad based and weakly and irregularly incised.

Dimensions:

For the measurements see the Appendix. Whorl height and whorl width show almost isometric growth (Fig. 20) and a comparison with *S.* (*Sulaites*) shows that there is considerable overlap in the lower part of the curve and only the larger specimen ofeach subgenus are distinct. (See also Fig. 21.) Similarly, height shows isometric growth with diameter and width shows isometric growth with diameter also (fig. 22, 23). The curve for H vs. D is almost the same as that of *S.* (*Sulaites*). Below a diameter of c.35 mm. the two overlap, but above this diameter *S.* (*Sulaites*) tends to be higher than *S.* (*Parasulaites*). In the same way when W and D are considered, below c.55 mm. diameter the two subgenera overlap, but above this diameter they diverge strongly, due to the negative allometric growth of the one and the isometric growth of the other.

There is a weak positive correlation between U/D and H/W in *S.* (*Parasulaites*) Fig. 24) and there is considerable overlap between the immature diameters of the two subgenera, but if only the maximum preserved diameters are plotted (Fig. 25) they fall into two clusters, large *S.* (*Sulaites*) being more involute and more depressed than large *S.* (*Parasulaites*).

The rib density curves of *S.* (*Parasulaites*) and *S.* (*Sulaites*) overlap completely (Fig. 26) and the number of ribs per whorl remains constant from an early stage (Fig. 27).

Remarks:

Since the inner whorls of *Sulaites* s.s. and *S.* (*Parasulaites*) appear to be indistinguishable and the diagnostic characteristics are manifested only on the outer whorls, the taxonomic separation would seem to be, at most, at the subgeneric level. Moreover, since *Sulaites* s.s. attains a larger size, in general, than *S.* (*Parasulaites*), while the latter possesses lappets, suggests that the two may form a dimorphic pair. Without information concerning the stratigraphic distribution or faunal associations of the specimens, however, this hypothesis must remain tentative.

The only suggestion of any association is given by L290 (*Bullatimorphites* sp. juv.), which occurs in a fragment of a concretion together with the incomplete imprint of a strongly ribbed ammonite, which appears to have bulli-tuberculate primaries on the inner whorl. The specimen is so badly preserved that no firm conclusion may be drawn.

Of previously described ammonites from Indonesia, only "Coeloceras" moermanni Kruizinga (1926) seems to show a possible resemblance. This form is known only from the holotype, which consists of an internal mould, only one side of which is preserved. The whorls are evolute and appear to be bulli-tuberculate, but the figure is poor and it is not certain that it is Sulaites. The external suture (Kruizinga, 1926; text-fig. p.44) is simple like that of Sulaites, but the E/L saddle is the same size as the L/U_2 saddle and U_3 is retracted, whereas in Sulaites E/L is larger than L/U_2 and U_3 is not retracted.

Arkell (1954) and Donovan (in Visser & Hermes, 1962; encl.17, fig.24) considered Kruizinga's species to be Normannites, but the specimen figured by Donovan, although small, has typical bulli-tuberculate primaries, the secondaries are bullate on the shoulder and weaken on the venter, exactly as in Sulaites, and the specimen can be closely matched by small examples in the present collection, e.g. L107 (pl.XIII fig. 4). Arkell later (1956) tentatively assigned "C." moermanni to Coeloderoceras, which is an evolute genus, with bituberculate ribs, which lose the inner tubercles and become Stephanoceras-like on the outer whorls. However, the inner tubercles on the inner whorls lie above the umbilical edge and the outer tubercles are situated high on the flank, at the umbilical seam of the next whorl, so that the primaries are relatively long. The whorl section of Coeloderoceras is rounded, with an arched venter (see Bremer, 1965; text-fig. 3r,s,t). On the outer whorls the inner tubercles are lost first and the outer are lost later, in the specimens described by Bremer (1965).

The suture of Sulaites resembles certain Coeloceratinae (Fig. 30), largely in the simple form of the elements, although the internal suture in this subfamily possess a split U_1, which may be matched in the internal suture of Sulaites.

The affinity of Sulaites is dubious and its systematic position, therefore, uncertain. The probably macroconchiate Sulaites s.s. appears stephanoceratid-like, while the probably microconchiate S. (Parasulaites) appears perisphinctid-like.

Age:

If the imprint associated with Bullatimorphites (Treptoceras) sp. indet. (L290) is in fact Sulaites, a possibly Middle Bathonian to Lower Callovian age is suggested. However, the evidence is highly equivocal and the genus could be from any horizon from the Lower Jurassic to the Cretaceous.

Sulaites sp. juv.
Plate XIII, fig. 3-4

Material:

Four specimens (L107, L53, L206, L235) all more or less complete, none of which are more than C.40 mm. diameter.

Description:

All the examples are moderately evolute with compressed oval whorls, in which the venter is tabulate. The primaries are strong, bulli-tuberculate and straight, while the secondaries become bullate on the shoulder and weaken on the venter. One specimen (L235) is rather wider than the others and develops a lateral edge at c.22 mm. diameter, but this is soon lost again.

Remarks:

Although small, these specimens are clearly Sulaites. They have not, however, attained the size where subgeneric distinction is possible, although the wider whorls of L235 may suggest that it could perhaps be an incipient Sulaites s.s.

Dimensions:

See the appendix. Comparison of the scatter of H vs. D and W vs. D (Fig. 29,30) for L107 and L235 with the corresponding scatters for Sulaites s.s. and S. (Parasulaites) show that these small examples fall within the range of the other specimens assigned to Sulaites s.l.

Age:

See above, under S. (Parasulaites).

IV. COMPARISONS WITH OTHER FAUNAS

The geographical distribution of the genera represented in the collection under discussion is shown on Map 8, which demonstrates the essentially Tethyan and Pacific affinities of the fauna.

Of these genera, Macrocephalites s.l., Bullatimorphites and Stephanoceras are world-wide and known from many localities; Macrocephalites is not found in Japan or Australia and may be represented by "Lilloetia" (= ?Eurycephalites) in the Boreal Realm, while Stephanoceras occurs throughout the Tethys and northern Pacific. It has also been found in Argentina (Westermann, pers. comm.). The Arabian species referred to as "Stephanoceras" by Arkell (1952a) has been shown to be Ermoceras (family Thamboceratidae) by Westermann (1965).

The more restricted distribution of Bullatimorphites may be due to the marine regression in the Bathonian (Arkell, 1956), but it is found outside western Europe, in the Balkans (Stephanov, 1963), north Africa, south Caspian and the Pamirs (Arkell, 1956) and in Argentina (Westermann, pers. comm.). Olcostephanus is known from western Europe, the Indo-Madagascar region, Japan, Sumatra and central and southern America, so that it too is world-wide.

Several other genera are widely distribut e d, but found only in a few localities. These include Bullatimorphites (Treptoceras), Docidoceras and Fontannesia. The first is known from central and western Europe (Enay, 1959), the Balkans (Stephanov, 1963), and may be represented by a record of "Sphaeroceras" microstoma (d'Orb.) from the Julfa Gorge. It also occurs at Kutchh (Enay, 1959) and may be more widely dispersed, but concealed by the nomenclature.

Fontannesia occurs in western and central Europe and in Turkey (Bremer, 1966), but is also recorded from British Columbia (Crickmay, 1930) and is said to occur in Argentina (Jaworski, 1926). The last, however, may be a misidentification (Westermann, 1967, in press). Arkell (1954) described a number of species from West Australia, which indicate a connection between this area and New Guinea in the Middle Bajocian, which is confirmed by the presence of Pseudotoites in both regions.

Docidoceras s.s. occurs outside western Europe in Turkey (Bremer, 1966) and, doubtfully, in southern Alaska and Oregon. D. (Trilobiticeras) however, has been found in West Australia (Arkell, 1954) and this subgenus is considered by Westermann (1964b) to be the microconch equivalent of Docidoceras s.s. The latter is not known from Australia, but the species in the present collection may represent the macroconch.

The Callovian Subkossmatia is known only in Kutchh and Madagascar and is, therefore, indicative of the Ethiopian province (Arkell, 1956), which continued into the Oxfordian when it was characterised by the Mayaitidae. Unless the specimens which have been described as Macrocephalites? are, in fact, Mayaites, there are no representatives of this later family in the present collection. Eucycloceras is most abundant in the Indian Realm, but has also been recorded from North Africa ("Treatise"). Cobbanites, which is penecontemporaneous with

Eucycloceras, indicates a connection across the north Pacific, since the other specimens of the genus occur in southern Alaska, Montana and British Columbia (Imlay, 1962a). This connection is also suggested by Stephanoceras aff. S. skidegatense as well as Pseudotoites and Zemistephanus (Arkell, 1956).

Blanfordiceras occurs in the Indo-Madagascar region and in South America, but Himalayites, with which it is associated, is also found in Central America, North Africa and southern Europe (Arkell, 1956). The reaons for this divergence in distribution may have been ecological, but are not identifiable.

Finally, Sulaites is known only from New Guinea, perhaps from the Sula Islands and the island of Babbar.

V. STRATIGRAPHIC DISTRIBUTION OF THE FAUNA

The stratigraphic information given in the Systematic Descriptions is summarised in Table I, together with the approximate number of specimens in each genus. Nearly half the identified material belongs to *Sulaites* gen. nov. the horizon of which is not known, but if Arkell was correct in placing it as an ally of *Coeloderoceras*, which may be possible, it should be of Lower Lias (Carixian) age, and therefore, the oldest known ammonite from New Guinea. The only other deroceratids from the Indonesian area are a poorly preserved *Eoderoceras* (Sinemurian) figured by Krumbeck (1922) from Retti, and a *Microderoceras* (Sinemurian) figured by Boehm (1908, pl. 11, fig. 5) from the same island.

No Lower Bajocian ammonites are known from the southwest Pacific islands and the *Fontannesia* and *Docidoceras* are, therefore, the next in order of age. In northwest Europe both genera are characteristic of the Discites Subzone, Sowerby Zone, but it would be unreal to argue from that that they are of precisely the same age in New Guinea. It is rather more probable that they indicate some horizon within the Sowerbyi Zone as a whole.

The Sauzei Zone is probably not represented here unless by *Stephanoceras* (*Stemmatoceras*), but the close affinity between *S.* (*Stephanoceras*) aff. *skidegatense* and the Humphriesianum Zone forms of Western Canada and, indeed with *S. humphriesianum* itself, indicates that the Humphr. Zone occurs on the island. Another lacuna occupies the Upper Bajocian.

The Bathonian is probably represented by Bullatimorphites which is common in the Middle and Upper Bathonian. B. (Treptoceras) is not known from below the middle Bathonian and ascends into the Lower Callovian, so that its range corresponds with that of Bullatimorphites s.s.

Lower Callovian is attested by the presence, not only of ?Macrocephalites s.l., but also of Eucycloceras and Cobbanites, while both B. (Treptoceras) and Bullatimorphites may continue into this horizon.

Subkessmatia is from the Middle Callovian of Kutchh (Rehmanni and Lower Anceps Beds, probably equivalent to the Jason Zone and lower part ?, of the Coronatum Zone (Callomon, 1955)).

A more substantial lacuna occurs above this point, with the Upper Callovian, the entire Oxfordian and Kimeridgian and the Lower and Middle Tithonian unrepresented.

The next diagnostic form is Himalayites, which appears to be confined to the Upper Tithonian in Europe and South America (Arkell, 1956), although its complete range in the type area of the Himalayas is uncertain. Blanfordiceras also occurs not earlier than the Upper Tithonian and is also known from the Berriasian (Arkell, 1956), while Olcostephanus is restricted to the Upper Valanginian ("Treatise"), and is the youngest form to have yet been retrieved from West New Guinea.

VI. CONCLUSIONS

The oldest ammonites in the collection are Middle Bajocian (Sowerbyi Zone, and belong to genera known from Europe, Australia and perhaps the Americas, (Fontannesia, Docidoceras). The presence of the Humphriesianum Zone is attested by the world wide genus Stephanoceras, while Bullatimorphites s.s. (also world wide) and B. (Treptoceras), previously known only from western and central Europe, the Balkans and Kutchh, indicate Middle Bathonian to Lower Callovian.

Lower Callovian is also indicated by Macrocephalites?, Eucycloceras and Cobbanites, the first of which is world wide, the second is typical of the Ethiopian province of the Tethyan Realm and the last is known elsewhere only from western North America.

The youngest ammonites are from the topmost Jurassic and Lower Cretaceous. Both Blanfordiceras and Himalayites occur in the Upper Tithonian of the Ethiopian province and South America, but Blanfordiceras is known from the Lower Cretaceous also. Himalayites is more widely distributed geographically, being found in central America and southern Europe. Olcostephanus is the youngest genus known from West New Guinea and has a world wide distribution.

The present collection, therefore, comprises a fauna which shows a mixture of both Pacific and Tethyan (Ethiopian province) elements, together with a new genus, Sulaites, the age of which is uncertain, which appears to be restricted to New Guinea, the Sula Islands and Babbar.

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APPENDIX

a) Parameters of _Sulaites_ (_Sulaites_) _pinguis_ Getty, nov.

(All measurements in millimeters.)

L363 Holotype

D	H	W	U	Ribs/Whorl
(32.5)	(9.7)	(11.2)	14.4	23
38.4	11.5	13.2	17.3	26
45.2	15.0	17.0	20.0	27
52.8	17.0	19.6	23.1	27
(54.5)	17.5	20.0	25.3	28
66.0	21.5	30.7	27.8	-
84.0	26.2	41.3	37.6	-

L139

D	H	W	U	Ribs/Whorl
30.0	11.2	12.0	11.7	(21)
40.7	14.0	16.0	15.6	23
51.5	17.0	20.2	21.4	25
(58.5)	21.0	25.3	25.0	26
67.6	24.2	(30.6)	26.0	27
82.3	28.0	38.1	30.7	28

	D	H	W	U	Ribs/Whorl
<u>L49</u>					
	4.6	2	2.5	2	-
	6.6	2.5	3	2.8	(23)
	10.5	3.8	4.5	4.5	27
	14.2	6.0	5.5	6.2	26
	22.0	7.5	7.5	8.8	25
	28.2	8.7	9.8	12.4	22
	39.0	13.5	13.8	16.7	22
	49.0	14.5	16.7	17.7	-
	51.0	16.0	17.6	22.3	26
	53.0	16.2	17.8	22.3	26
	53.2	16.5	19.0	23.3	26
	54.6	16.4	18.5	24.0	27
	55.3	16.7	22.0	24.2	27
	56.6	17.3	22.4	24.7	-
	59.5	18.0	23.5	26.0	28
	63.3	19.5	26.5	27.0	28
<u>L136</u>					
	1.4	.5	1.0	.4	-
	2.0	.7	1.2	.6	-
	3.0	1.0	1.6	1.1	-
	4.3	1.8	2.3	1.6	-
	6.1	2.5	2.8	2.2	-
	8.6	3.1	3.6	3.3	25
	12.3	4.6	5.0	4.7	24
	16.7	5.2	6.0	7.1	21
	22.5	7.5	8.4	10.0	22
	32.0	11.2	12.6	14.3	23
	36.3	12.3	16.4	16.0	24
	41.0	14.0	16.8	17.0	24
	44.2	14.6	19.0	18.2	25
	46.5	15.5	19.5	18.8	25
	50.5	15.8	21.7	19.5	25
	54.7	17.0	23.2	21.3	25

	D	H	W	U	Ribs/Whorl
L47					
	(34.4)	10.5	13.0	14.6	24
	(38.7)	13.3	16.0	17.5	26
	45.8	15.0	18.3	19.4	27
	53.2	16.8	23.5	23.0	28
	57.2	18.4	24.6	25.3	29
L69					
	8.7	9.5	-	-	-
	10.0	11.5	-	-	-
	13.2	15.7	-	-	-
	18.7	27.5	-	-	-
	21.3	29.6	-	-	-
L352					
	7.5	8.5	-	-	-
	12.5	12.0	-	-	-
	15.2	13.4	-	-	-
	17.3	22.3	-	-	-
	18.4	24.1	-	-	-
L29					
	11.7	12.7	-	-	-
	12.5	16.3	-	-	-
	16.2	24.7	-	-	-
	20.7	29.0	-	-	-

b) Parameters of <u>Sulaites</u> (<u>Parasulaites</u>) <u>serpentiformis</u> Getty, nov.

(All measurements in millimeters.)

<u>L162 Holotype</u>

D	H	W	U	Ribs/Whorl
46.0	13.0	13.7	21.4	24
49.5	14.0	14.6	23.5	24
54.0	15.2	16.3	26.8	25
61.0	16.0	18.5	29.7	25
65.0	17.0	20.0	32.0	27
67.2	17.3	20.2	32.7	-
70.0	18.0	21.0	35.5	29
76.4	22.5	23.7	38.6	32

<u>L132</u>

D	H	W	U	Ribs/Whorl
8.2	2.4	3.5	-	-
12.0	5.5	6.0	7.0	-
22.0	7.0	7.2	9.7	-
30.5	10.5	10.5	13.2	(23)
41.2	12.3	12.8	18.5	(24)
51.0	15.2	15.5	25.3	(29)
(53.5)	16.3	17.2	25.7	(30)

<u>L337</u>

D	H	W	U	Ribs/Whorl
5.0	2.0	3.5	2.5	-
8.9	3.5	4.7	4.0	18
13.5	4.5	6.2	5.3	(20)
19.0	6.0	7.6	8.3	(20)
24.5	8.1	9.3	11.2	22
34.2	10.4	12.0	16.2	23

L337 (cont'd.)

D	H	W	U	Ribs/Whorl
42.0	12.4	13.7	19.0	24
45.2	13.0	14.6	22.7	25
52.0	14.6	17.0	25.6	27
57.6	15.0	18.5	28.0	29
60.0	15.5	19.4	29.5	30
(63.5)	18.7	-	31.3	31
68.8	20.0	(23)	32.4	-

L9

8	2.7	3.5	4.6	26
(13)	5.1	6.0	8.6	24
17.2	7.0	7.2	-	23
26.4	10.0	10.0	11.4	23
37.3	10.4	12.5	15.4	25
48.5	14.1	16.3	22.2	26
43.7	13.2	15.0	20.0	25
50.6	14.5	16.5	23.8	26
51.7	15.1	18.0	24.7	28

L10

4.3	1.8	2.5	1.7	-
5.8	2.3	3.0	2.5	(18)
9.6	3.3	4.0	3.8	22
14.0	5.5	5.0	5.0	20
19.0	6.8	(7.0)	7.2	19
25.6	9.2	9.0	11.0	20
36.2	9.3	11.4	15.5	22
(49)	(14.0)	15.3	22.7	25

L15

D	H	W	U	Ribs/Whorl
23.3	7.8	8.5	9.8	26
31.8	10.0	10.5	14.3	24
43.1	13.0	14.2	19.6	26
(49.0)	14.1	15.5	23.2	28

L31

32.5	9.0	10.4	15.2	21 *
(40.5)	11.0	12.0	18.0	22 *
45.5	13.9	14.2	21.8	25 *
51.0	13.3	15.2	24.2	26 *

* Ribs on left side (Right side crippled)

L5

(32.5)	10.3	8.6	(16.0)	24
(41.0)	11.6	11.4	(20.0)	(25)
(49.0)	14.0	13.7	24.1	28
54.5	16.5	16.5	27.0	33

L138

(5.4)	2.0	3.0	2.0	-
7.3	2.8	3.4	3.0	-
15.3	5.0	5.0	6.5	25
21.5	7.2	7.0	9.6	23
30.5	9.3	8.0	13.2	23
40.0	11.0	10.8	19.0	24
51.5	14.7	15.1	25.6	25

c) Parameters of Sulaites sp. juv.

(All measurements in millimeters.)

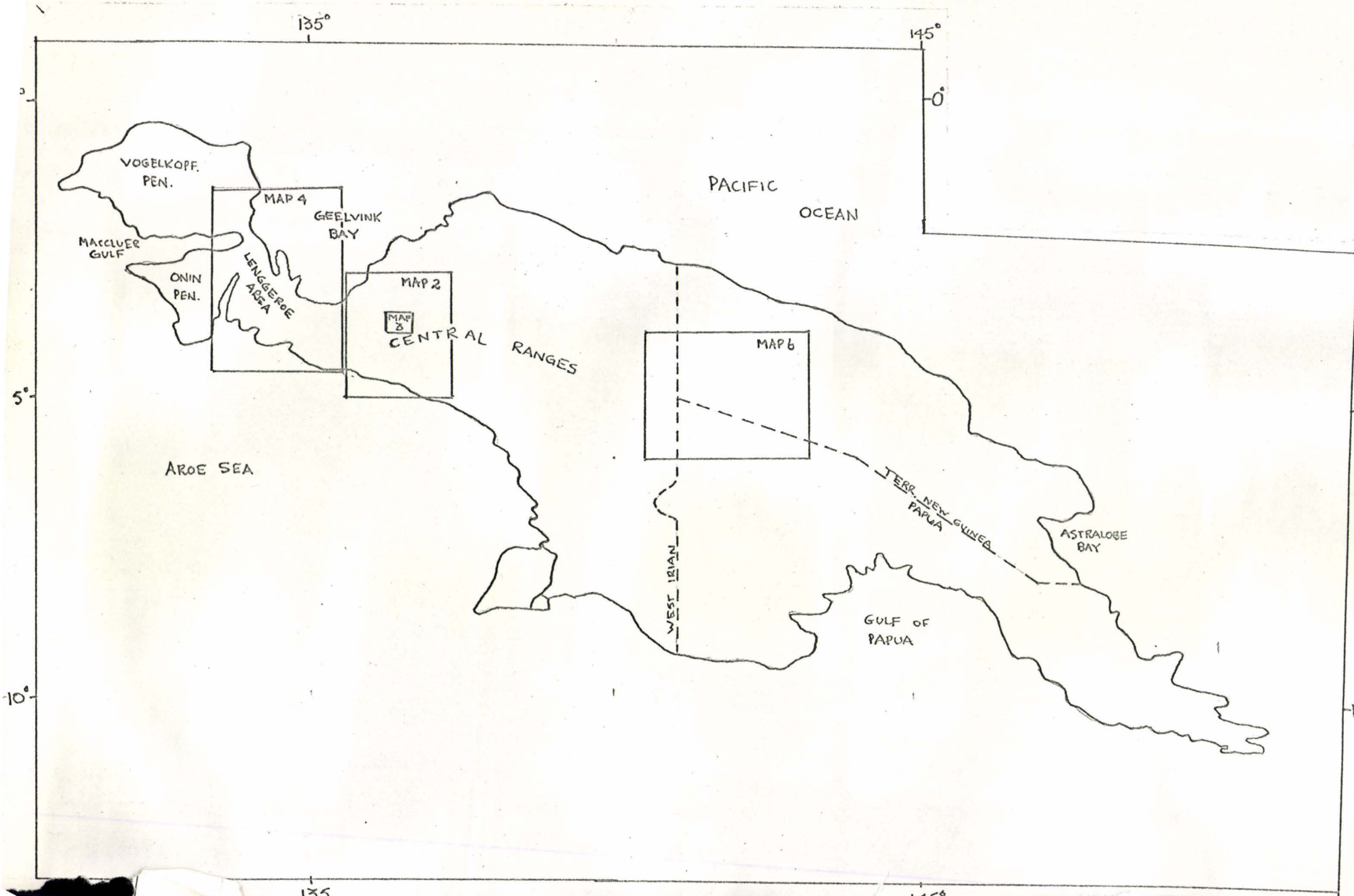
	D	H	W	U	Ribs/Whorl
L107	-	-	-	-	-
	25.0	9.2	10.0	9.3	-
	28.1	9.6	11.4	10.5	-
L235					
	(23.0)	8.2	11.0	10.0	24
	32.7	11.1	14.3	13.2	24
	40.0	13.0	15.4	16.9	27

TABLE

STRATIGRAPHIC DISTRIBUTION OF THE FAUNA.

GENUS	Nº OF SPECS.	"LIAS" L	"LIAS" M	"LIAS" U	AAL.	BAJOCIAN L* Sow.	BAJOCIAN L* Saug.	BAJOCIAN L* Humph.	BAJOCIAN U	BATHONIAN L	BATHONIAN M	BATHONIAN U	CALLOVIAN L	CALLOVIAN M	CALLOVIAN U	OXF.	KIM.	TITHONIAN L	TITHONIAN M	TITHONIAN U	BERR.	VALANG. L	VALANG. U
Olcostephanus s.l.	1																						—
Blanfordiceras	5																			—	—		
Himalayites	1																			—	-?-		
Cobbanites	1											-?	—										
Subkossmatia	2													—									
Eucycloceras	1												—										
? Macrocephalites	1												—										
B.(Treptoceras)	6?										—	—	—										
Bullatimorphites	10?									—	—	—	—										
Stephanoceras s.l.	4?						—	—															
Docidoceras	1					—																	
Fontannesia	9					—																	
Sulaites	37+	?																					

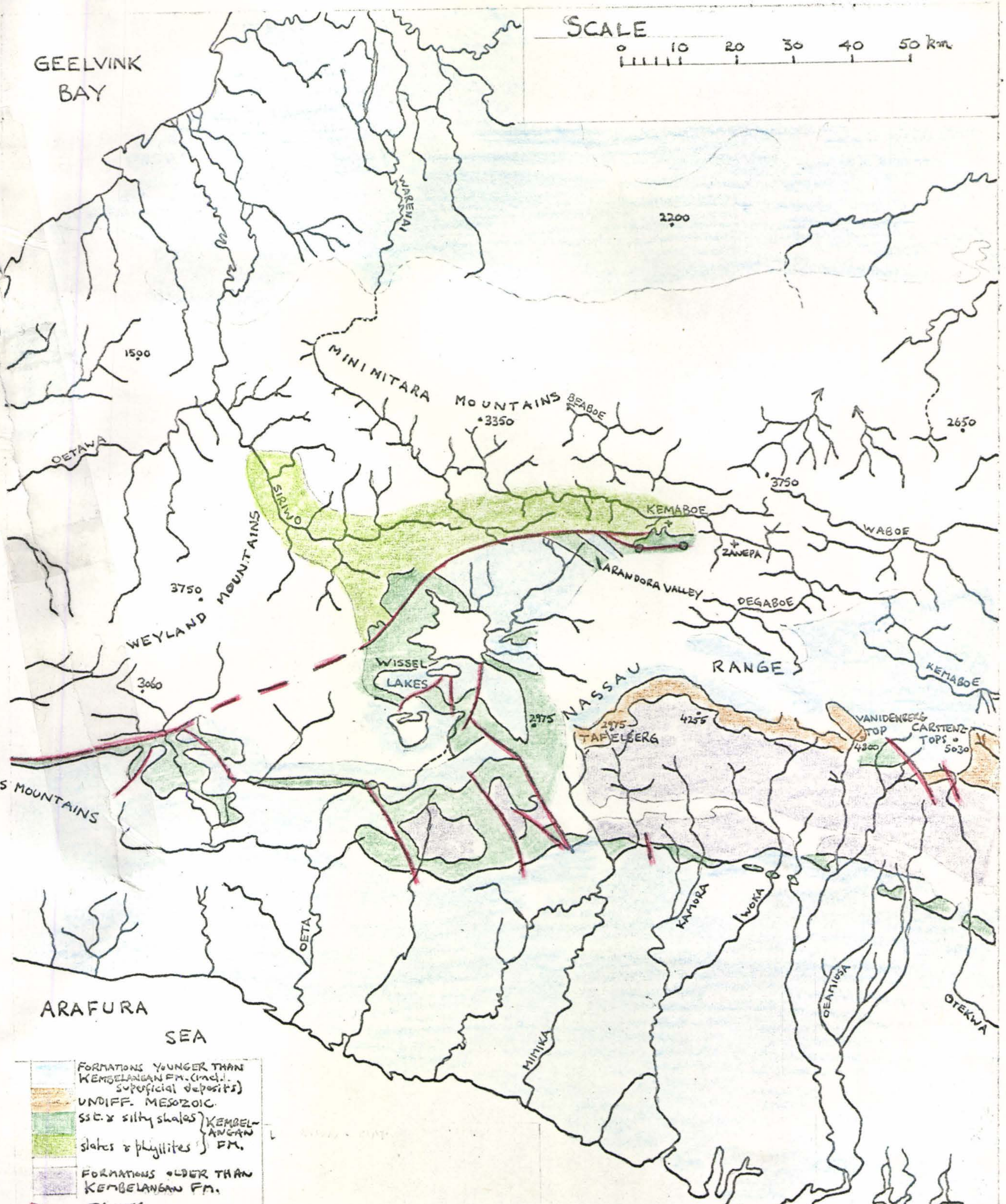
* CORRESPONDS TO THE 'MIDDLE BAJOCIAN' OF ARKELL, 1956.


135°
145°
0°
5°
10°
VOGELKOPF. PEN.
MAP 4
GEELVINK BAY
MACCLUER GULF
ONIN PEN.
LENGGEROE AREA
MAP 2
MAP 3
CENTRAL RANGES
PACIFIC OCEAN
MAP 6
AROE SEA
WEST IRIAN
TERR. NEW GUINEA
PAPUA
ASTRALOBE BAY
GULF OF PAPUA
135
145°

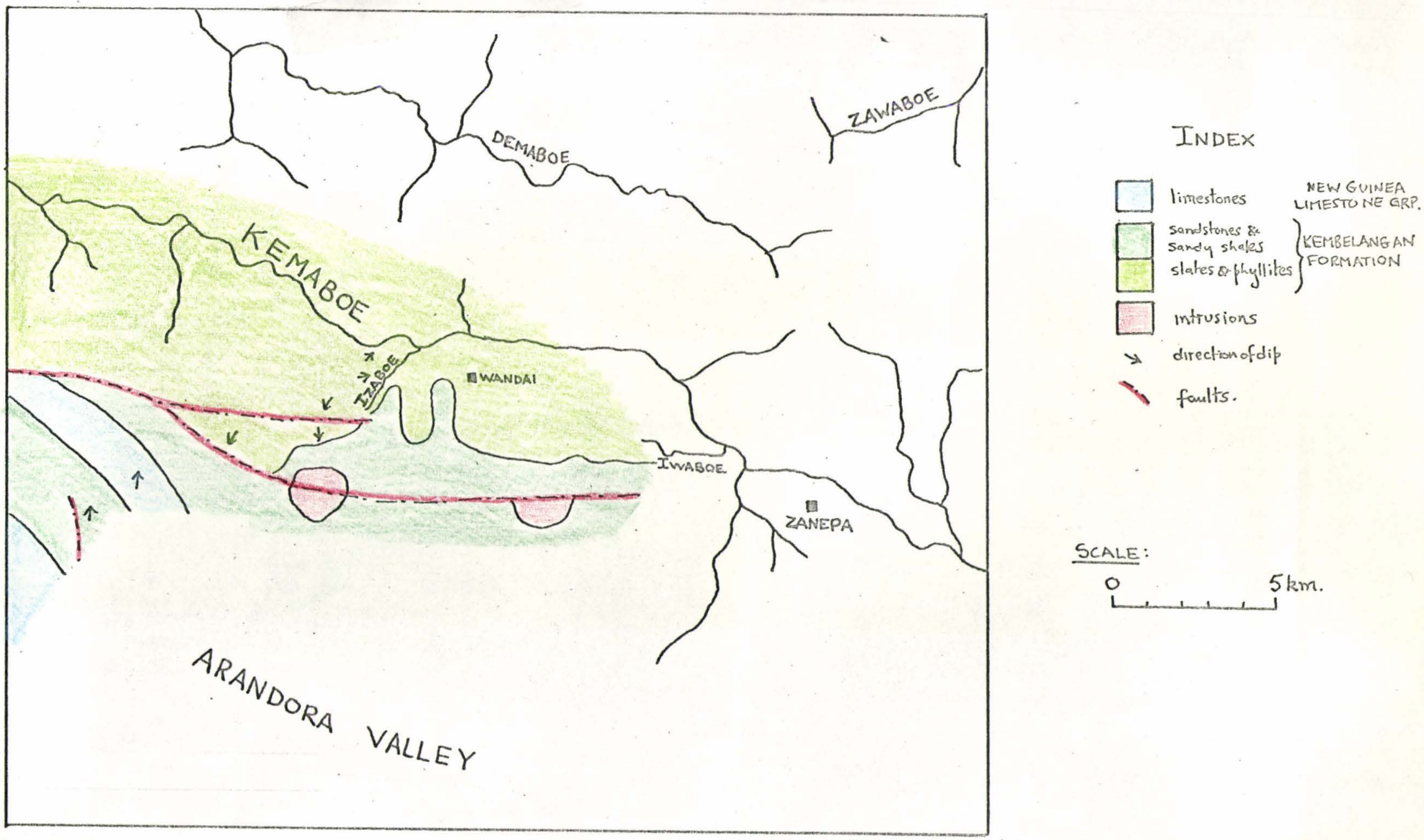
MAP 1.

GEOLOGICAL MAP OF THE WESTERN PART OF CENTRAL NEW GUINEA

(AFTER VISSER & HERMES, 1962). MAP 2.

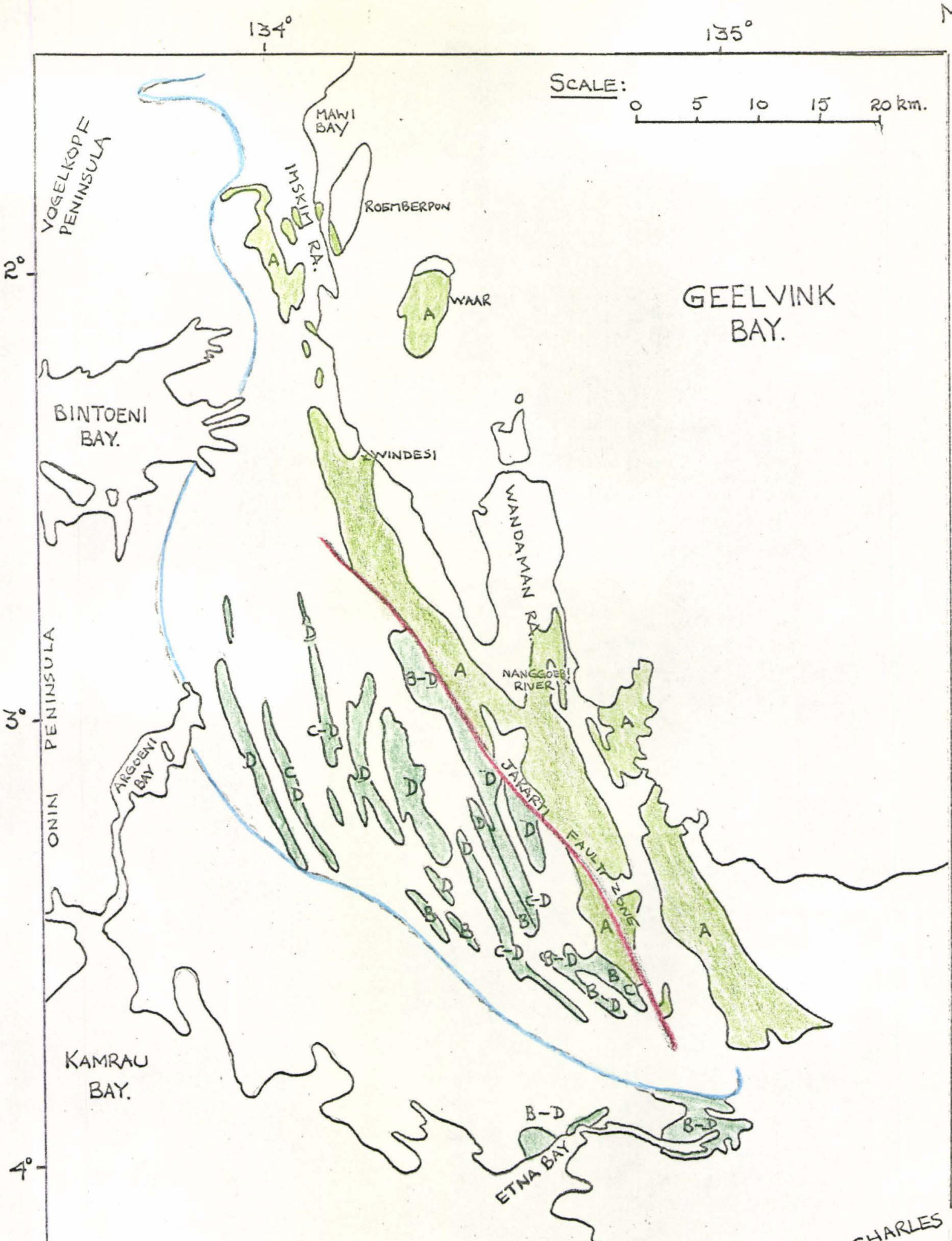


GEOLOGICAL MAP OF THE KEMABOE VALLEY.



MAP 3.

MAP 4.



INDEX.

Arenaceous facies } Kembelangan Formation (letters denote members: see Fig. 2–4)

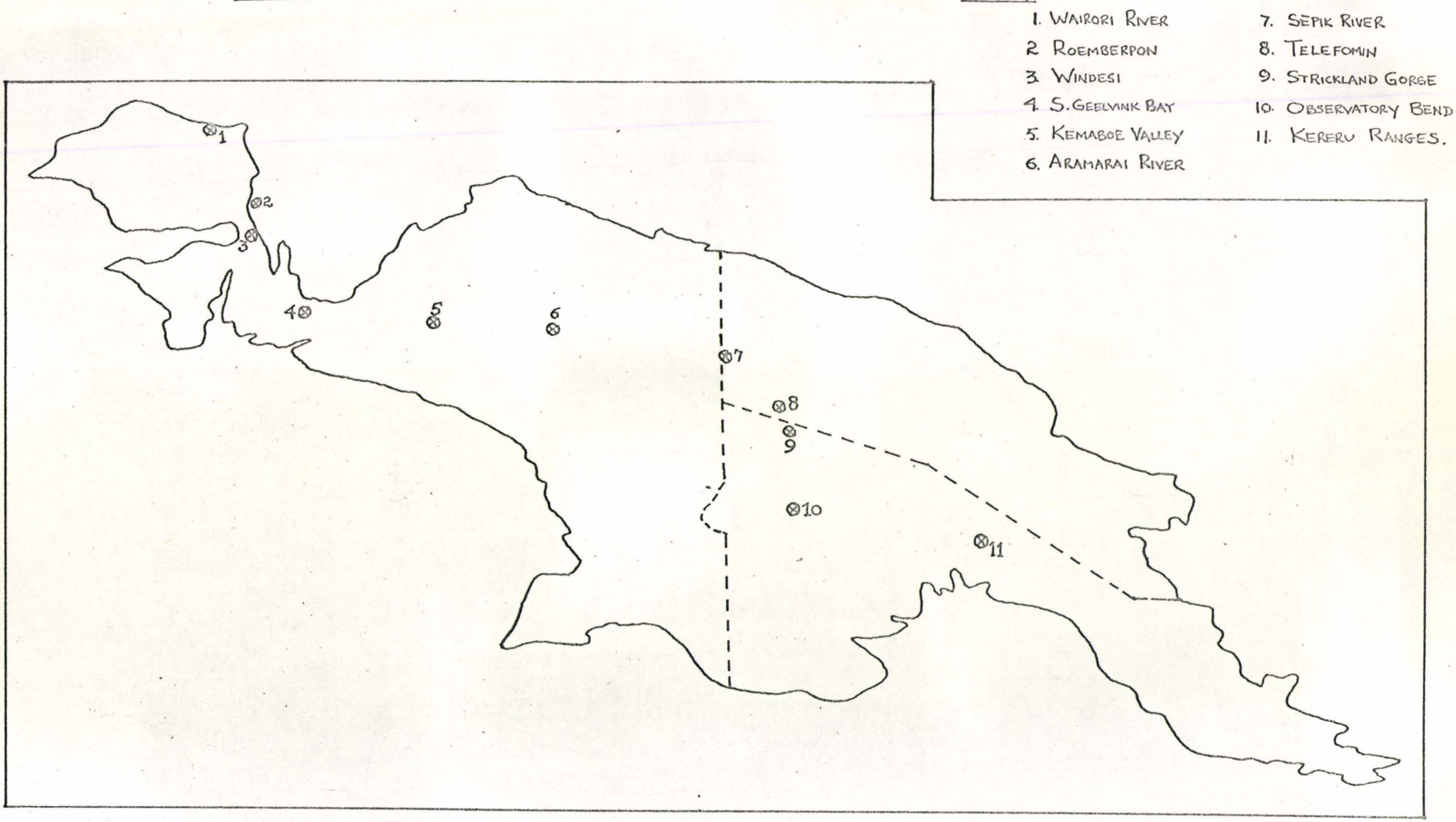
Argillaceous facies

Eastern limit of Imskim Formation

Faults.

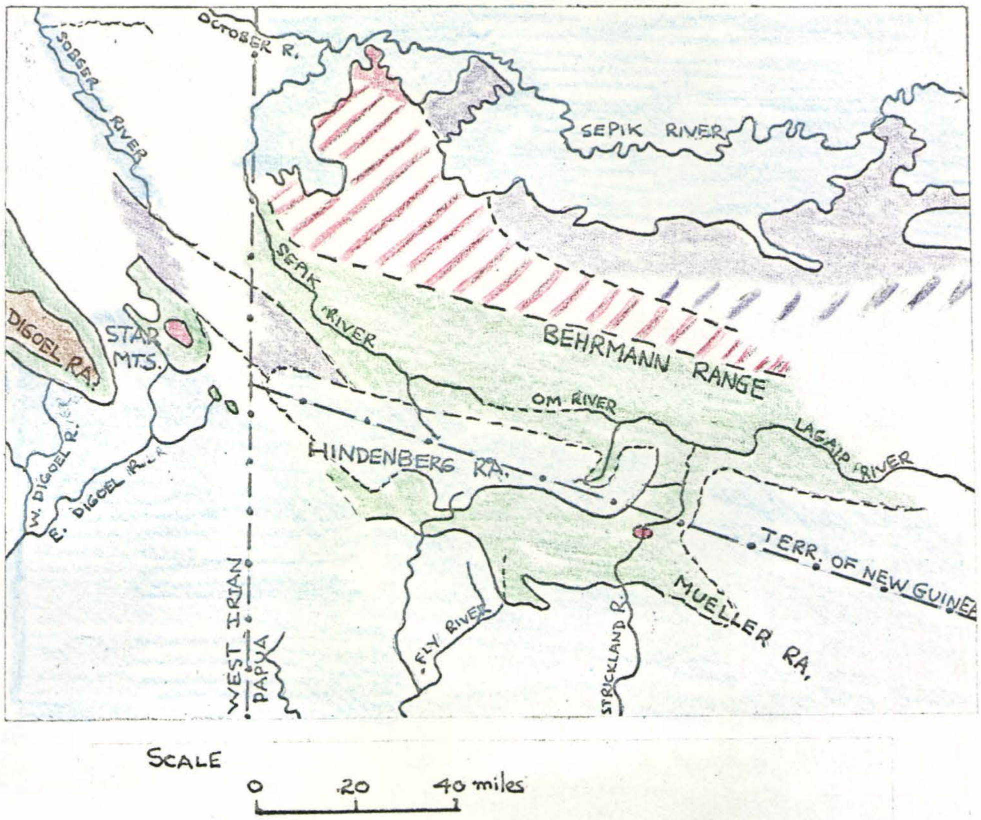
... LOCALITIES

IN NEW GUINEA.



MAP 5.

MAP 6.



POST-MESOZOIC ROCKS

MESOZOIC ROCKS

PRE-MESOZOIC SEDIMENTS

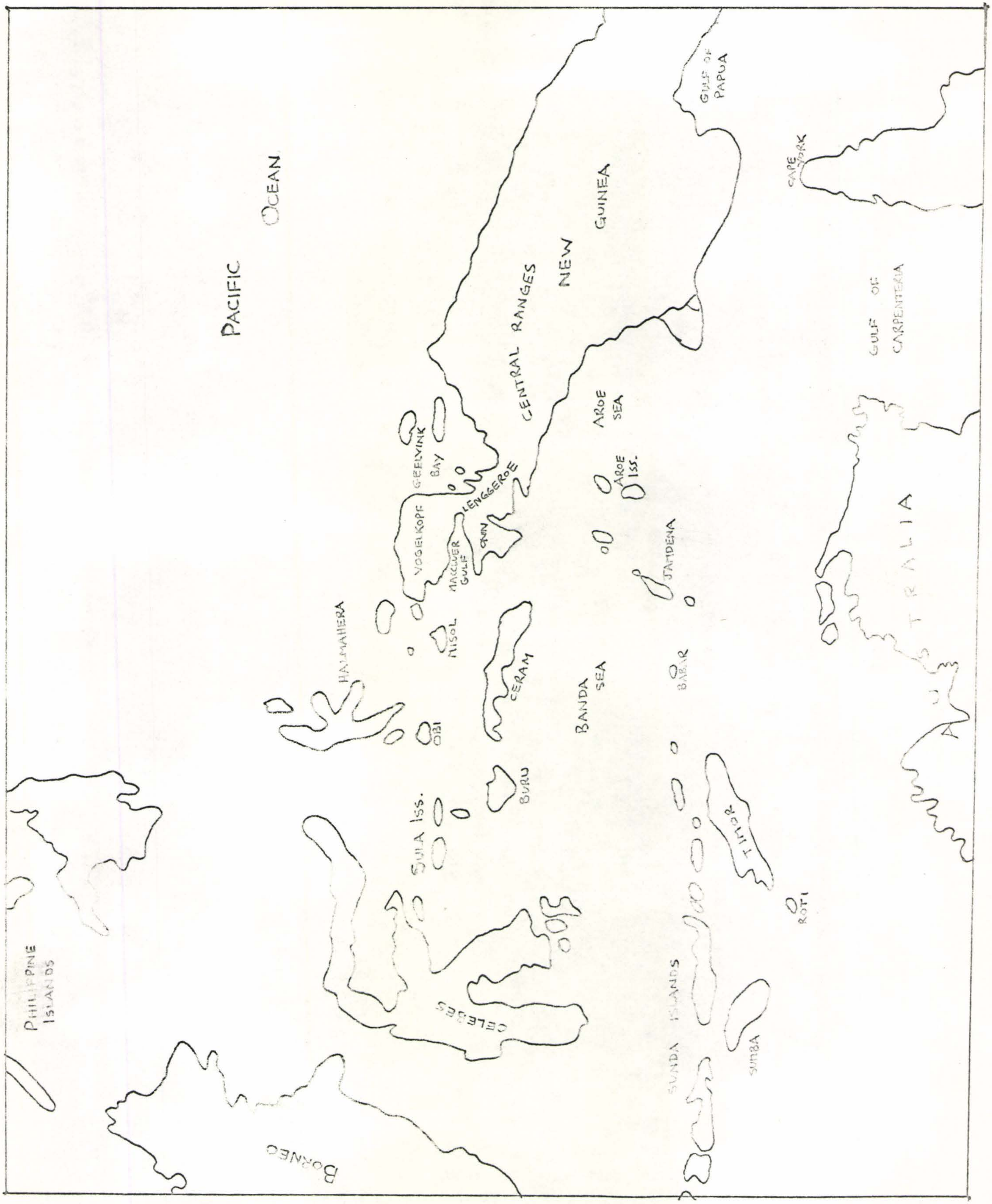
IGNEOUS ROCKS OF UNCERTAIN AGE (IN PART, PRE-MESOZOIC)

METAMORPHIC ROCKS " " "

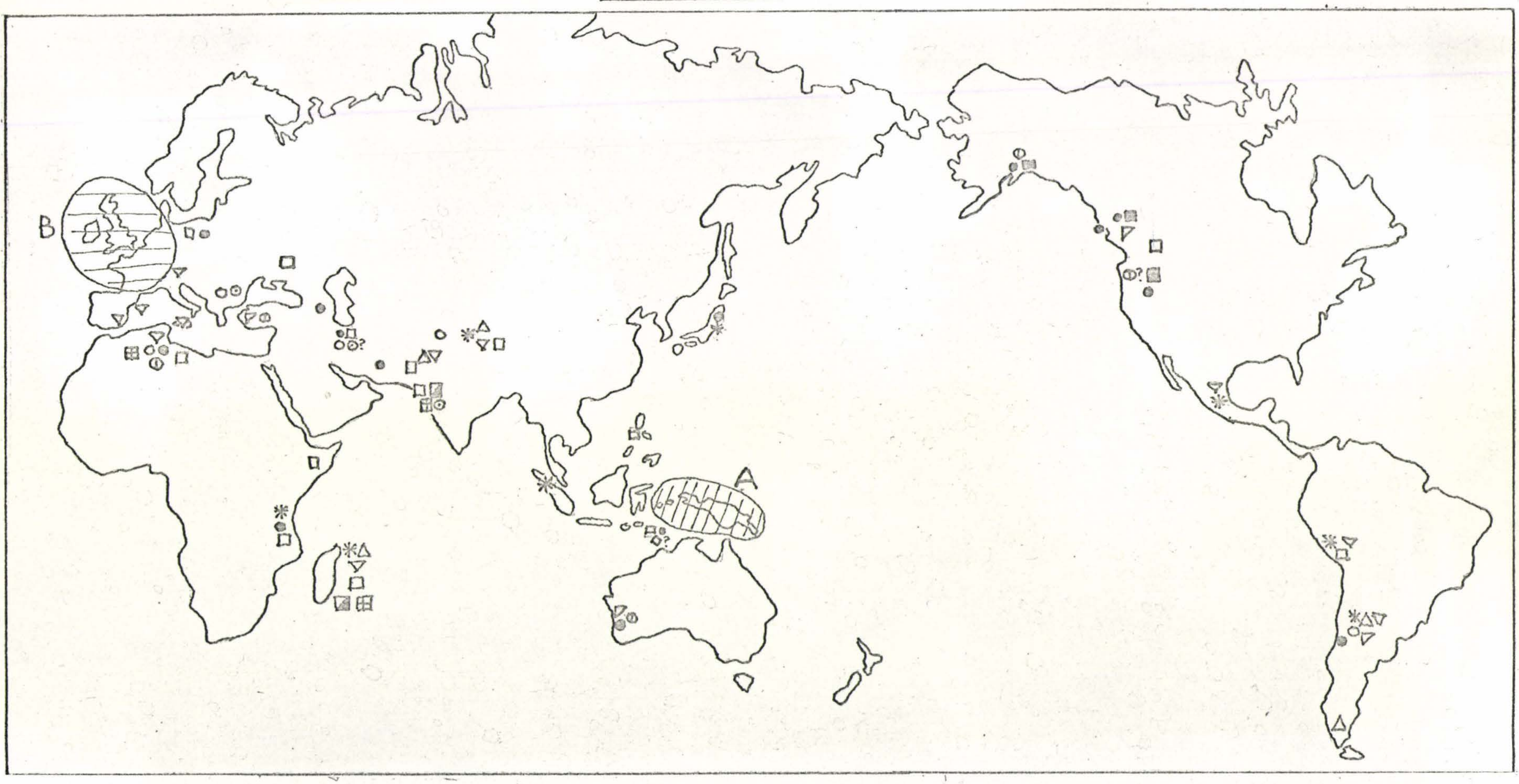
BLANK AREAS UNMAPPED.

INTERNATIONAL BOUNDARY.

EASTERN INDONESIA.



GEOGRAPHICAL DISTRIBUTION OF THE FAUNA.



✱ Olcostephanus
△ Blanfordiceras
▽ Himalayites
▩ Cobbanites
⦶ Docidoceras
● Stephanoceras s.l.
○ Bullatimorphites.
⊙ B. (Treptoceras)
◸ Fontannesia
□ Macrocephalites s.l.
▨ Subkossmatia
⊞ Eucycloceras

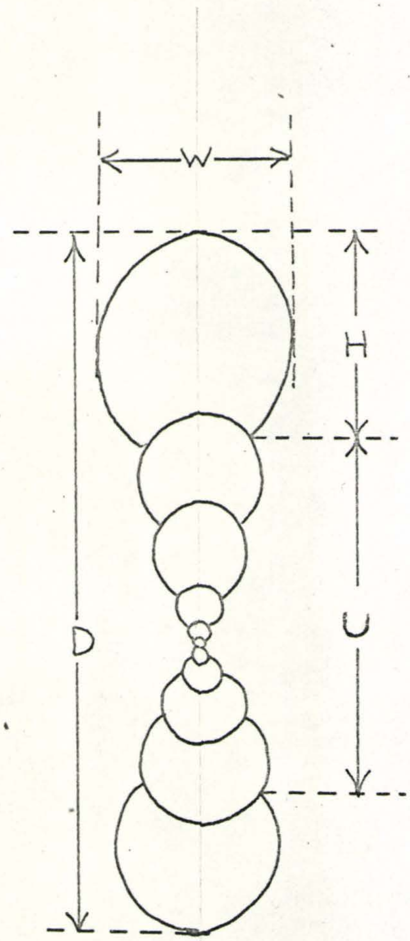
◇ Sulaites

A — NEW GUINEA – SULA ISS. All genera represented.

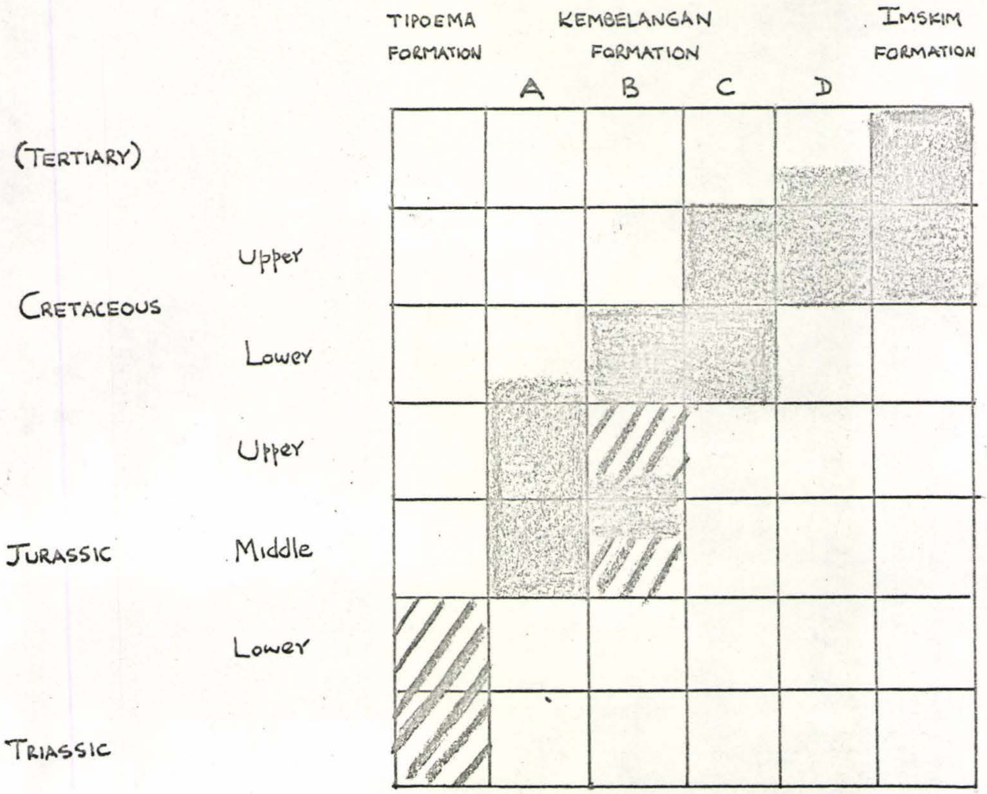
B — N.W. EUROPEAN AREA. Olcostephanus, Docidoceras, Stephanoceras s.l., Bullatimorphites, B. (Treptoceras), Fontannesia, Macrocephalites s.l. are represented.

MAP 8.

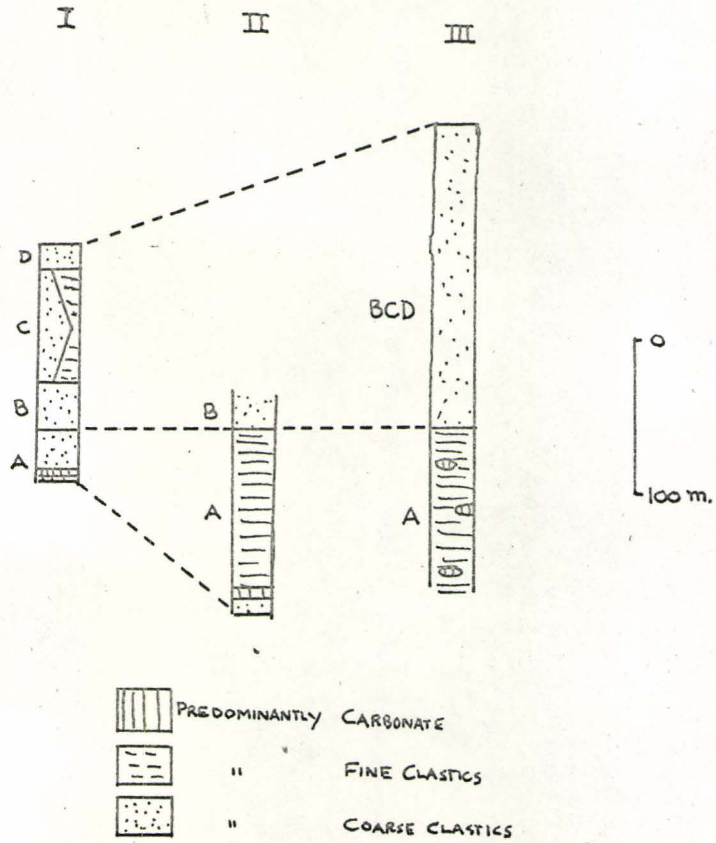
DIAGRAMMATIC CROSS-SECTION OF AN AMMONITE TO SHOW THE PAPAMETERS MEASURED.



AGE RELATIONS OF THE MESOZOIC FORMATIONS OF WEST IRIAN (WEST NEW GUINEA).
(DATA FROM VISSER & HERMES (1962)).



LATERAL VARIATION IN THE KEMBELANGAN FORMATION.

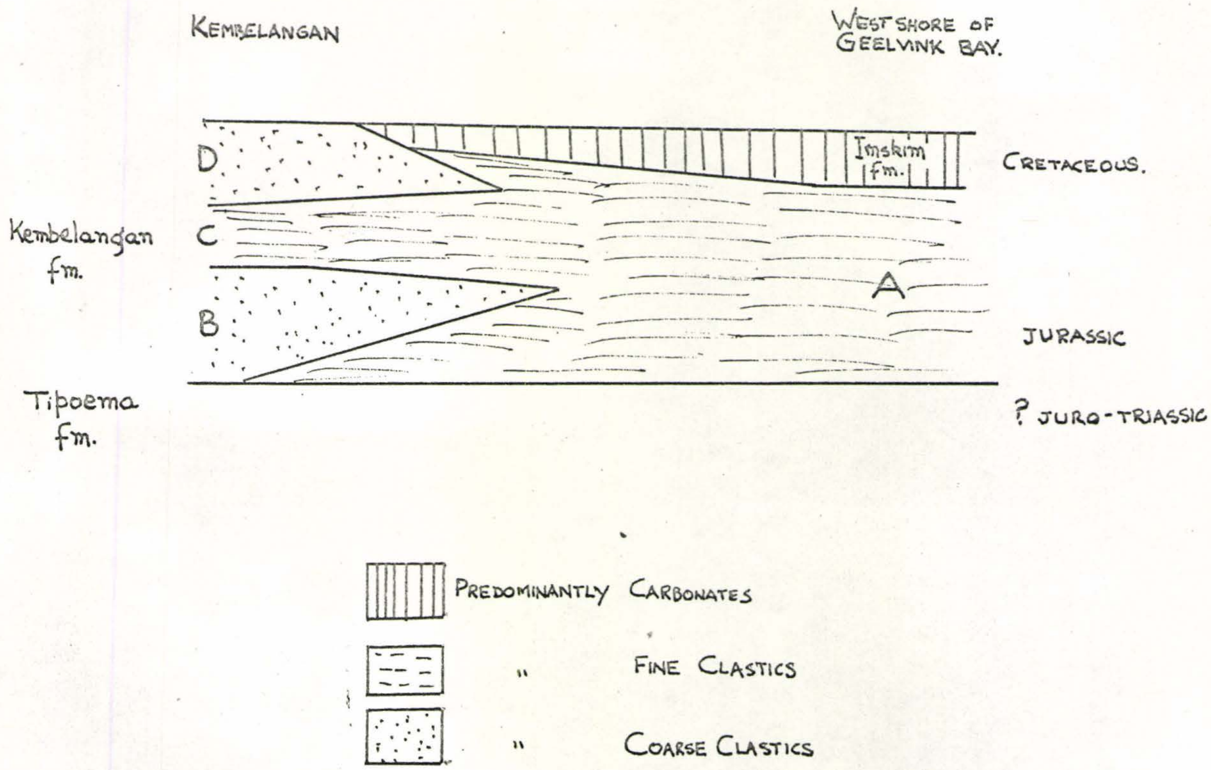


I. Well Kembelangan N° 1

II. Nanggoebi River.

III. North of the Wissel Lakes.

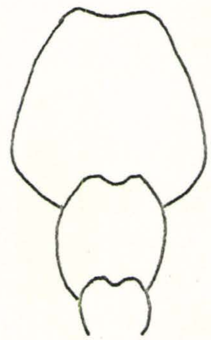
DIAGRAMMATIC STRATIGRAPHIC SECTION OF THE KEMBELANGAN FORMATION ON THE WEST SIDE OF GEELVINK BAY.
(AFTER VISSER & HERMES, 1962).



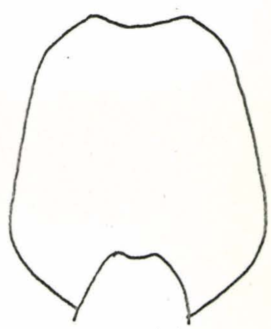
(After Visser & Hermes, 1962.)

Blanfordiceras wallichi (Gray)

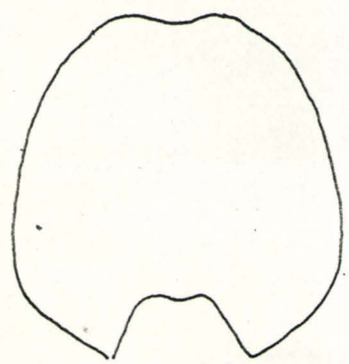
WHORL-SECTIONS.



(i) L73



(ii) var 'c'.
(Uhlig 1904-10; pl. 30, fig. 1)

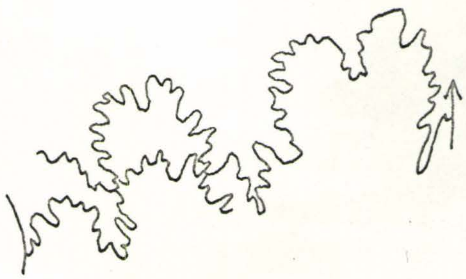


(iii) var 'b'
(Uhlig 1904-10; pl. 31, fig. 1)

Blanfordiceras wallichi (Gray)

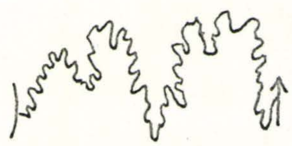
SEPTAL SUTURES.

a. L73

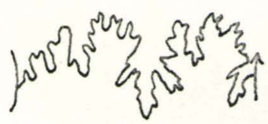


×3.

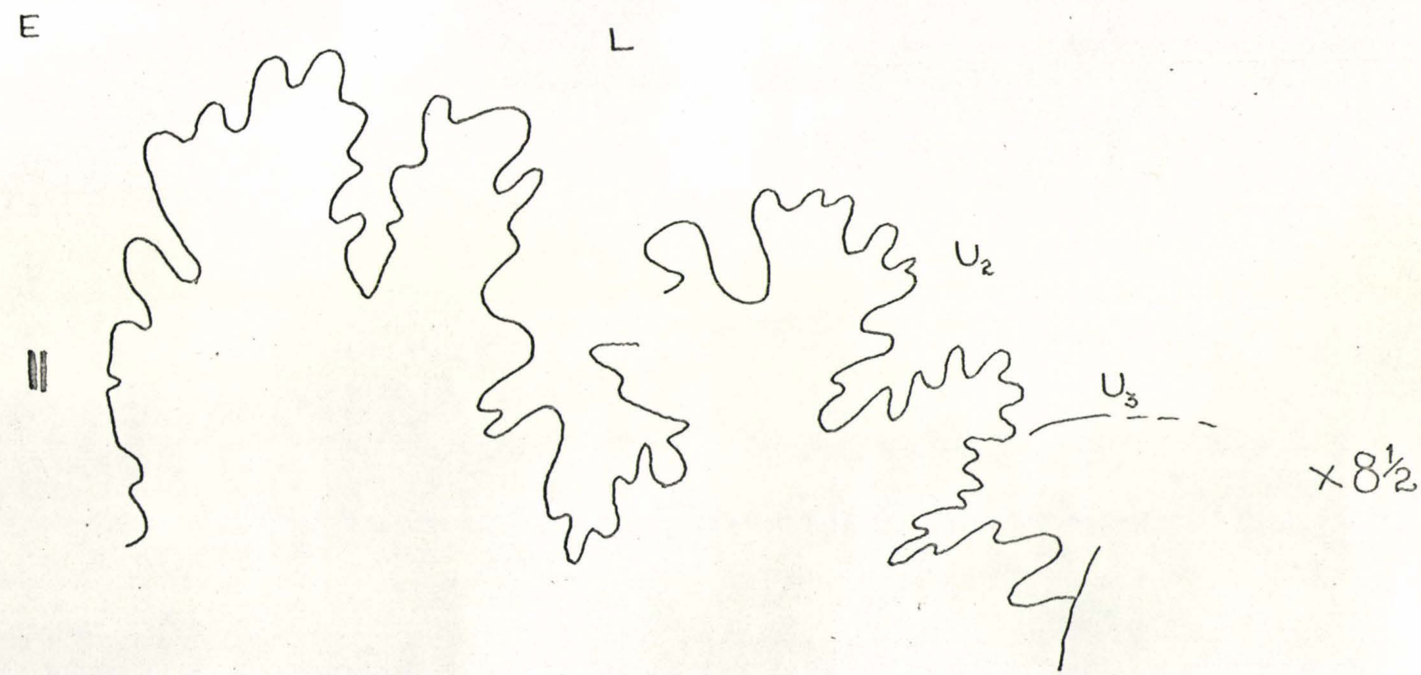
b. Uhlig, 1905.



c. Boehm, 1904.

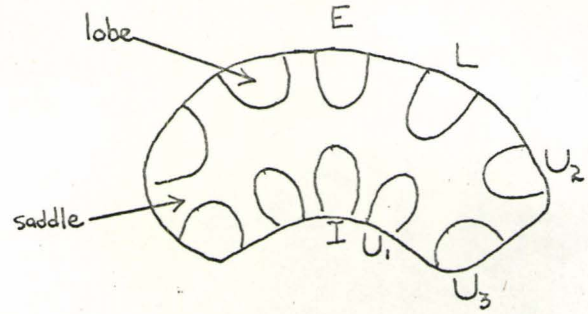


(?) Cobbanites aff. C. engleri (Frebold)
(L37) SEPTAL SUTURE.



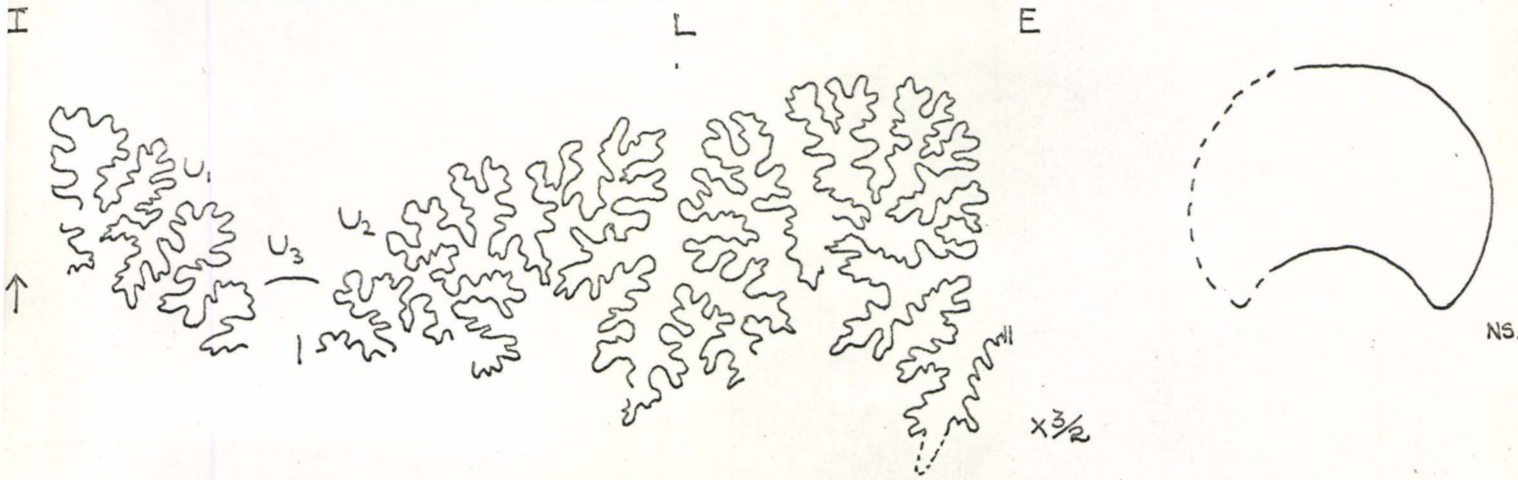
Docidoceras aff. D. longalvum (Vacek).

SEPTAL SURFACE.



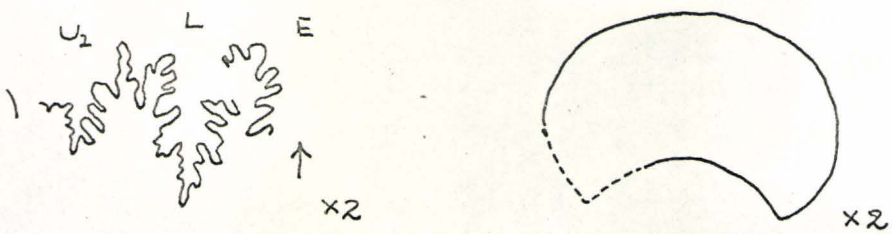
a. Stephanoceras (Stephanoceras) aff. S. skidegatense (Whiteaves)

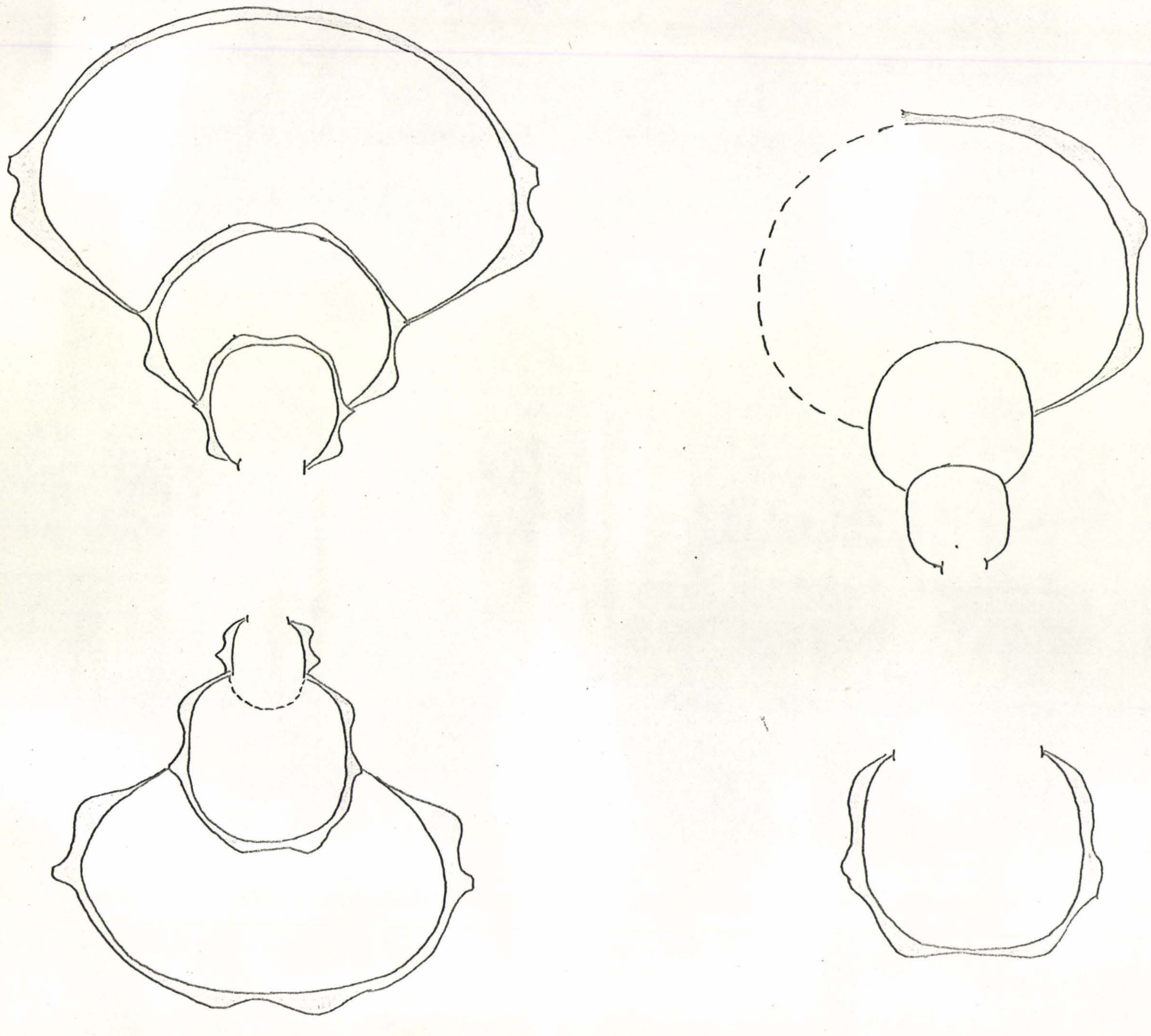
SEPTAL SUPURE AND WHORL SECTION.



b. Cadomites aff. C. deslongchampsi (McMASTER COLL. J35)

SEPTAL SUTURE AND WHORL SECTION



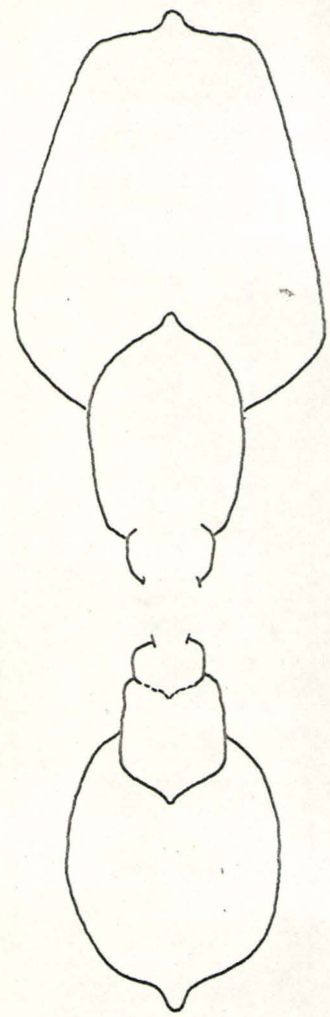


b. L49.

FIG.

Fig.

Fontannesia aff. F. grammoceroides (Haug).
(L186). WHORL SECTION.

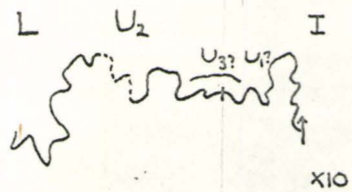


x 2

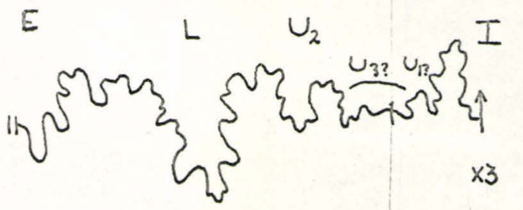
Fontanesia aff. F. luculenta Buckman.

(L165) SEPTAL SUTURES. AND WHORL SECTIONS.

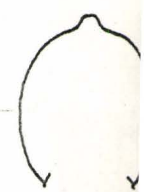
a. H = 5.0 mm.



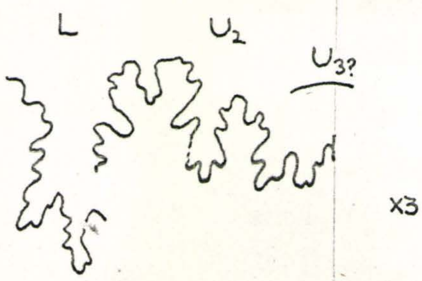
b. H = 12.0 mm.



Reversed for comparison.



c. H = c. 50 mm.



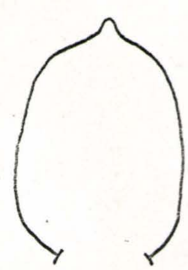
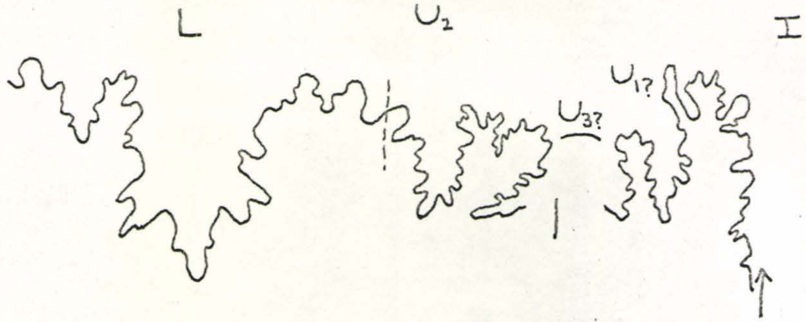


FIG.

<u>Sulaites</u> (<u>Sulaites</u>) <u>pinguis</u> Getty.

a. SEPTAL SUTURE.

H = c. 25 mm.



b. WHORL-SECTION.

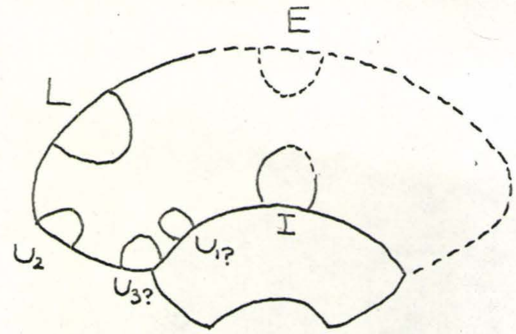


FIG. 14.

SCATTER DIAGRAM, WHORL HEIGHT (H) VS. WHORL WIDTH (W).
SULAITES (SULAITES) PINGUIS GETTY.

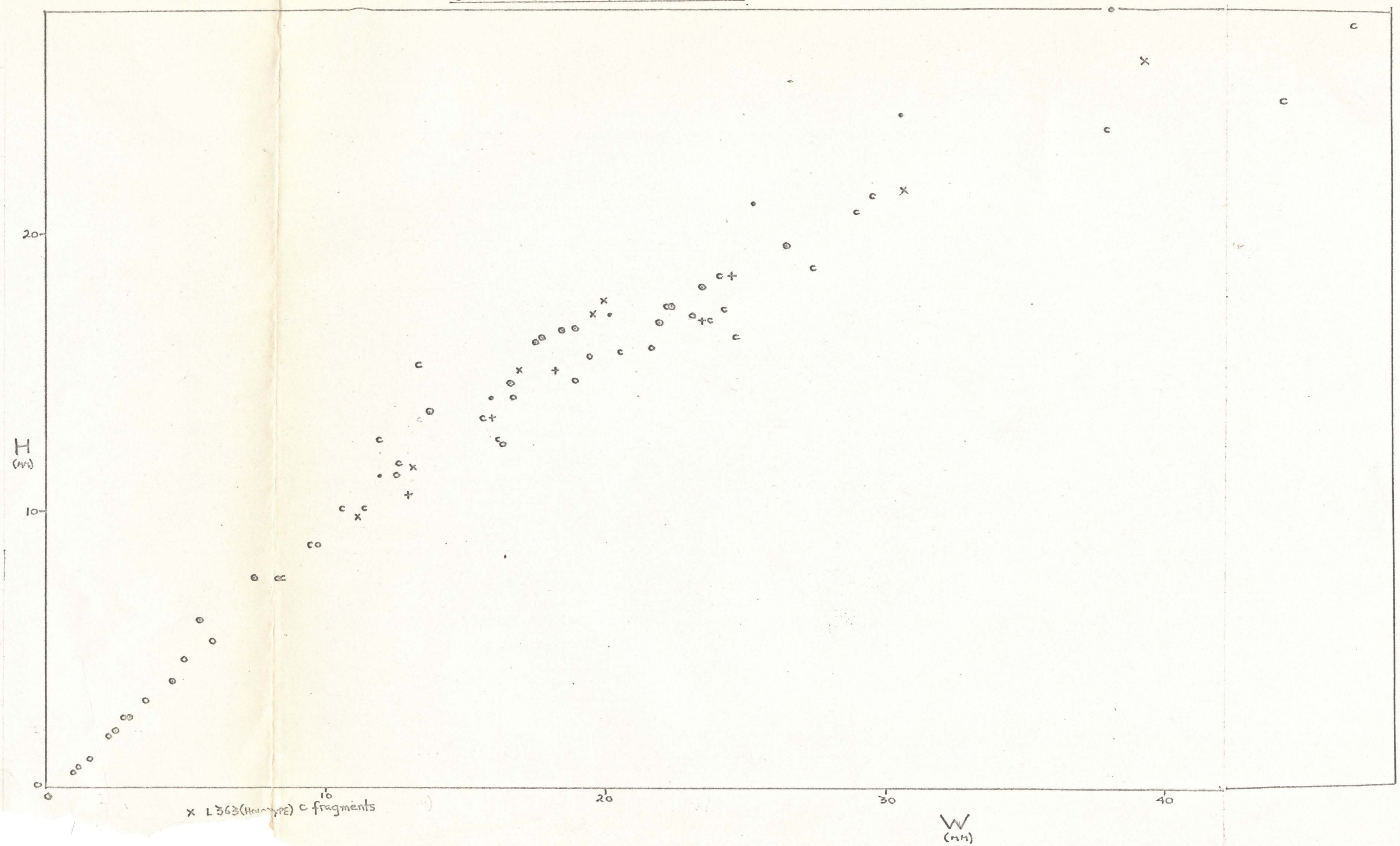
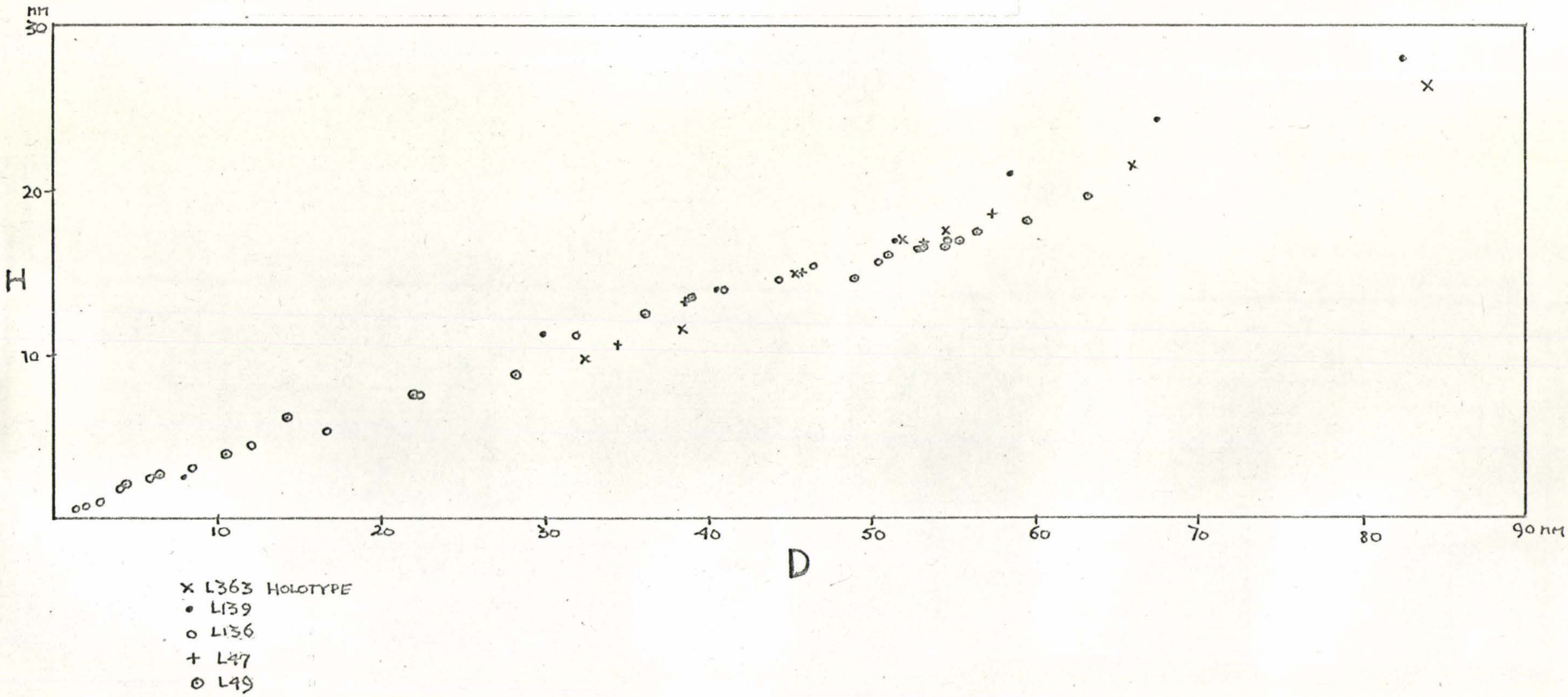
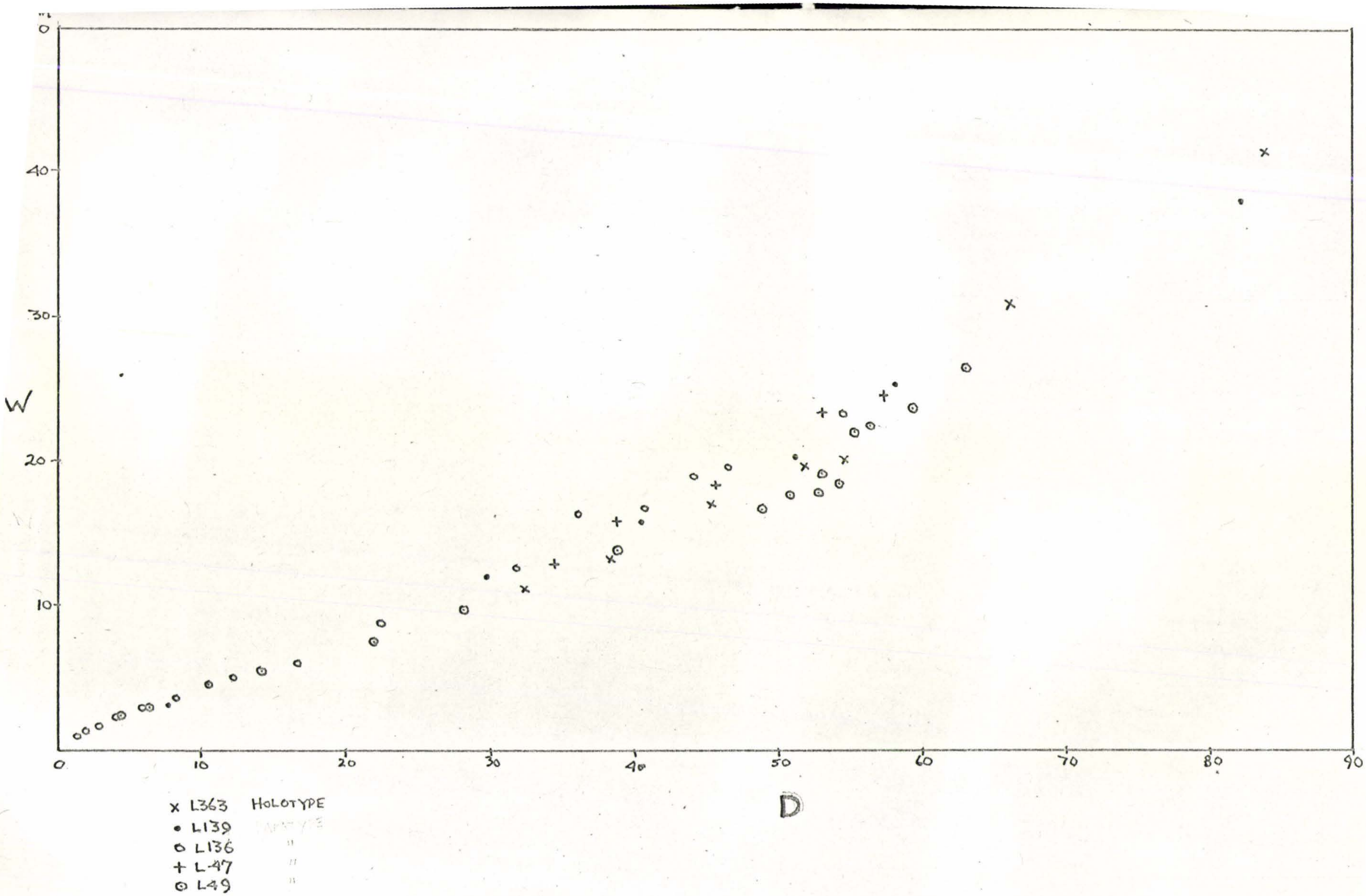


FIG. 15.

SCATTER DIAGRAM, WHORL HEIGHT (H) VS. DIAMETER (D)
SULAITES (SULAITES) PINGUIS GETTY.

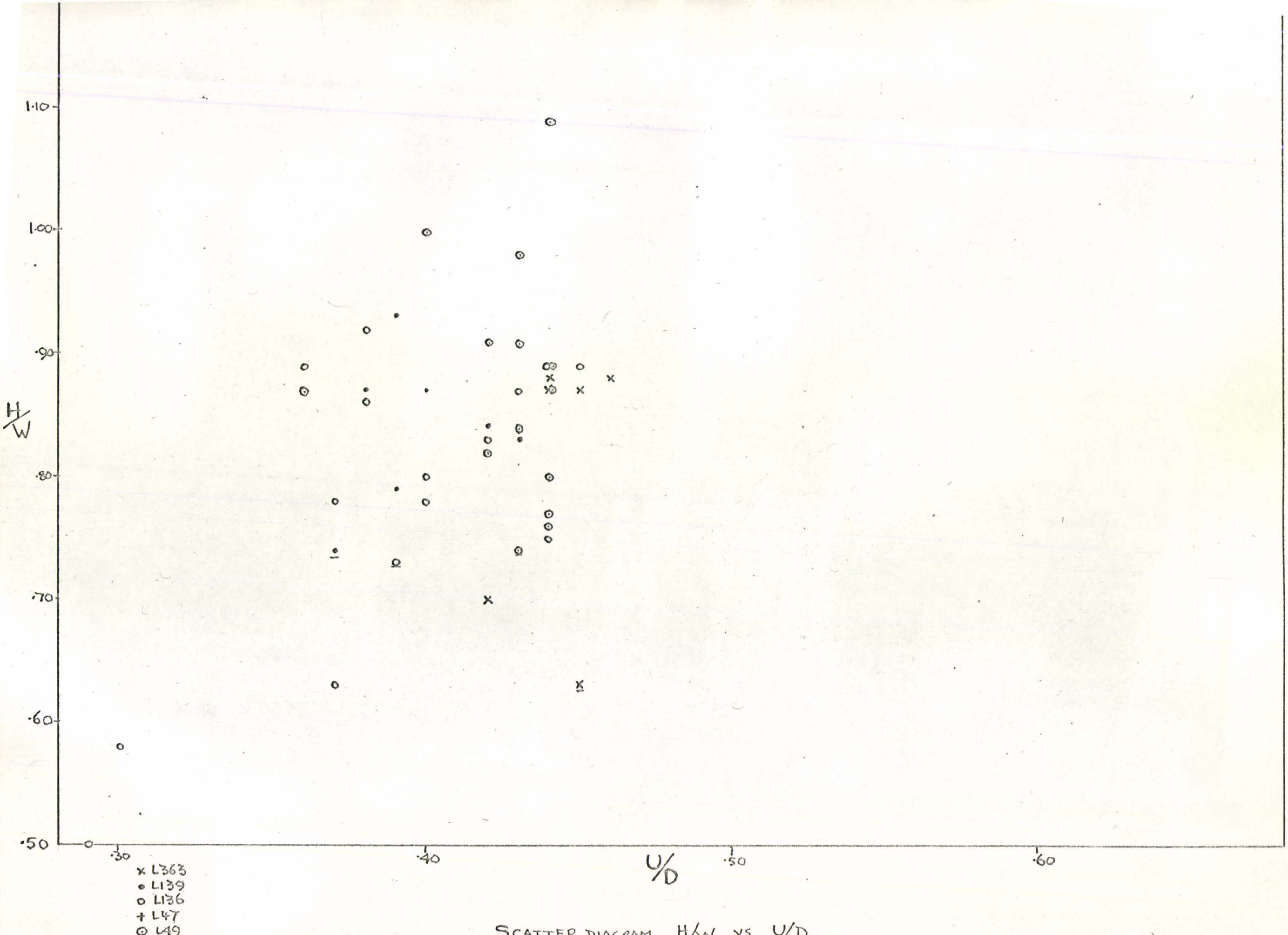




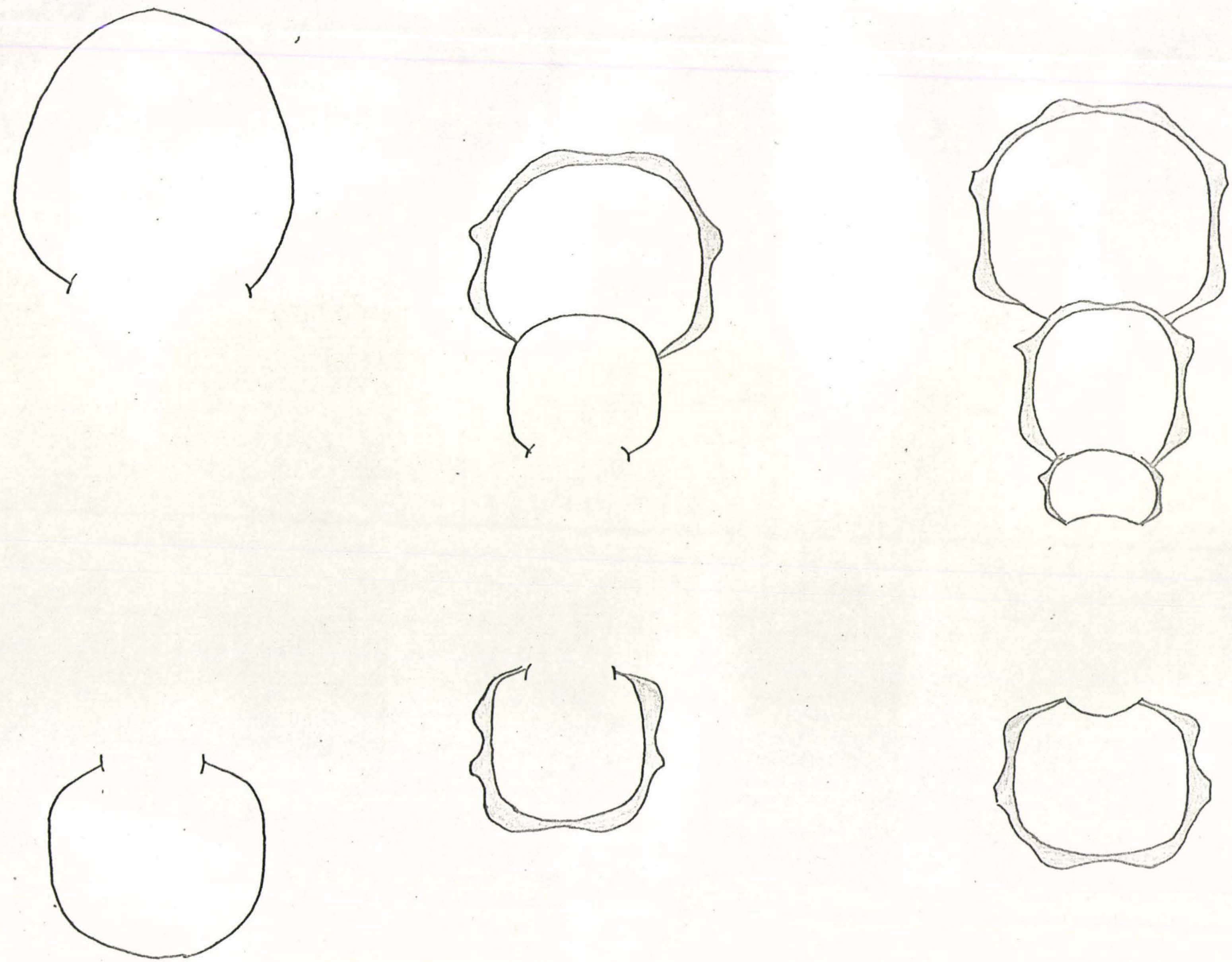
SCATTER DIAGRAM, WHORL WIDTH (W) VS. DIAMETER (D)

SULAITES (SULAITES) PINGUIS GETTY.

FIG. 16.



SCATTER DIAGRAM, H/W vs. U/D.
SULAITES (SULAITES) PINGUIS GETTY.



a. HOLOTYPE (L162)   b. L132.   c. L337.

All figures ×2

FIG. 18.

FIG. 19.

Sulaites (Parasulaites) serpentiformis Getty

SEPTAL SUTURES.

L138 H = 1.5 mm. — Reversed for comparison.

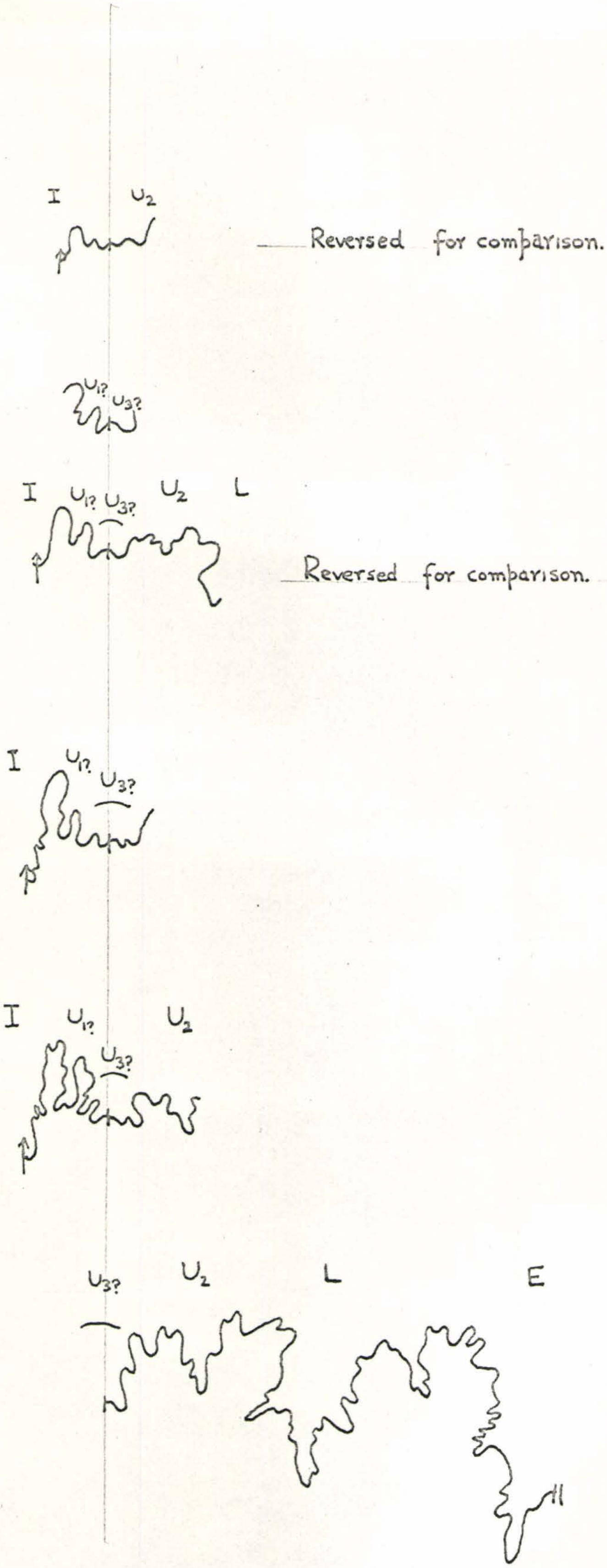
L10 H = 2.0 mm.

L153 H = 2.5 m.m. — Reversed for comparison.

L325 H = 3.5 mm.

L337 H = 5.5 mm.

.337 H = 12.0 mm.



SCATTER DIAGRAM, WHORL HEIGHT (H) VS. WHORL WIDTH (W).

SULAITES (PARASULAITES) SERPENTIFORMIS GETTY.

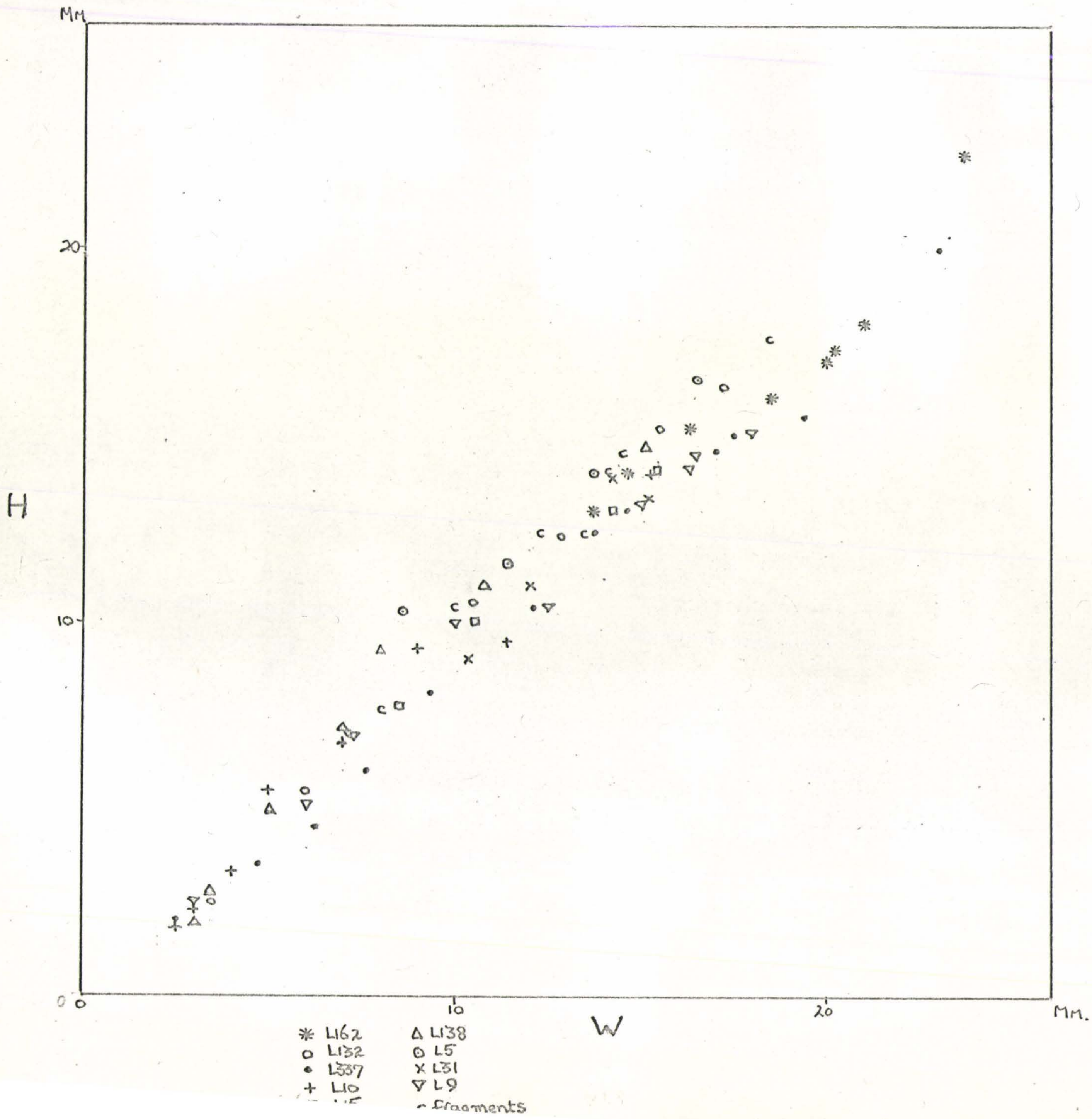


FIG. 20.

Scatter Diagram, H vs. W.

Sulaites (Sulaites) and Sulaites (Parasulaites)

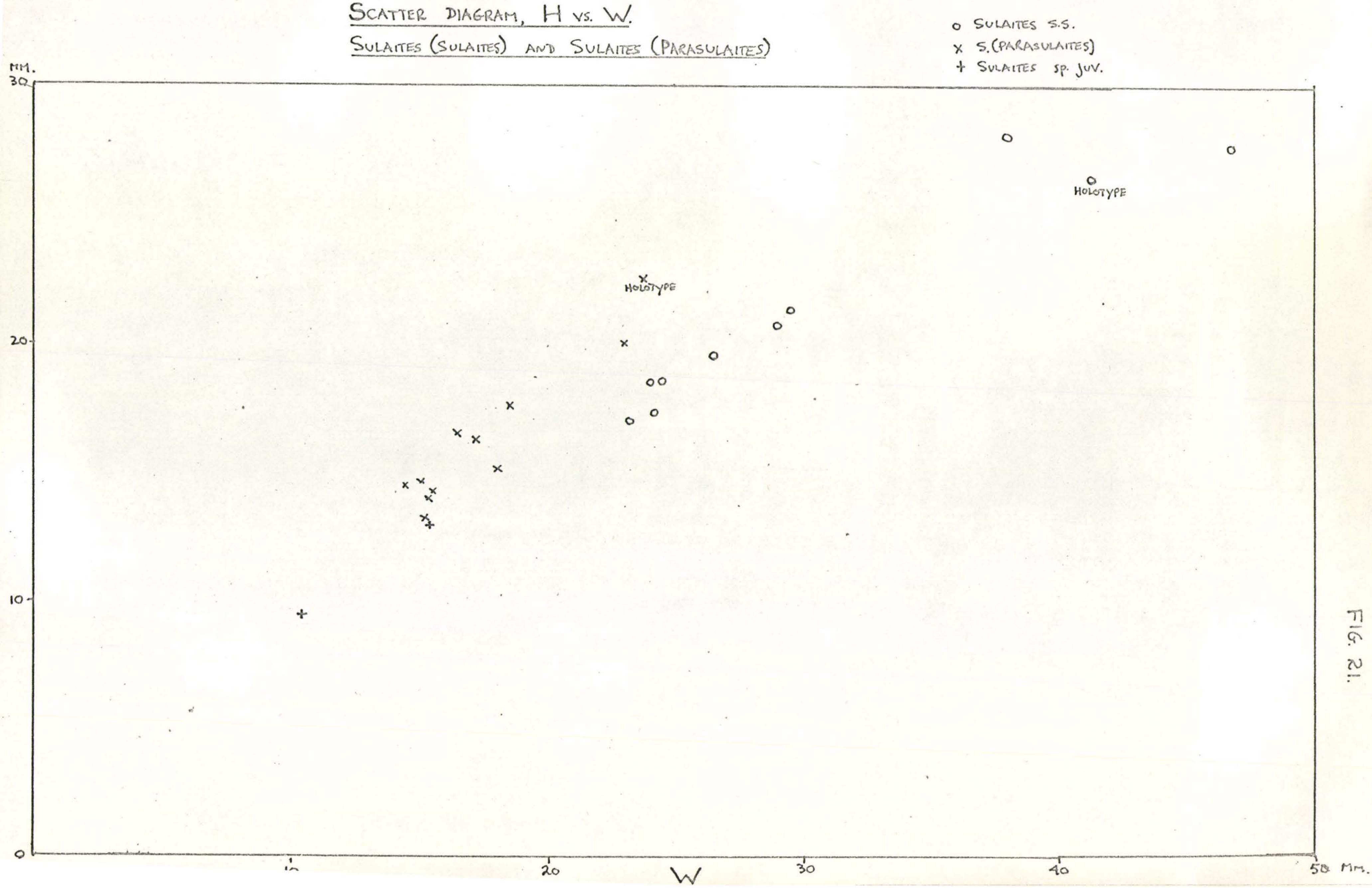
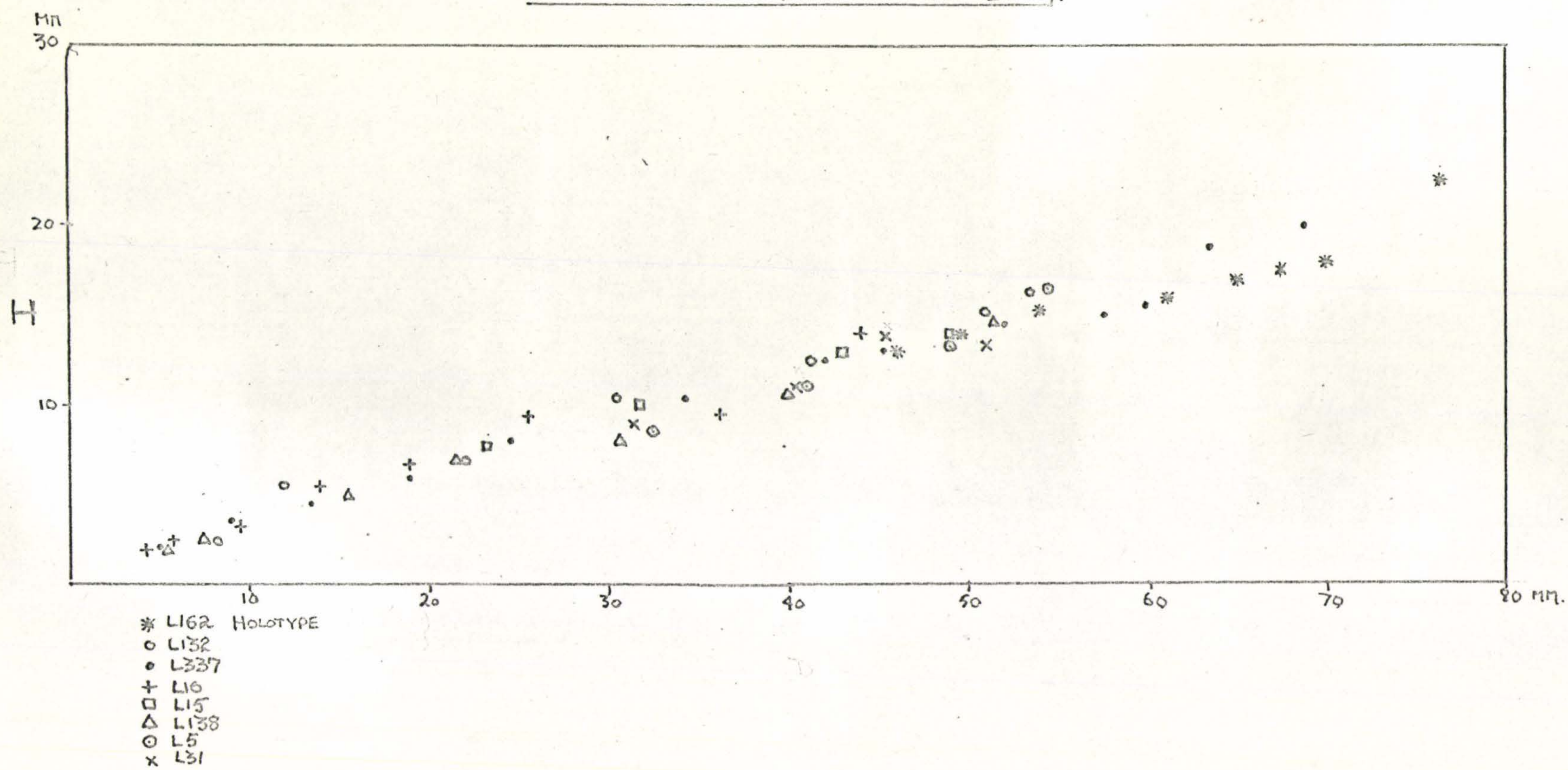


FIG. 21.

FIG. 22.

SCATTER DIAGRAM, H. vs. D

SULAITES (PARASULAITES) SERPENTIFORMIS GETTY.



Scatter Diagram, W. vs. D.

Sulaites (Parasulaites) serpentiformis Getty.

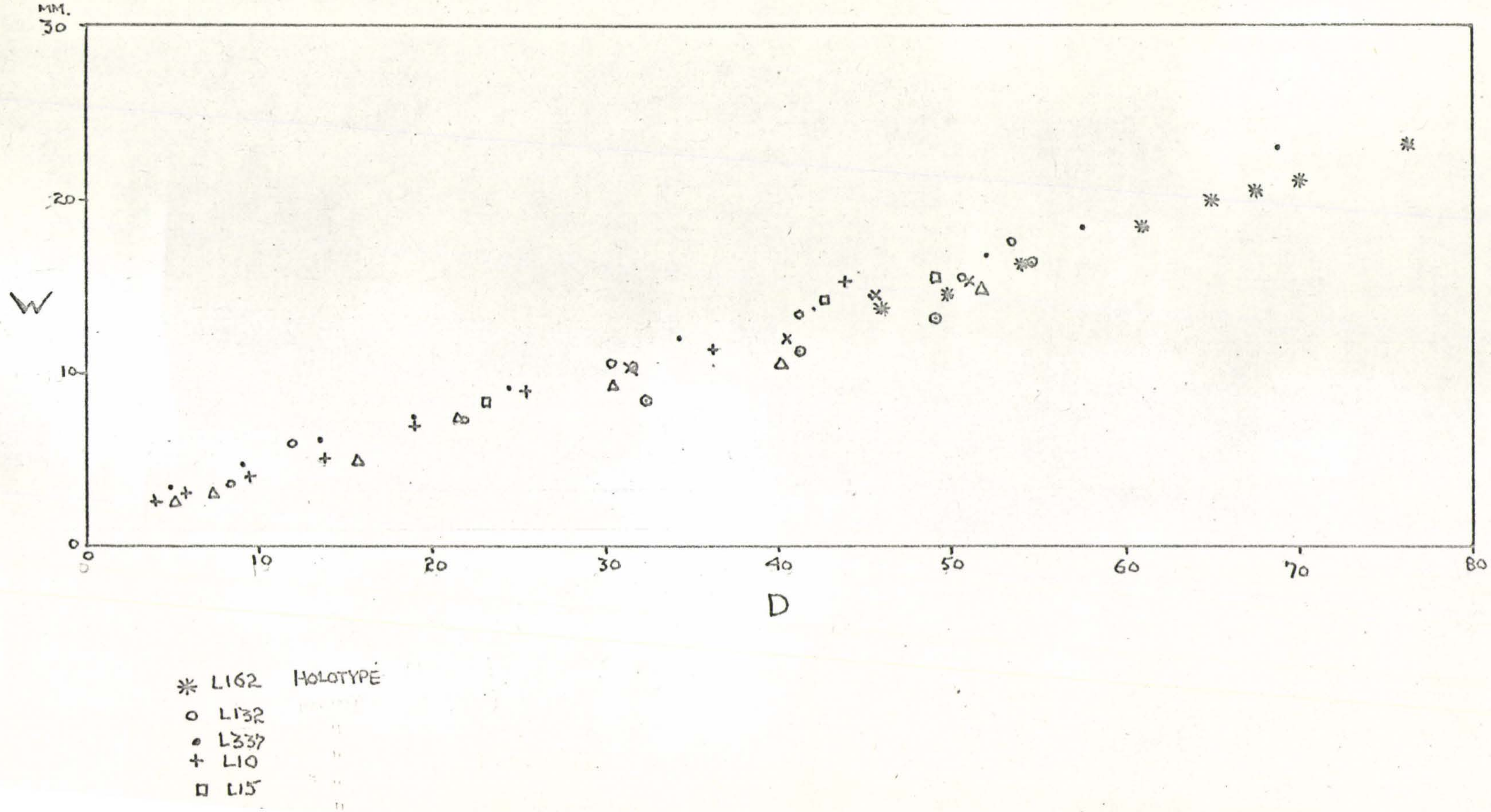


Fig 23.

SCATTER DIAGRAM, H/W vs. U/D
SULAITES (PARASULAITES) SERPENTIFORMIS GETTY

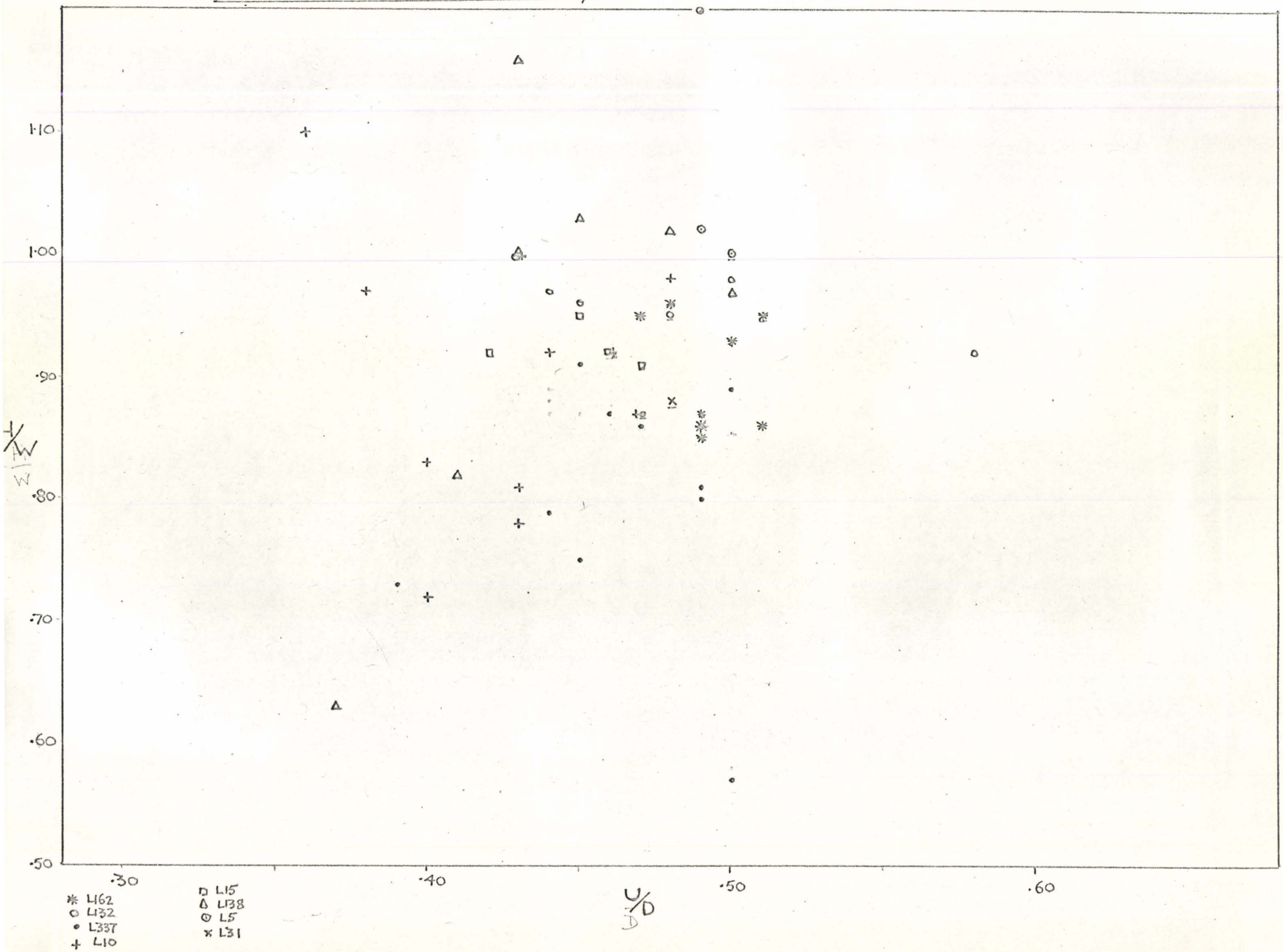
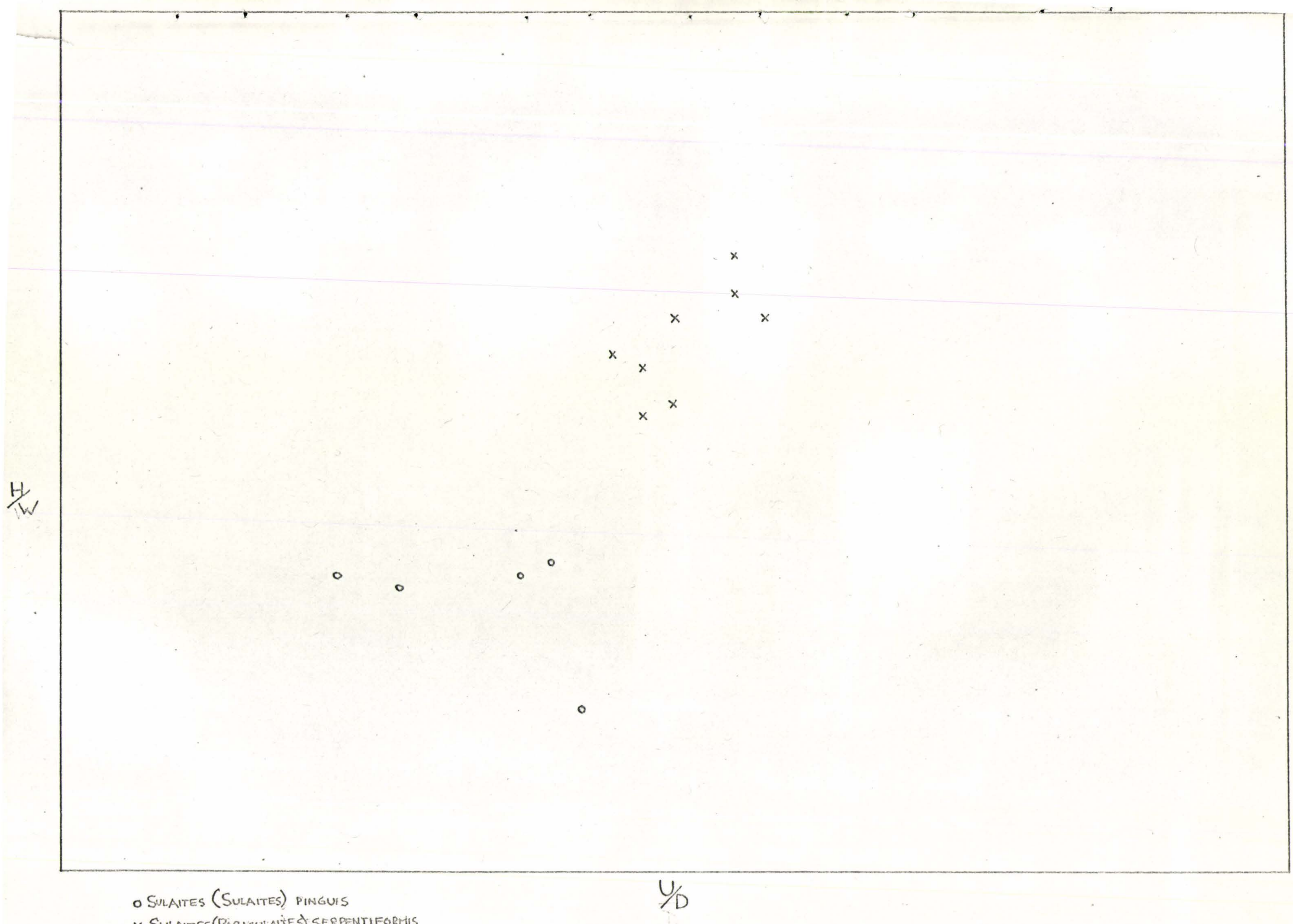


FIG. 24.

FIG. 25.



Scatter diagram, H/W vs. U/D for Sulaites s.s. and S. (Parasulaites) at largest preserved diameter.

RIB DENSITY, SULAITES SS. AND S. (PARASULAITES).

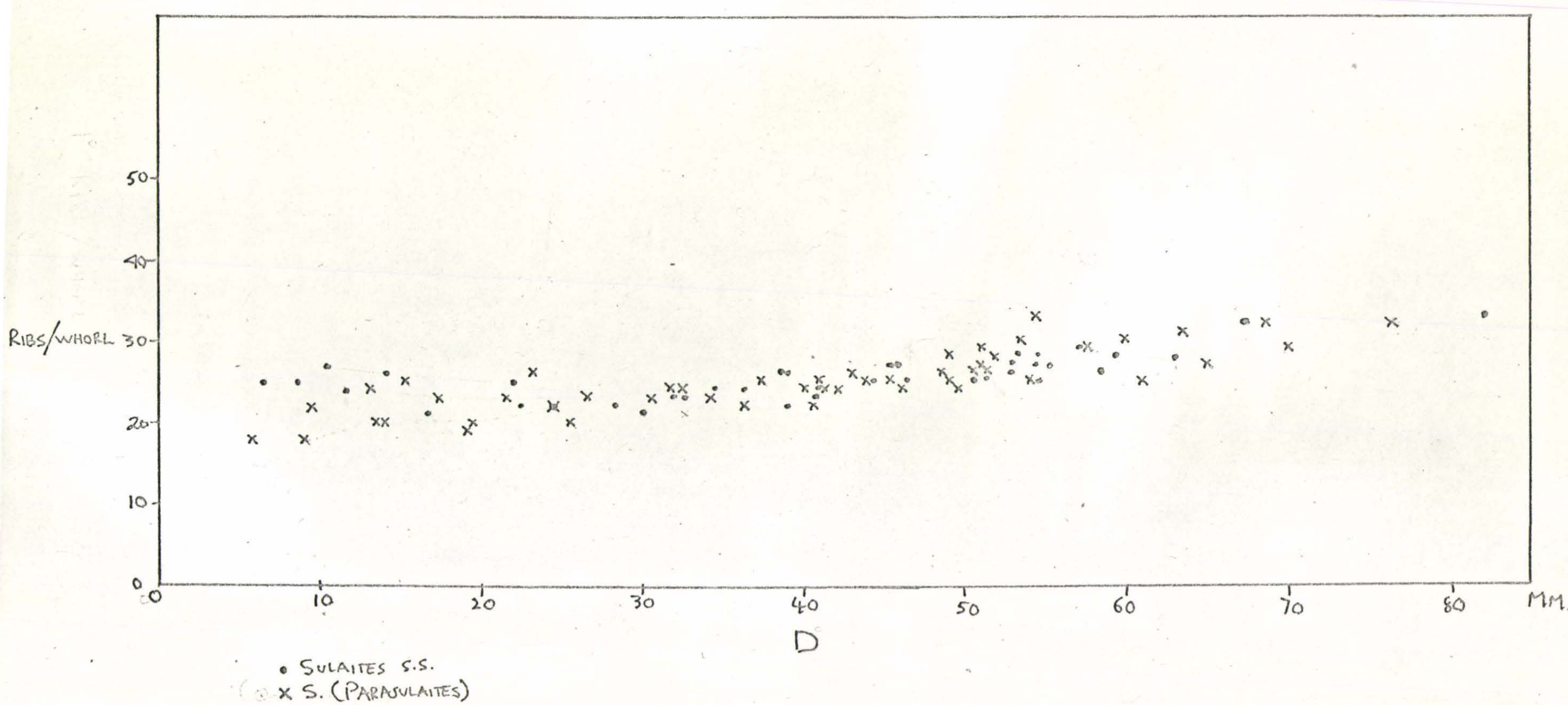
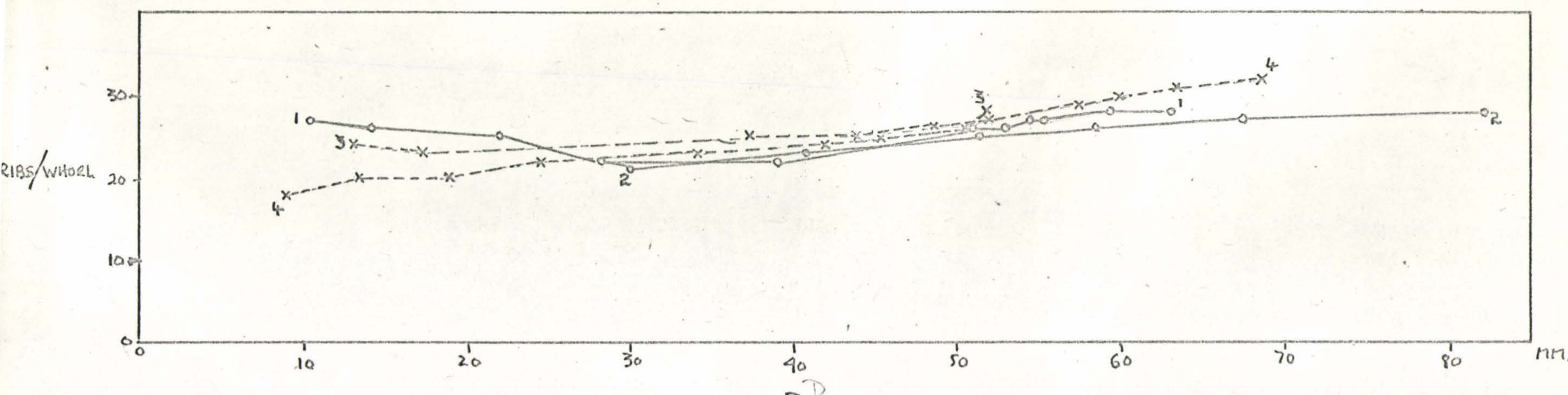


FIG 26.

RIB DENSITY CURVE (ONTOGENETIC) FOR SULAITES S.S AND S. PARASULAITES.

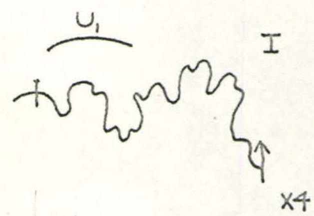


o—o Sulaites (Sulaites) pinguis
x--x Sulaites (Parasulaites) serpentiformis

1. L49
2. L139
3. L9
4. L337

INTERNAL SUTURES OF COELOCERAS AND BEANICERAS.

a. COELOCERAS
H = 13 mm.



b. BEANICERAS
H = 8 mm.

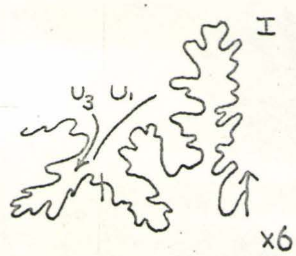
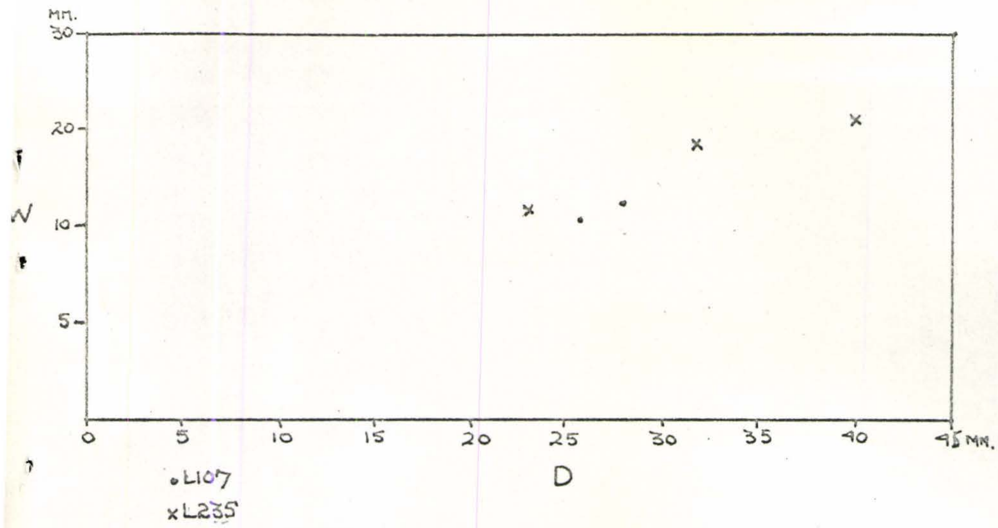
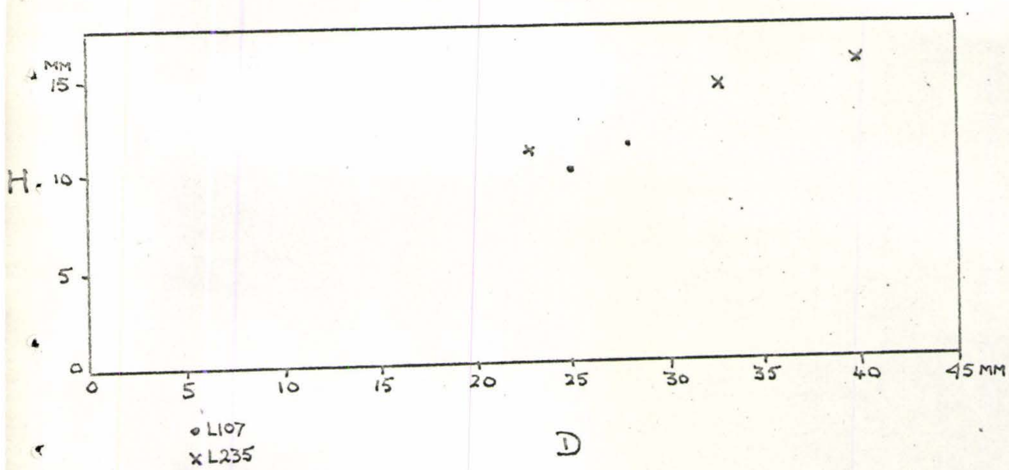


FIG. 29



SCATTER DIAGRAM, W. vs D.
Sulaites sp. juv.

FIG. 30



SCATTER DIAGRAM H vs. D.
Sulaites sp. juv.

PLATES I - XIII

All figures natural size unless otherwise stated.

"X" indicates beginning of body-chamber.

⟶ indicates constriction.

PLATE I

Fig. 1 Olcostephanus (Rogersites) sp. indet. (L81).

a) Side view of complete specimen. b) Apertural view of same.

c) Ventral view, last part of body-chamber removed. Page 23

Fig. 2 Blanfordiceras wallichi (Gray). (L73).

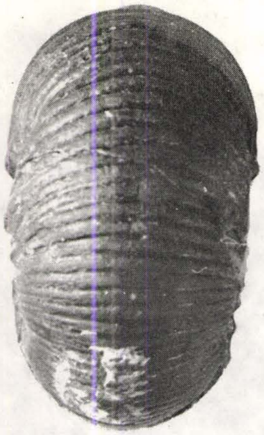
a) Side view. b) Apertural view. ("X" indicates end of phragmacone).

c) Ventral view of body-chamber. Page 26

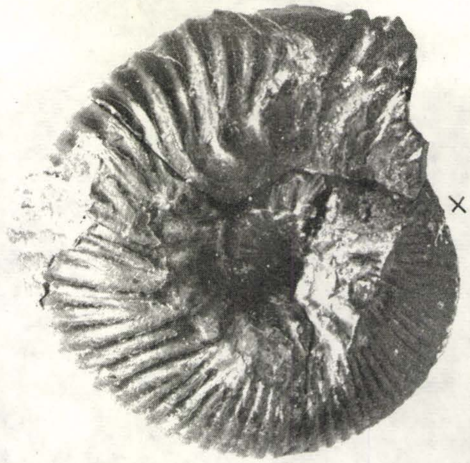
Fig. 3 Himalayites (Himalayites) sp. nov. aff. H. nederburghi Boehm. (L50).

a) Side view (Pyritised internal mould). b) Side view of opposite flank, showing spines. c) Ventral view. Page 32

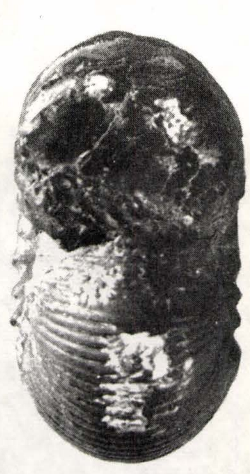
PLATE I.



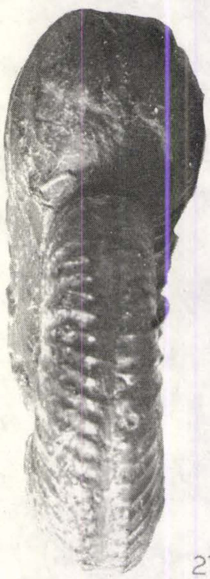
1c.



1a.



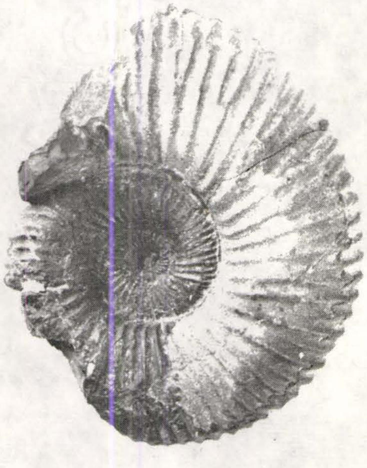
1b.



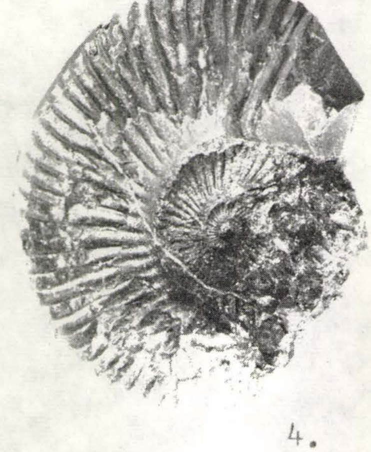
2b.

2a.

2c.



3b.



4.

PLATE II

Fig. 1 (?) Cobbanites aff. C. engleri (Frebold) (L37)

a) Side view. b) Apertural view. Page 34

Fig. 2 Docidoceras aff. D. longalvum (Vacek) (L360)

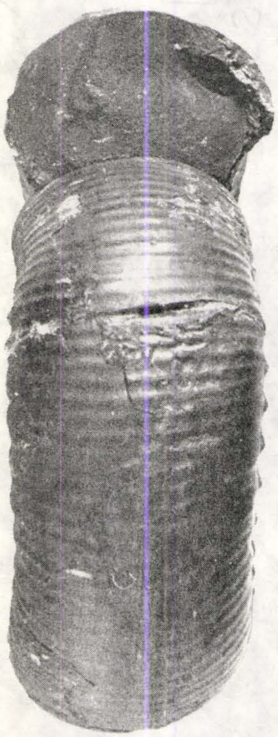
a) Side view of complete specimen. b) Ventral view, showing aperture. c) Apertural view, with the last 2 cm. of the body-chamber removed to show the contraction of the outer whorl. d) Surface of the last septum. X2 Page 38

PLATE II.

1a

1b

2d



2c

2a

2b

PLATE III

Fig. 1 Stephanoceras aff. S. skidegatense (L245)

a) Side view of specimen. b) Ventral view of same. Page 42

Fig. 2 Stephanoceras sp. indet. (L131)

a) Side view of specimen. b) Ventral view of same.

c) Apertural view of same. Page 46

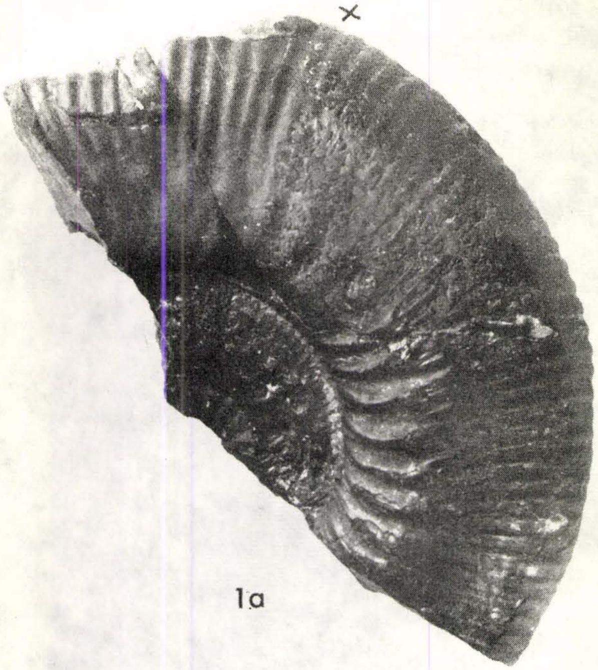
Fig. 3 S. (Stemmatoceras) aff. S. etheridgei Gerth (L41)

a) Side view of sawn specimen. b) Ventral view of last half whorl. Page 47

Fig. 4 (?) S. (Stemmatoceras) sp. indet.

a) Lateral view. b) Ventral view. Page 51

PLATE III.

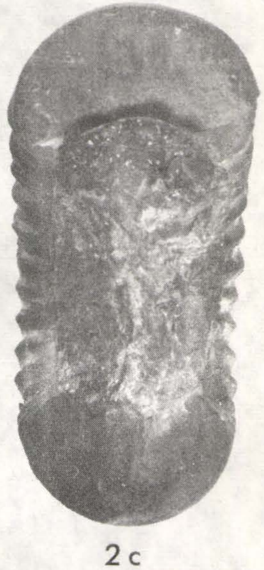


1a

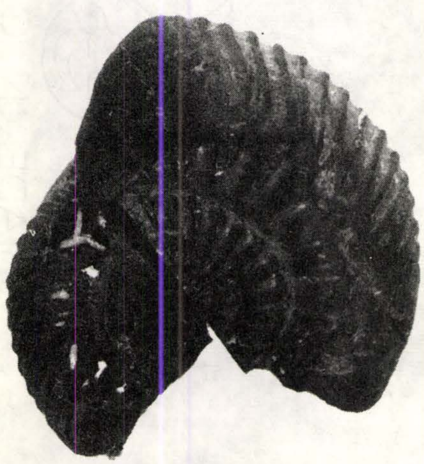
1b

2b

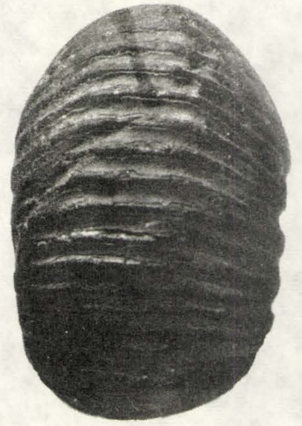
2a



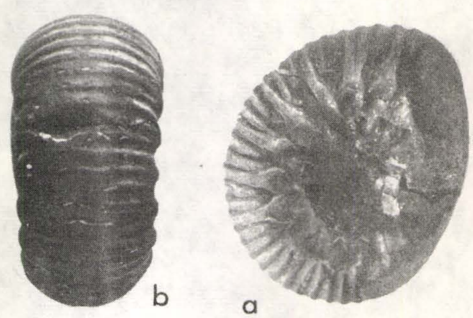
2c



3 a



3b



b a

4

<u>PLATE IV</u>

Fig. 1 <u>Bullatimorphites</u> (<u>Bullatimorphites</u>) sp. indet.'a'(L274)

a) Side view. b) Ventral view. <u>Page</u> 51

Fig. 2-5 <u>B</u>. (<u>Bullatimorphites</u>) sp. indet. 'b' (L205)

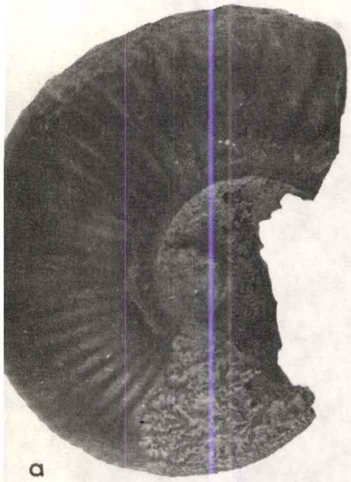
2a) Side view of slightly crushed example (L205). b) Apertural view of same. c) Ventral view of same.

3a) Side view of typical example (L275). b) Apertural view of same. c) Ventral view of same.

4a) Side view of large example with constrictions (L276). b) Ventral view of same.

5a) Side view of example with acutely elliptical umbilicus (L315). b) Apertural view of same. <u>Page</u> 53

PLATE IV.

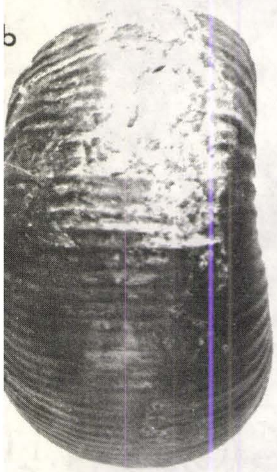


a x

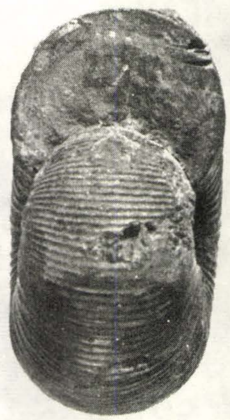
2b

2a

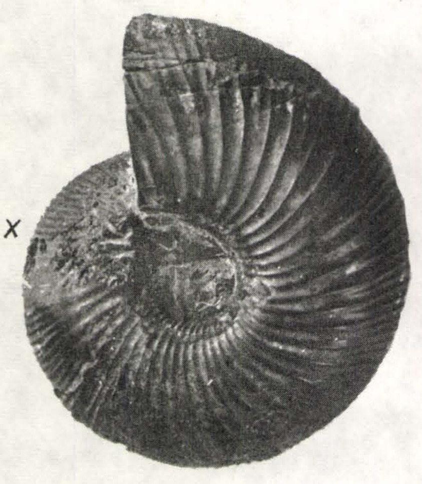
2c



b

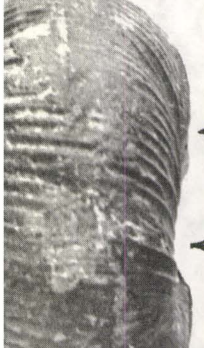


3b



3a

3



4b

4a

5a

5b

PLATE V

Fig. 1 Bullatimorphites (Treptoceras) aff. B. (T.) microstoma (d'Orbigny)(L277)

a) View of right side showing lappet and constriction. b) View of left side. c) Apertural view. Page 55

Fig. 2-3 Bullatimorphites (Treptoceras) sp. nov. ?

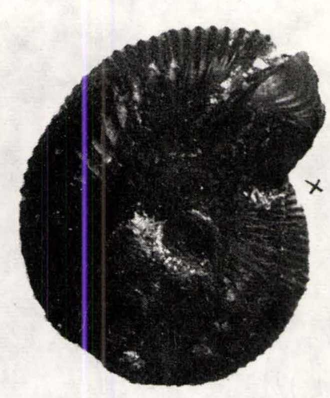
2a) View of left side of complete example (L278) (cf. fig. 3a).

b) View of right side. c) Ventral view.

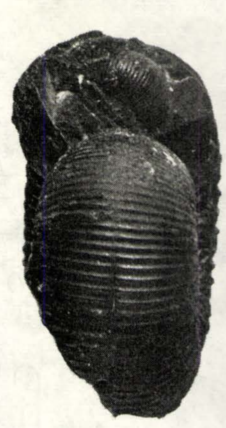
Fig. 3a) Side view of incomplete example (L291). b) Ventral view.

Page 60

PLATE V.

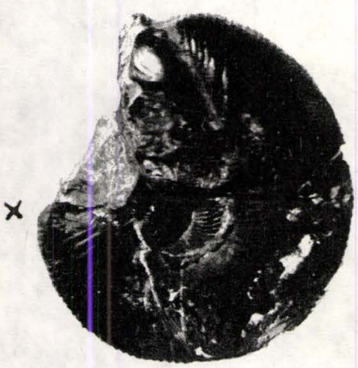


1a



1

1b



2a

2c

2b

3b

3a

PLATE VI

Fig. 1 (?) Bullatimorphites (Treptoceras) sp. indet. (L150)

Side view. Page 63

Fig. 2-3 (?) Bullatimorphites (Treptoceras) sp. juv.

2a) Side view of dorso-ventrally crushed example (L272)

b) Ventral view.

Fig. 3a) Side view of a more coarsely ribbed example (L289).

b) Ventral view. Page 64

Fig. 4-5(?) Macrocephalites sp. indet.

4a) Side view of wholly septate example (L317)

b) Apertural view

c) Ventral view.

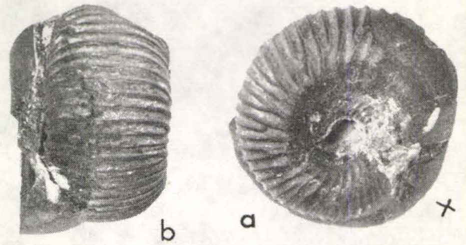
Fig. 5a) Side view of compressed example with modification of ribs on body-chamber

b) Apertural view (L204)

c) Ventral view. Page 66

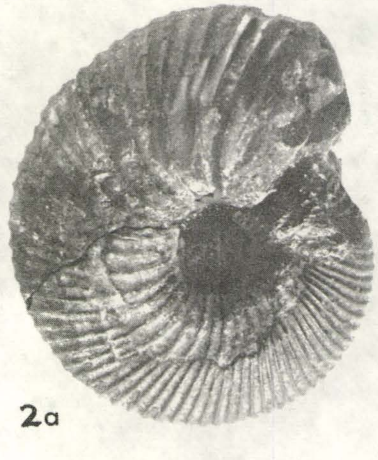
PLATE VI

b a x
2



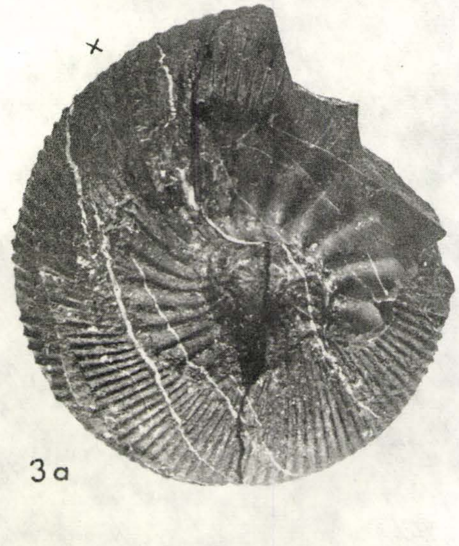
b a x
3

1a



2a

2b



3a

3b

PLATE VII

Fig. 1 Subkossmatia cf. S. beta-gamma (Boehm) (L51)

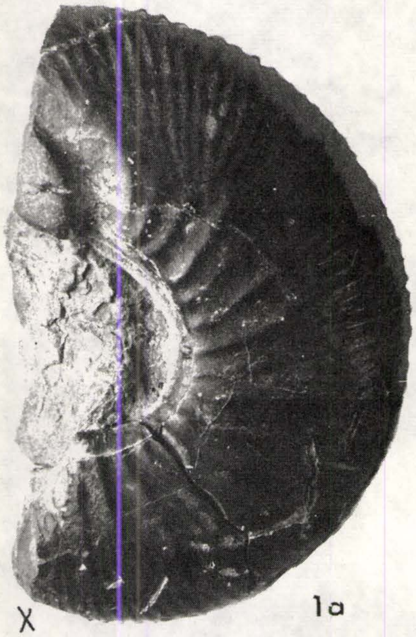
a) View of left side. b) View of right side, beginning of body-chamber removed to expose inner whorls. c) Ventral view.

Page 68

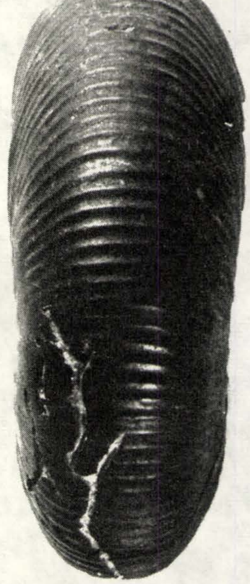
Fig. 2 Eucycloceras sp. indet. (L19)

a) Side view. b) Ventral view. Page 70

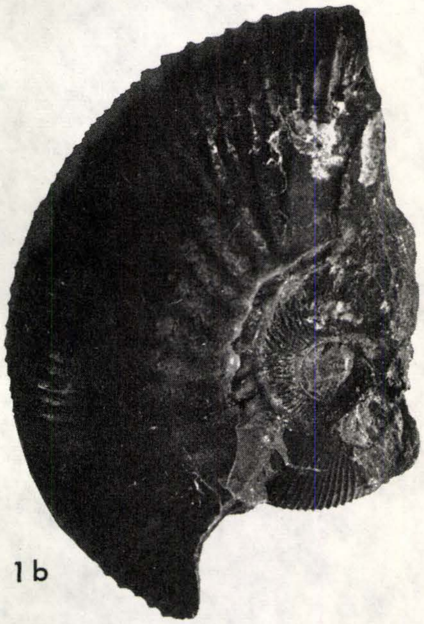
PLATE VII.



X 1a



1c



1b

a

b

2

PLATE VIII

Fig. 1 Fontannesia aff. F. grammoceroides (Haug) (L186)

a) Side view. b) Apertural view. c) Ventral view. Page 71

Fig. 2 Fontannesia aff. F. luculenta Buckman (L165)

a) Side view. b) Apertural view. Page 74

Fig. 3 Fontannesia obruta Buckman (L167)

a) Side view. b) Ventral view. c) Apertural view. Page 77

PLATE VIII.

1c

1a

1b

2b

2a

3a

3b

3c

PLATE IX

Fig. 1-3 Fontannesia sp. indet.

Fig. 1a) Side view of example without fasciculate ribs (L168)

b) Ventral view.

Fig. 2a) Side view of example with falcoid ribs (L312).

b) Ventral view.

Fig. 3a) Side view of fragment with strong fasciculate ribs (L148)

b) Ventral view. c) Apertural view showing septum. Page 78

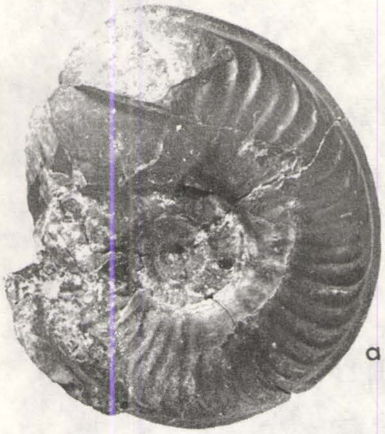
Fig. 4-5 (?) Fontannesia sp. indet.

Fig. 4 Side view of example with straight strong ribs (L316)

Fig. 5a) Side view of example with slightly falcoid ribs (L190)

b) Ventral view. Page 79

PLATE IX



a

b

1

a

b

2

3 b

3 a

3 c

4

X

a

b

5

PLATE X

Fig. 1-2 Sulaites (Sulaites) pinguis Getty

Fig. 1a) Side view of holotype (L363). b) Ventral view of outer whorl. c) Apertural view showing inner whorls.

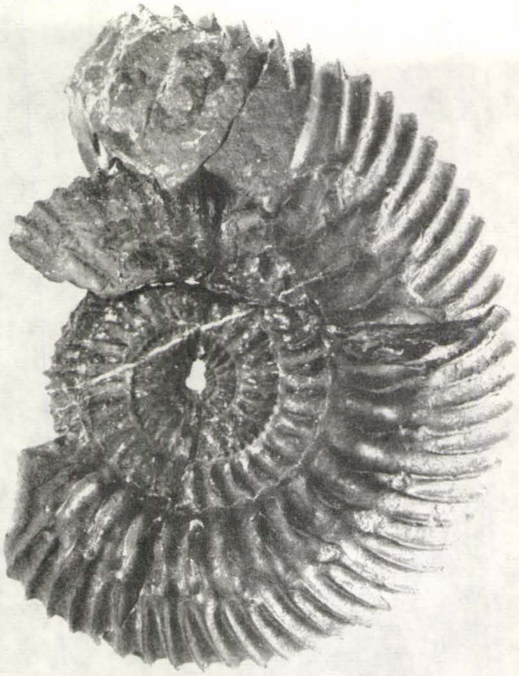
Fig. 2a) Side view of slightly worn example (L139)

b) Apertural view.

Page 80

PLATE X

1b



1a

b

a

2

PLATE XI

Fig. 1-4 Sulaites (Sulaites) pinguis Getty

Fig. 1 Side view of example becoming inflated at a smaller diameter than usual (L4).

Fig. 2 a) Side view of example with constriction (L49).

b) Ventral view of same.

Fig. 3 a) Side view of example showing typical gradual inflation (L136).

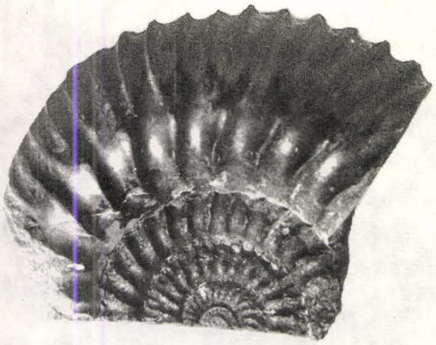
Fig. 4 a) Side view of large fragment (L357) showing similarity to Teloceras, but with bulli-tuberculate ribs.

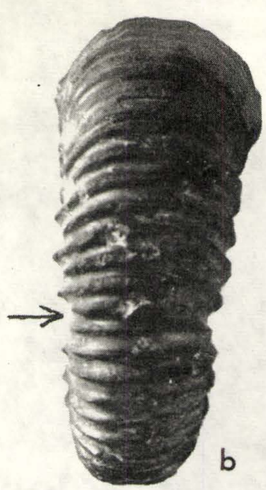
b) Apertural view of same.

c) Ventral view of same.

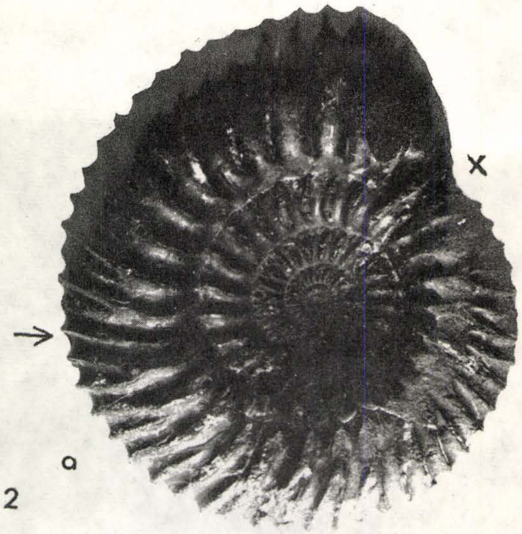
Page 80

PLATE XI



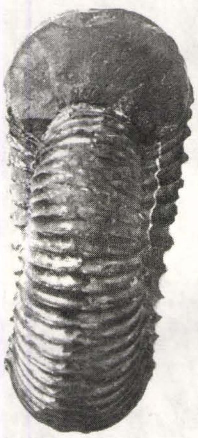


b

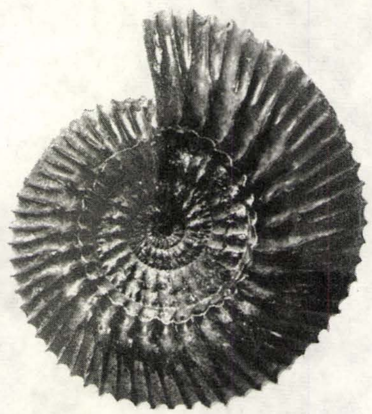


a

2



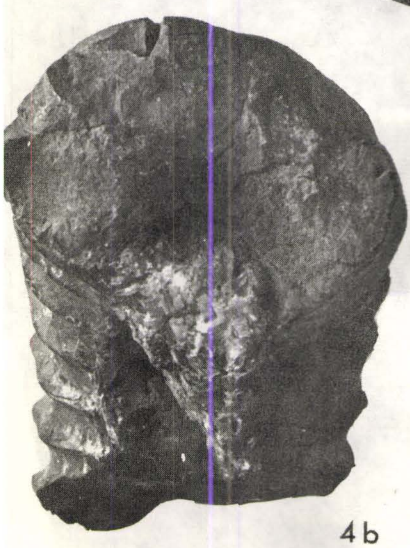
3c



3 a

3b

4a



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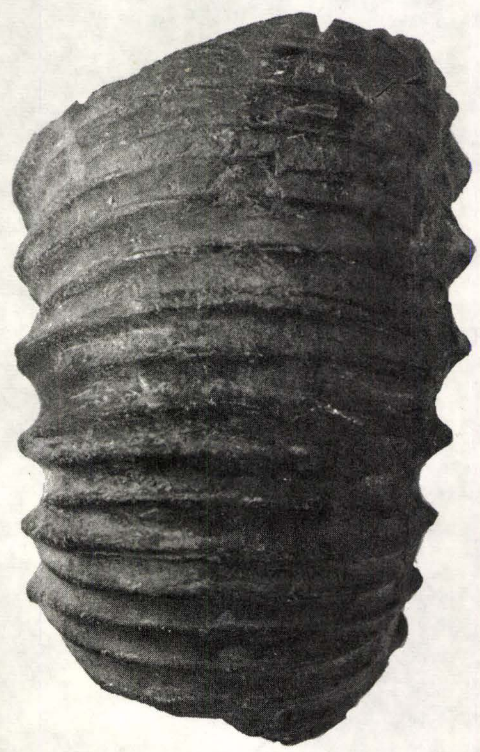


4c

PLATE XII

Fig. 1-3 Sulaites (Parasulaites) serpentiformis Getty.

Fig. 1 a) Side view of holotype (L162) with lappets.

b) Ventral view.

Fig. 2 a) Side view of the other example with lappets (L132).

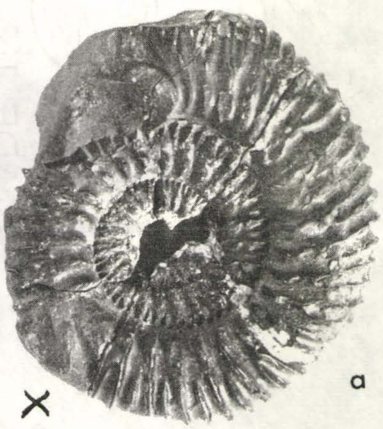
b) Ventral view.

Fig. 3 a) Side view of incomplete example (L337). Page 83

PLATE XII

1b

1a



X a

b

2

X

b a

3

PLATE XIII

Fig. 1-2 Sulaites (Parasulaites) serpentiformis Getty.

Fig. 1 a) View of right side of crippled specimen (L31).

b) View of normal left side.

c) Ventral view, slowing loss of tubercles on right side.

Fig. 2 Side view of example with ventral damage at the start of the body-chamber (L9).

Fig. 3-4 Sulaites sp. juv.

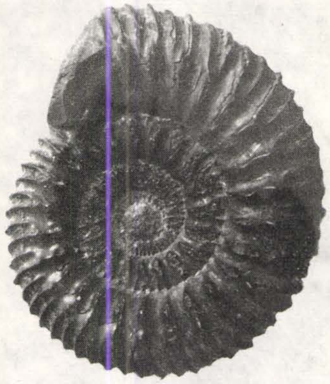
Fig. 3 a) Side view of inflated example (L235).

b) Apertural view.

Fig. 4 a) Side view of typical example (L107).

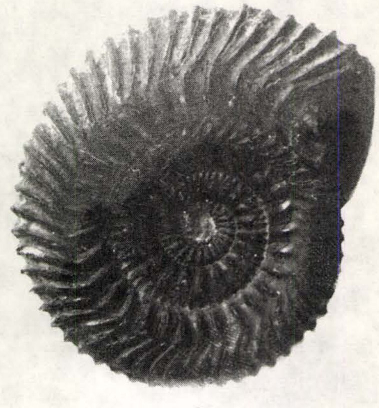
b) Ventral view.

PLATE XIII

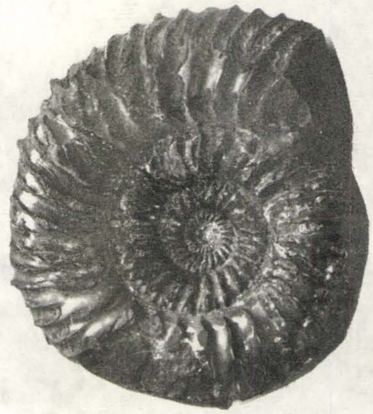


1b

1c



1a



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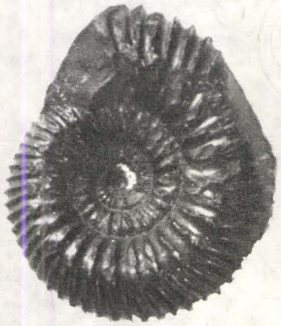
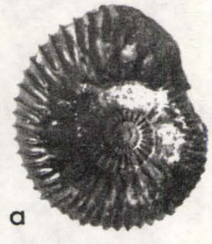


3a

3b

b



a

4