

CONTRIBUTIONS TO THE GEOLOGY AND PALAEOLOGY
OF SOUTHEAST ASIA, L

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Mindoro, Philippines*

By

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***The Jurassic Mansalay Formation, Southern
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[With Plates XXVIII-XXX]

Introduction

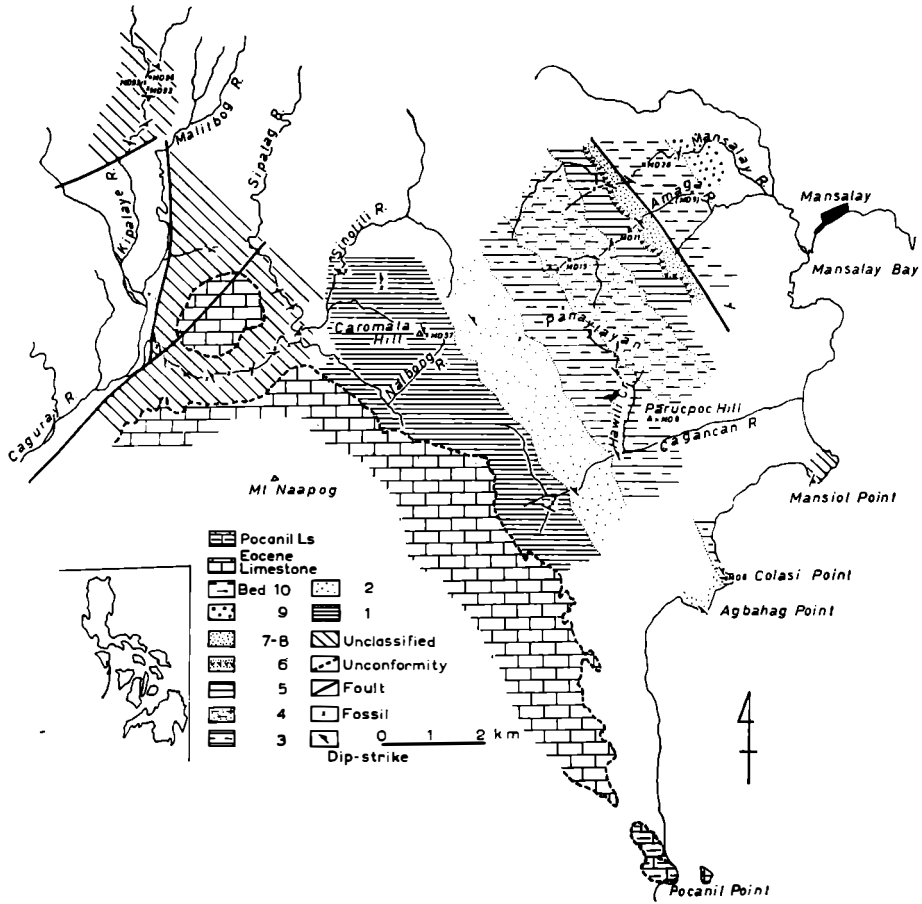
Except for a small patch of Paleozoic limestone in Carabao Island, south of Tablas Island, carrying fusulines (P. P. ANDAL, 1966), and probable Upper Triassic near Abra de Ilog (unpublished), as suggested by the occurrence of doubtful molluscs, the oldest rocks dated by fossils in Philippine Archipelago are of the Jurassic Mansalay Formation. Thus the Jurassic might present an important key to elucidate the earlier part of the geological history of the Philippines. The occurrence of Jurassic fossils around Mansalay, Oriental Mindoro, has been repeatedly reported by various authors (HAYASAKA, 1943, DE VILLA, 1944, RIVERA, 1954, KOBAYASHI, 1957, TEVES, 1957 and SATO, 1961). But these reports are based mostly on fragmentary collections and fail to note precise stratigraphical sequence, so that no fundamental data, such as stratigraphy and geologic structure, was given.

The authors' exploration of the southern part of Mindoro Island had as its primary aim the establishment of the stratigraphy of the Jurassic, and was successfully carried out by close cooperation between the Philippine Bureau of Mines at Manila and a Japanese Inter-University team, with the aid of a grant from the Overseas Research Fund of the Japanese Ministry of Education.

Due to difficulties which arose during the mission, meteorological and subsistence conditions, the survey was limited to a relatively small surface of the hypothetical Jurassic. Some important key areas remain unexplored.

A part of the stratigraphical sequence of the Mansalay formation was established through painstaking fossil hunting. It ranges, according to the results obtained from both field and laboratory work, from the upper part of Callovian to Oxfordian (upper Middle to lower Upper Jurassic). The relation to overlying and underlying strata was unfortunately not observed in situ, but important stratigraphical gaps can be expected at its upper and lower limits.

Paleontologically it presents an interesting fauna of Molluscs, including abundant ammonite and pelecypod species, all of Pacific type. A complete



Text-fig. 1. Geologic Sketch Map of the Mansalay Area.

list of the species occurring in the formation is not, however, given here, because of the rarity of well preserved specimens, except for some found in argillaceous nodules.

Description of Species

Tadashi SATO*

Family Perisphinctidae STEINMANN, 1890

Subfamily Perisphinctinae STEINMANN, 1890

Genus *Perisphinctes* WAAGEN, 1869

Perisphinctes (*Kranaosphinctes*) cf. *bullingdonensis* ARKELL

Pl. XXIX, fig. 5a, b

* The author is responsible for the determinations of ammonite species.

Dimension:—Maximum diameter of preserved whorls, 165 mm. At 165 mm., width, 41 mm., height, 41.5 mm., umbilical diameter, 92 mm. (.25, .25, .56). At 100 mm., 37 mm., 35 mm., 45 mm. (.37, .35, .45). At 50 mm., 22.5 mm., 20 mm., 24 mm. (.45, .40, .48).

Description:—A coarse ribbed *Kranaosphinctes*, of which nearly half a whorl is lost. Whorl section depressed at the 18 mm. diameter, gradually becoming more compressed with increase in diameter. The last visible portion of the whorl is as high as it is thick, and rounded to circular in section. Sides and ventral margin are consequently well rounded. Two or more constrictions per whorl, rather deep, fairly prorsiradiate, accompanied by simple ribs.

The ribs are strong, slightly prorsiradiate, originating on the umbilical shoulders, and generally biplicate on the last whorl with frequent insertion of intercalatories. Number of ribs varies little throughout the ontogeny (exact number is not calculated because half of the specimen is lost), ranges about 40 at the 50–100 mm. diameter stage, but increases to 55–60 at the 150 mm. stage.

Septal sutures are characterized by very long and slender lobes. The external part is not visible but highly retracted umbilical lobes with four long auxiliary lobes are of *Kranaosphinctes* type.

Observations:—The specimen described above is a unique adult one, but one young whorl was discovered from the float of the same lithology. A number of young whorls, but no adult ones, are found from the calcareous argillite concretions in Parucpoc Hill.

The following characteristics of the whorls and septal sutures allow reference to the genus *Perisphinctes* (*Kranaosphinctes*): nearly circular whorl section, gradual changing of ornamentation (ribbing), and highly retracted umbilical lobes with slender and very long auxiliary lobes.

Unfortunately the number of ribs at successive growth stages is not obtainable; comparison to known species is thus somewhat difficult. Among *Kranaosphinctes* species reported from the South Pacific area, no form can be directly compared to the present one. Several *Kranaosphinctes* forms described by BÖHM from Sula Island, including *Perisphinctes buri* (from Buru Island), have no direct relationship with this form, judging especially from the widely spaced ribs of the latter.

P. (K.) bullingdonensis, an Oxford ammonite, is a species in which ribs are separated by a comparatively wide area on the sides; ARKELL counted 37 ribs at the 65 mm. diameter, 43 at 100 mm., and 49 at 150 mm. The exact number in the present form being unknown, a detailed comparison is impossible, but the suggested number of ribs is not very far from that of *bullingdonensis*. The present species differs, however, from *P. (K.) bullingdonensis* by the irregularly biplicating secondaries on the venter of the last chamber, frequent intercalatories, and above all, the size of the British species which attains 415 mm. in its maximum diameter.

There is a group of species that includes *P. bullingdonensis*, and that represents a link between *Kranaosphinctes* and *Arisphinctes*. The smooth ventral region of the young whorls and somewhat quadrate whorl section of adult whorls are inseparable characteristics of the two. Therefore it is fairly safe to relate the present form to *P. bullingdonensis*.

Occurrence:—[MD-9],* [MD-15], MD-8, MD-96. Amaga River and Kipalay River.

Perisphinctes subgen. and sp. indet. A

Pl. XXIX, fig. 1

A single specimen, highly crushed and corroded. A portion of the last septum is preserved but surface ornamentation is difficult to observe. A shallow and slightly prorsiradiate constriction exists, accompanied by a single rib. Septal sutures characterized by stout LI and suspensive lobes less retracted than typical perisphinctid ones. Formula: $E=U<L$.

It is impossible to determine the subgenus and species because of the poor state of preservation. But the specimen certainly belongs to a *Perisphinctes* genus, judging by the following characteristics: regularly biplicate secondaries at the ventrolateral edge, circular and evolute whorls, characteristic constrictions, elaborated septal sutures and general display of lobes, especially suspensive lobes.

Dimension:—Width at the last septum, 36 mm., height, 36 mm.; other dimensions not obtainable.

Occurrence:—[MD-11], river float of the Amaga River.

Perisphinctes subgen. and sp. indet. B

Pl. XXX, fig. 5

A completely flattened specimen of which a large part is lost. Evolute and gradually growing whorls with long, dense primaries twisted at the umbilical margin and slightly prorsiradiate on the sides. Deep and prorsiradiate constrictions, at least two per whorl. Septal sutures are characterized by long and retracted suspensive lobes. Formula: $LI=U$.

The ribbing, as far as can be seen on the preserved whorls, is of the typical *Perisphinctes* type, and is especially close to that of the finely ribbed *Dichotomosphinctes*.

Occurrence:—[MD-28], Mansalay River float, black sandy shale with *Posidonia*-like small pelecypods.

* Locality numbers in brackets indicate the code for sites of collection from the river float.

Perisphinctes sp. juv.

A specimen from Parucpoc Hill, small but living chamber persisting. Compressed whorl section with somewhat quadrate ventral edge and flat sides. The ribbing generally prorsiradiate and looped by the parabolic tubercles on the ventral edge. Very shallow and prorsiradiate constrictions, at least three per whorl. Septal suture not observable.

The incompleteness of the specimen prevents any reliable determination. The peculiar shape of the ribbing at this stage of development suggests some relation to a Mollusca species of *Perisphinctes* (*P.* [*K.*?] *sularum* BOEHM), though parabolic tubercles are frequent in *Grossouvria*, from which the present form definitely differs by the presence of long and fine primaries.

Dimensions:—Maximum diameter, 27 mm., width, 7 mm., (.26), height, 9 mm. (.33), umbilical diameter, 12.7 mm. (.47). Ribs number 55–60 per whorl at 27 mm.

Occurrence:—MD-8, Parucpoc Hill.

Family Aspidoceratidae ZITTEL, 1895

Subfamily Aspidoceratinae ZITTEL, 1895

Genus *Euaspidoceras* SPATH, 1931

Euaspidoceras cf. *hypselum* (OPPEL)

Pl. XXVIII, fig. 8a, b

A depressed *Euaspidoceras* imperfectly preserved. Rate of growth rather slow with small and deep umbilicus. Whorl section much larger than high and quadrate with rounded ventral margin. Two rows of lateral tubercles of which the outer is very prominent and of pyramidal form, while the inner is far from the umbilical suture and less prominent than the outer, interconnected by blunt, short, swollen ribs. Faint and rather straight secondary ribs passing on the ventral region sprung from the outer tubercles.

Septal suture of typical *Euaspidoceras* pattern, with widely spaced small lobes and unretracted suspensive lobes. Formula: $E=L>U$.

Affinities:—This species should be closely related to the depressed and strongly tuberculate *E. hypselum* for which DORN established a specialized group of *Aspidoceras oegir*, characterized by strong tuberculation and a quadrate whorl section. *E. hypselum* is a rather small species; DORN thought it to be no bigger than 150 mm. in diameter. Its outer tubercles, as seen in DORN's plates (e.g. Pl. XIX, fig. 1) are all rounded mammiform although this Mindoro species is provided with sharply pointed and sometimes flattened edge-like tubercles. In other respects, the present species is most probably conspecific with *hypselum*.

E. perarmatum (SOWERBY), type-species of the subgenus, represents a less depressed and more slowly growing form. It can attain a bigger diameter, but at a comparable stage (about 60 mm.), it differs in having a high quadrate whorl section and more evolute coiling.

Dimensions:—Maximum diameter 56.6 mm., but the last part of the body chamber lost. Dimensions at this stage are: whorl height, 20 mm. (.35), width, 29 mm. (.51), umbilical diameter, 21 mm. (.37), number of ribs 19. At a 45 mm. diameter, height, .34, width, .45, umbilical diameter, .40.

Occurrence:—[MD-11], from the river float farther upstream than MD-11, Amaga River horizon. Probably MD-8, fragmental specimen.

Subgenus *Paraspidoceras* SPATH, 1925

Paraspidoceras cf. *knechti* (JEANNET)

Pl. XXVIII, fig. 9a, b

Highly divergent (coronate) whorl section and enormously projected clavate outer tubercles are the most impressive characteristics of this species. Unfortunately only a fragment of the living chamber and a small part of the penultimate whorl are preserved. The tubercles exist only in the ventrolateral edge, and the inner row of tubercles is absent. On the very wide and slightly convex venter, faint and blunt secondary ribs connect all tubercles of both sides. This characteristic holds also in the penultimate whorl, but the outer tubercles are more clavate.

Septal sutures are of typical *Euaspidoceras* type. The big and stout external lobe is as deep as the lateral, but suspensive lobes lie flat and are not retracted.

Affinities:—The *Paraspidoceras* was created for that group of species represented by *Amm. meriani* OPPEL, and includes JEANNET's *Extranodites* which is said to be characterized by spinous instead of clavate tubercle. But, as our specimen clearly shows, this distinction has no generic importance, because the degree of clavate character depends on the growth stage. Hence, *Paraspidoceras* is adopted here.

As our specimen is largely destroyed, no definitive determination can be given. But with respect to the observable characters, such features as the tubercles and whorl section can best be compared to the *Extranodites knechti* JEANNET. The outer tubercles are, however, much more clavate in shape in this form.

Dimensions:—In last whorl, height, 31 mm., width 42 mm. (57 mm. on the tubercles); in penultimate whorl, height, 14 mm., width, 19 mm.

Occurrence:—MD-11d, Amaga River, right bank. (Amaga River horizon)

Subfamily Peltoceratinae SPATH, 1924

Genus *Parawedekindia* SCHINDEWOLF, 1925

Parawedekindia arduennensis (D'ORBIGNY)

Pl. XXX, figs. 3, 4, 7, 8

1848. *Ammonites arduennensis* D'ORBIGNY, p. 500, pl. 185, Figs. 4-7.
1875. *Peltoceras arduennense* WAAGEN, p. 79, pl. 16, fig. 2.
1898. *Peltoceras arduennense* DE LORIOU, p. 91, pl. 7, figs. 1-3.
1925. *Parawedekindia arduennensis* SCHINDEWOLF, p. 321.
1931. *Peltoceras arduennense* DORN, p. 66, pl. 33, fig. 9.
1937. *Peltoceratoides arduennensis* PRIESER, p. 94, pl. 9, fig. 10, pl. ix, fig. 5.
1951. *Parawedekindia arduennensis* JEANNET, p. 178, pl. 79, fig. 2, text-fig. 315.
1961. *Parawedekindia arduennensis*, juv. sp. SATO, p. 142, pl. 7, fig. 1.

This species was already described from Mindoro Island in 1961. Unfortunately the 1961 description was based on an imperfect single outer cast. The collection of this species is now largely amplified: the characters now observable corroborate the determination.

Whorls subquadrate in section, slightly convergent, and very evolute. Ventral region broadly convex and well distinguished from the sides. Umbilical edge deep and vertical with rounded shoulders.

Ornamentation composed of fine, closely spaced ribs which are generally biplicate near the umbilical edge, and persisting unchanged until the end of the preserved whorls. Primary ribs slightly more elevated than the secondaries, curved forward, giving rise to generally two secondaries. Secondary ribs, slightly convex forward and fairly rursiradiate as a whole, continue without interruption on the siphonal area, where they are more elevated. A shallow depression of the ventral ribs at the middle of the ventral area can be observed in some specimens. Free intercalatories exist but are few in number.

Septal sutures not very denticulate, characterized by broad and long LI and relatively small and unretracted suspensive lobe.

Dimensions:—A typical, well preserved specimen (Pl. XXX, fig. 7a. b). Diameter 59 mm., umbilical diameter 24 (.40), height 20 (.33), thickness unknown.

Occurrence:—Mostly very fragmentary juvenile whorls, found from argillaceous nodules in the clayey shale which forms the Parucpoc Hill horizon, frequently occur gregariously. Fully grown specimens are relatively rare. The specimen described in 1961 is from the same locality.

Remarks:—A fragment of the adult whorl from the same locality suggests the *Peltoceratoides* species (Pl. XXVIII, fig. 7). This part of the whorl shows ridge-like primary ribs and obscure and prorsiradiate secondaries. On the inner side rest the molds of the ventral region of the penultimate whorl, which shows the regular, normal ribbing of the *Peltoceratoides*. Another,

more fragmentary specimen of an adult whorl, still septate, shows on its side blunt, straight swells, nearly rectiradiate with very wide spaces.

These two specimens indicate the occurrence of *Peltoceratoides*, but no definite conclusion can be given here.

Three fragments of whorls present a clearly rursiradiate, simple ribbing, revealing an affinity to the *Rursiceras* (cf. Pl. XXX, fig. 2). However, as shown in *Parawedekindia torosa* (OPPEL) (cf. JEANNET, Pl. 79, fig. 8), this type of ribbing can appear in *Parawedekindia*. Lack of complete specimens prohibits their definite determination but despite their fragmentary nature, this is strong evidence of the presence of different Peltoceratid species in our Parucpoc Hill ammonite collection.

Superfamily Haplocerataceae ZITTEL, 1884

Family Oppeliidae BONARELLI, 1894

Subfamily Taramelliceratinae SPATH, 1928

Genus *Taramelliceras* DEL CAMPANA, 1928

Taramelliceras cf. *trachinotum* (OPPEL)

Pl. XXVIII, fig. 6

A single specimen discovered on the wall rock of the Amaga River, of which a rubber replica was made at the site. The specimen shows nearly a quarter of the last whorl, and is about 10 cm. in diameter.

Though very fragmentary, the specimen clearly suggests a compressed, discoidal and somewhat involute whorl, and the ribs are of true *Taramelliceras*-type. Primary ribs slightly flexuous, merging into very prominent, tangentially elongated clavi at the ventro-lateral margin. A median row of elongated tubercles is suggested at the median line of the ventral area. Septal sutures not observable.

Discussions:—The exact systematic position in *Taramelliceras* is undeterminable, due to highly fragmentary preservation. Some known species quite resemble our specimen; examples are an old species, *T. costatum*, containing a group of forms actually inseparable from the *trachinotum*, *T. compsum*, and *T. pseudotrachynotum*.

Although it is very difficult to determine the species definitely, the present specimen is placed near *T. trachinotum* because of gross and robust ribbing, tangential clavi on the ventral margin, tendency to have a sunken umbilical area.

Occurrence:—MD-11a, Right bank of Amaga River (Amaga River horizon).

Subfamily Hecticoceratinae SPATH, 1928

Genus *Hecticoceras* BONARELLI, 1894*Hecticoceras* (*Zieteniceras*) sp.

Pl. XXIX, figs. 3, 4

Dimensions:—The best preserved shell, diameter 43 mm., umbilical diameter 11 mm. (.25), height 23 mm. (.53), thickness unknown due to crushing. Other materials are too fragmentary to give dimensions.

Description:—Whorls of moderate size and with rate of growth rather high; coiling very involute. Whorl section is not observable due to compression. Umbilicus small and possibly deep. *Characteristic ribbing on the sides, which originally must have been weakly convex in spite of the present flat state; composed of two clearly discernible parts: the primaries fine, but with rather high relief, strongly prorsiradiate, and occupying the inner one-third of the side; secondaries generally finer than the primaries and distinctly falcoïd, arising at one-third the height of the side by bifurcation of primaries. The very pronounced bending of the ribs at the point of bifurcation is typical of *Taramelliceras*, but is also seen in some *Hecticoceras* species. A single specimen shows two or more minute tubercles on the ventral margin, but this is not present on the other specimens. On inner whorls, loose and clear ribbing is observable at a diameter of 13 mm. or thereabout.

Observations:—Only four ill-preserved specimens were found. The soft, fine-grained mother rocks are themselves easily compressed, so that the specimens are all very fragmentary and deformed. Due to the lack of evidence on important characteristics such as ventral aspect and septal sutures, accurate determination is impossible. The citation as *Hecticoceras* (*Zieteniceras*) is thus strictly preliminary and open to question.

The peculiar ribbing on the sides with pronounced geniculation is not necessarily a definite characteristic of the genus *Hecticoceras*. Similar ribbing is known in various other genera, i.e. *Taramelliceras* of Kimmeridgian, *Campylites* of Oxfordian-Kimmeridgian, and even *Graphoceras* of Early Jurassic.

In general, *Taramelliceras* has a more conspicuous ribbing in which the external ends are looped. *Campylites* has no external tubercles on the ribs, although its outer ribs swell terminally. The present species has no characteristics in common with the above-mentioned two genera. The present specimens cannot be placed near known *Hecticoceras* (*Zieteniceras*) species, especially when the ribbing is considered. Similar ribbing is known in *H. (Z.) zieteni* DE TSYTOVITCH, holotype of the species (DE TSYTOVITCH, Pl. I, fig. 2), but this differs in having less flexuous and less fine ribbing.

In spite of the pronounced ornamentation of *Hecticoceras* adults, their inner whorls are generally smooth, and ornamentless; only faint ribs on the outer margin of the sides exist. Some groups of *Hecticoceras* such as *Lunulo-*

ceras keep the ornamentation of the young stage. Therefore, inner smooth whorls might indicate a common origin for some of the *Hecticoceras* subgenera.

Occurrence:—MD-57, near the top of Caromata Hill, about 8 km WSW of Mansalay (Caromata Hill horizon).

Subgenus *Lunuloceras* BONARELLI, 1894

Hecticoceras (*Lunuloceras*) cf. *lunula*

(REINECKE) (non ZIETEN)

Pl. XXVIII, fig. 5

Materials:—All very fragmentary and ill-preserved specimens impressed on black shales. A relatively well-preserved one gives the following dimensions: diameter, 34 mm., umbilical diameter, 11 mm. (.32), height, 13 mm. (.38), thickness unknown.

Descriptions:—Small shells completely compressed, with rather involute volution, whorls slowly growing. Inner whorls nearly smooth, devoid of all ornamentation on the sides. Outer whorls have typical *Hecticoceras* sculpture, namely very faint primary ribs on the inner third of the sides, numerous, fine and weakly falcoïd secondaries on the outer part of the sides. No tubercles observable on the ventro-lateral margin. No spiral furrow or ridge on the middle of sides. Ventral region not seen.

Observations:—The type species of *Lunuloceras* BONARELLI is disputed (for example, ZEISS believed that it was *Lunuloceras lunula* ZIETEN, non REINECKE, and gave a new name to this species, *H. (L.) fallax*, [ZEISS, 1959, p. 27]). The list of species given by ZEISS includes, however, *H. (L.) lunula* REINECKE sp. among others, so that BONARELLI's original concept is not largely modified.

Among the forty or so species identified throughout the world, one group, *Hecticoceras pompeckyï*, as designated by E. LEMOINE (1932), can fairly readily be distinguished. It is characterized by smooth inner whorls and delicately ornamented outer whorls, and generally falcoïd and fine secondaries. The present species shows falcoïd secondary ribs; the primaries are very faint or non-existent. The same characteristics are seen also in *H. (L.) compressum compressum* (QUENSTEDT) (1849, Pl. 8, fig. 3) and *H. (L.) pompeckyï* (PARONA & BONARELLI) (1895, Pl. 4, fig. 6). Thus the holotype of *Nautilus lunula* by REINECKE, refigured by JEANNET (1951, Pl. 13, fig. 1) and ARKELL (1957, fig. 325, 2), represents the typical features of the group. The present species is referred to *H. lunula*, but definite determination is now open to question.

Occurrence:—MD-93, river bank of the Kipalaye River, a branch of the Caguray River, about 12 km. west of Mansalay (unclassified horizon).

Subgenus *Sublumloceras* SPATH, 1928*Hecticoceras* (*Sublumloceras*) cf. *guthei* (NOETLING)

Pl. XXVIII, figs. 1a, b, 2a, b

Dimensions:

		mm.	mm.	mm.	mm.
Specimen 1		30	8 (.27)	15 (.50)	8 (.27)
2		22.5	6.5 (.28)	10 (.4)	6 (.26)
3		—	—	12 —	8 —
4		16.5	5 (.30)	8 (.48)	4.5 (.27)

Description:—Shell of small size, rate of growth rather slow, coiling involute, whorl section oval in general, with slightly convex side and well-defined ventral region. There is a rounded keel of low relief on the middle of the ventral region. Ribbing of *Hecticoceras* type, with primaries very feeble and almost smooth in the inner half of the side, and with secondaries arising at the middle of the side and forming pronounced convex forward geniculation, generally fine but more numerous than the primaries, bundled by finer striations on the rib surfaces. No tubercles on the ventral margin but ribs swell somewhat at the ventral extremities, at a diameter of about 30 mm.

Septal sutures composed of four elements: a large and deep, profoundly bifid E=L, L minutely incised, and a small U1 preceded by a relatively large U2. The general alignment of the elements is slightly oblique to the radius, as in the case of *Hecticoceras*.

Observations:—The *Sublumloceras* is a subgenus of rather large size. The present specimens are young immature whorls, so that the adult characters are not observable. The main characteristics of the subgenus are, following HAAS, a lesser degree of sinuosity of the ribs as compared with *Brightia*, which is in turn characterized by the presence of well developed bullae on the inner half of the sides. The general aspect of the line of ribs coincides well in comparative size with that of *Sublumloceras guthei* (NOETLING), as figured by HAAS (1955, Pl. 6, fig. 16). It is difficult, however, even if the genus *Hecticoceras* is certain, to determine the subgenus, due to insufficient material. The fine demarcation between more or less similar subgenera of *Hecticoceras*, such as *Lumloceras* and *Sublumloceras*, precludes a definite determination, so we must be satisfied with only a most probable systematic position for the present specimens.

Occurrence:—Specimens 1 and 2 are from [MD-18], 3 and 4 from [MD-11], both in river float of the Amaga River.

Hecticoceras (Lunuloceras) sp.

Pl. XXVIII, figs. 3, 4

Materials:—Some ill-preserved specimens completely compressed and partly fragmentary. No measurements can be given.

Description:—Somewhat involute whorls, of which the inner whorls are nearly smooth, with only small prorsiradiate swells instead of true ribs, later ornamented by falcooid ribs of which inner primaries strongly prorsiradiate and of high relief, suggesting those of *Brightia*. Secondaries bifurcate at the middle of sides and are slightly rursiradiate, but swing forward at the extremity. No trace of tuberculation is observable. A similar ribbing is known in the *Hecticoceras*, e.g. in *Hecticoceras (Lunuloceras) pseudopunctatum*, as exemplified by *H. pseudopunctatum* or by *H. regulare*. The sinuosity of the rib is much less in this group than in *Brightia*. The absence of tubercles also indicates that this is not a true *Hecticoceras s.s.*

The imperfect state of preservation precludes any specific determination.

Occurrence:—MD-92, MD-93, river bank of the Kipalaye River.

Stratigraphy

Mansalay municipality is located on the Southeast coast of Mindoro Island. Thick tropical soils and jungles cover the surface. The stratigraphical sequence can, however, be partly established along the valleys to the west of Mansalay. The formation is composed exclusively of detritic sediments, except for thin layers of tuffs, and is rather rich in fossil remains. Ammonites, belemnites and pelecypods, along with some other indeterminable fossils, are collected in situ. Thus, fossiliferous parts of the formation can be dated exactly. The sequence observable along the Mansalay, Amaga and Cagancan Rivers is as follows, from top to bottom:

10. Black sandy shale, very finely laminated, revealing the so-called flysch facies, yielding abundant animal trails on the surface of the stratification. About 150 m. thick.
9. Granule conglomerate and coarse-grained sandstone: white, very arkosic, with pebbles of slates, cherts, and other older consolidated sediments, and of andesitic rocks to a lesser degree, thickness unknown.
—————Relation unknown, fault contact—————
8. Lithic sandstone: bluish gray in color, medium to coarse grained, intercalated by several black shale layers 30–50 cm. thick. Total thickness unknown.
7. Black shale: typical pure lutite, not arenaceous, intercalated by gray dirty lithic sandstone layers 10 cm thick. About 250–300 m. thick. No fossils.
6. Alternation of black shale, white vitritic tuff and devitrified cream fine

Jurassic Mansalay Formation, Mindoro

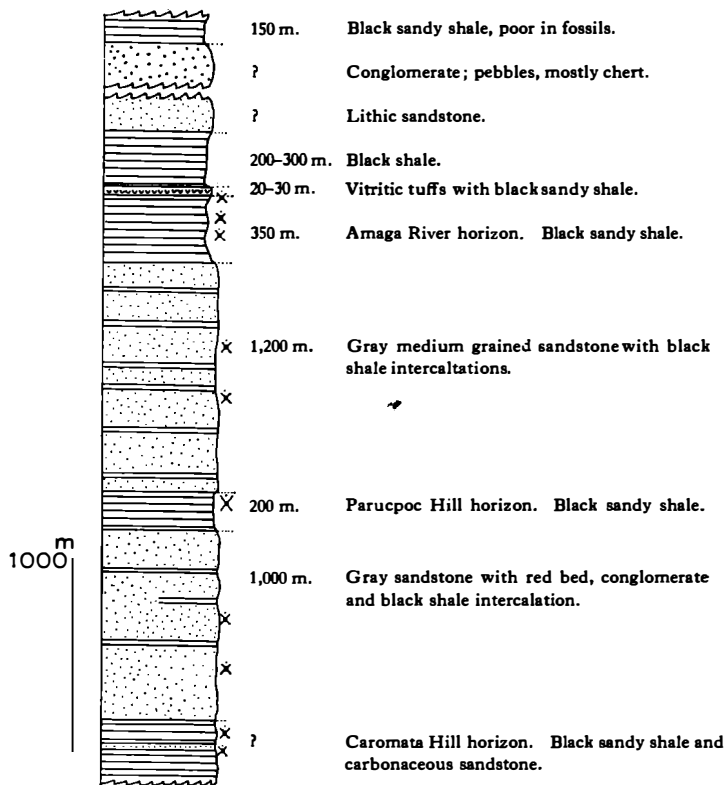


Fig. 2. Columnar Section in the Eastern Half of the Area.

tuff; this is a very characteristic and easily distinguishable marker horizon, traceable from the middle course of the Mansalay River to the lower course of the Amaga River. About 20-30 m. thick.

5. Amaga River horizon: black sandy shale or dark gray argillaceous siltstone with frequent intercalations of bluish gray clayey shale; relatively homogeneous in lithology; ammonites very common; fossil assemblage as follows:

Perisphinctes (Kranaosphinctes) cf. bullingdonensis ARKELL

Perisphinctes subgen. and sp. indet.

Euaspidoceras cf. hypselum (OPPEL)

Paraspidoceras cf. knechti (JEANNET)

Taramelliceras cf. trachinotum (OPPEL)

Myophorella orientalis KOBAYASHI & TAMURA

Inoceramus sp.

Pectinid sp.

Thickness about 350 m. The exposure of this horizon is best seen in the Amaga River and is hypothesized in the upper course of the Mansalay River.

4. Bluish gray, medium-grained, very compact sandstone; somewhat micaceous and arkosic, frequently interbedded with black sandy shale layers; yielding
Peltoceras sp. juv.
Phylloceras sp.
possibly *Perisphinctes* sp., *Myophorella* sp., *Plagiostoma* sp., collected from the river float near this horizon.
Thickness 1,200 m.
3. Parucpoc Hill horizon: black sandy shale with calcareous concretions; rich in ammonites; typically exposed in Parucpoc Hill and Hawili Creek, a tributary of the Cagancan River. Numerous ammonite specimens have been collected from the calcareous concretions in the black shale.
Parawedekindia arduennensis (D'ORBIGNY)
Parawedekindia sp.
Peltoceratoides sp.
Perisphinctes (*Kranaosphinctes*) cf. *bullingdonensis* ARKELL
Perisphinctes (*Kranaosphinctes*) sp.
Euaspidoceras? sp.
Campylites sp. (Pl. XXIX, figs. 2, 7)
Lissoceratoides sp. (Pl. XXX, fig. 1)
Astarte sp. ex gr. *spitiensis*
Myophorella sp.
and many other indeterminable ammonite species.
Thickness about 200 m.
2. Gray, fine to medium grained sandstone, very quartzose, and frequently intercalated by black, arenaceous, somewhat bituminous shale. In lower part thin layers of reddish brown sandy siltstone and granule conglomerate are inserted. Exposure in the Cagancan River (west of Hawili Creek), along the ridge west of Panaytayan, around point 622 (on the map) at the head of the Amaga River, and at Agbahag Point.
Calliphylloceras sp.
Proscaphites sp.
Perisphinctid sp.
Peltoceratid sp.
Myophorella sp.
Belemnites sp.
The age of the horizon probably does not differ much from the preceding.
Thickness roughly 700 to 1,000 m.
1. Caromata Hill horizon: black shale, frequently alternating with carbonaceous medium-grained gray sandstones: many animal tracks can be observed on the surface of the stratification; relatively rich in ammonites.
Hecticoceras (*Zieteniceras*) sp.
Perisphinctid sp.

Belemnites sp.

Cladophlebis-like plant impression

This horizon is observable at Caromata Hill, north of Nalbong Creek; probably correlative to the alternation of black shale and calcareous sandstone exposing along the upper course of the Kipalaye River (tributary of the Caguray River), judged from the similar fossil content (*Hecticoceras* [*Lunuloceras*] cf. *lumula* [REINECKE]). Thickness unknown.

—————Relation unknown, probably unconformity—————

Substratum.

Black carbonaceous shales and stratified dark carbonaceous sandstones, distinct from the above sequence, are exposed on a still larger surface in the drainage area of the tributaries of the Caguray River. Although some Jurassic fossils—*Phylloceras*, *Lytoceras* of the group *L. fimbriatus* (J. SOWERBY), *Hecticoceras* (*Lunuloceras*) sp., *Inoceramus galoii* BOEHM, *Aulacomyaella* sp. etc.—were discovered from the exposures of the Sipatag River, correlation even within the area is difficult, and their sequence is hard to establish.

There is a horizon characterized by boulder conglomerate with assorted gigantic boulders composed mostly of metamorphic rocks (green schist, quartz schist), consolidated detritic rocks and subordinate limestone. The limestone boulders yield Permian fusulinids. Another perceptible horizon is a sequence of red shale and sandstone seen at the lower part of the Kipalaye River. The stratigraphical relation to other known strata has not yet been determined. Hence the sequence given above represents merely a part of the Jurassic.

Correlation

The ammonite assemblage of the Amaga River horizon is essentially composed of *Perisphinctes* (*Kranaosphinctes*), *Euaspidoceras* and *Taramelliceras*. This combination of Upper Oxfordian genera is almost identical to the Perisphinctid assemblage reported by BOEHM (1908) and later by HUMMEL (1923) from the Mefa Beds of Buru Island. No Mayaitids occur in either assemblage. BOEHM believed that the Mefa Beds of Buru Island were somewhat younger than the well-known Wai Galo Ammonite Bed of Taliabu Island, because of the absence of Mayaitids and the existence of *Taramelliceras*. Thus the Amaga River horizon in Mindoro Island, should be slightly younger than both the Wai Galo Beds and Mefa Beds.

In turn, the Kantcote Sandstone of Cutch is certainly correlated to the *Bimmamatum* Zone, as it contains more developed Perisphinctids such as *Dichotomosphinctes* and *Discosphinctes*, in association with *Euaspidoceras*, *Taramelliceras* and many Mayaitids. Mayaitids in this sandstone are forms of a relatively later stage of phylogenetic development. It is therefore not directly comparable to the Amaga River horizon assemblage, because the

latter contains the typical *Perisphinctes* of the English *Plicatilis* Zone, *Kranaosphinctes*.

In Japan, the *Transversarium* Zone is represented by the K4 Zone of *Kranaosphinctes matsushimai* (Yambarazaka formation) of the Tetori Group (SATO, 1962). It occurs associated with a fragment of *Peltoceratoides*, but no other ammonite species have been discovered. A contemporaneous horizon is also hypothesized in the Nakanosawa formation of the Soma Group in Soma, but determinations of its ammonites are open to question.

The age of the Amaga River horizon is therefore that of the *Gregoryceras transversarium* Zone, probably its later part. It might extend, however, to a part of the *Epipeltoceras bimmamatum* Zone.

The Parucpoc Hill horizon is characterized by a fauna comprising *Parawedekindia*, *Perisphinctes* (*Kranaosphinctes*),* *Euaspidoceras* and *Campylites*. The above elements are strongly suggestive of contemporaneity with Dhosa Oolite of Cutch. The latter, which includes numerous Mayaitids, is correlated to the *Transversarium* Zone. But a difficulty arises from the absence of Mayaitids in the Parucpoc Hill horizon. The Wai Galo fauna in Taliabu also includes Mayaitids. As discussed above, the Wai Galo fauna should be of early *Transversarium* Zone age, and the Mefa Beds of later *Transversarium* Zone age. Since the Parucpoc Hill horizon underlie the Amaga River horizon, it must be older than the latter. The occurrence of *Kranaosphinctes* and *Parawedekindia* suggests a range from the late *Cordatum* to early *Transversarium* Zones. The complete lack of Mayaitids must be explained otherwise.

All the corresponding genera are found in Japan, but as they form no single definite zone they are not treated here.

The Caromata Hill horizon is difficult to date. *Hecticoceras* (*Zieteniceras*) is a genus suggestive of Lower-Middle Callovian. More associated genera are required to determine the precise age.

In general, all three ammonite horizons observable in the Mansalay formation are characterized by Pacific genera. Since the existence of an open seaway to Buru Island and the Sula Islands can be hypothesized, the connection to the Timor-East Celebes Geosyncline is clearly demonstrated. Since the fauna shows some affinity with the Japanese Upper Oxfordian, it can be safely assumed that the sea linked Japan to the Timor-East Celebes Geosyncline by the intermediate of Mindoro Island, so far as the Upper Oxfordian age is concerned.

The upper and lower limits of the Mansalay formation have not been determined. Even the fossiliferous sediments developed in the Caguray River cannot be placed exactly among the dated beds.

Geologic Structure

The area is apparently divisible into two sections which present different structural patterns, namely the section to the east of the water divide of the

island, and the section to the west.

The eastern section is drained by several small rivers, such as the Mansalay, Amaga and Cagancan, into the Tayabas Strait, and is characterized by a broad and gentle synclorium whose axis runs approximately NW-SE. The axial part is somewhat complicated by a fault parallel to the axis. The wing dipping to the east thus abruptly faces the opposite wing dipping to the west, by the intermediate of a disturbed zone due to the fault. Drag folds are frequently seen in the wings.

The deformation is judged to occur at the shallower part of the crust, because of the fact that all the folds are of flexure type. The argillaceous layers apparently suffered a strong internal disturbance, and slips are evident at the surface of the stratification. The sandstone, in turn, acted as a more rigid and competent bed. These features are all characteristic of this type of folding.

The western section is the drainage area of the upper tributaries of the Caguray River, and is structurally much more complicated by faults so that the stratigraphical correlation is difficult to establish. A picture of the geological structure which the western half presents is therefore not given here. To the west of Caromata Hill and its northern extension, the attitudes of the beds vary greatly from place to place. Faults resulting from some kind of block-movements postdated to the folding may be responsible for this complex structure.

The relation to the substratum of the Jurassic formation cannot be observed, but as discussed below, an unconformable relation would be expected between the Jurassic and the basement complex.

The Jurassic formation, in turn, is unconformably covered by an Eocene formation. The western part of the Jurassic exposure is bounded by the cliff-making Eocene limestone, along the line from the north of Mt. Naapog to Pocanil Point. The exposure of sandstones and shales on the river floor of the Sipatag River Gorge is clearly dated as Jurassic. Thus, Eocene organic limestones are judged to occupy the higher part of the mountain, lying unconformably on the eroded surface of the folded Jurassic formation.

Relation to the Metamorphic Rocks

The metamorphic rocks extensively distributed in the northern part of Mindoro Island are products of regional metamorphism. The key area where the relation between Jurassic formation and the metamorphic terrain might be observable is unfortunately not included in the surveyed area, hence the authors feel it premature to suggest the exact relationship between the two rock bodies.

It can, however, be pointed out that the conglomerate inserted within the Jurassic sequence includes boulders of metamorphic rock. Moreover, the general trend of the metamorphic terrain is NE-SW according to very

restricted observations near Puerto Galera; this is nearly vertical to the general fold axis of the Jurassic synclinorium. Even if it is not fully justified to say that this trend still holds in the southern part of the island, it is highly probable that the metamorphism took place before the sedimentation of the Jurassic, in other words, before the middle part of the Callovian. An unconformable relation could thus be expected to occur at the base of the Jurassic Mansalay formation.

The deformation pattern of the Jurassic formation also supports this view. It might act as a veneer at the time of the fragmentational phase of the metamorphic terrain. In fact, as was pointed out already, the Jurassic formation is folded at the shallower depth of the crust, as judged from the flexure type of folding.

The Jurassic Mansalay formation therefore plays a role in the post-orogenic sediments deposited in the depression formed on the surface of the metamorphic terrain, if the above observations are correct. The age, nature and deformation pattern of the formation are surprisingly similar to those of the Upper Jurassic Tetori Group in the Inner Belt of Southwestern Japan. In the case of the Tetori Group, the sedimentary basin in which it was precipitated is believed to have been formed along a fracture between gneissose and crystallophyllian terrains.

The older orogenic belt of the Philippine Islands is far more fragmented and difficult to reconstruct, but the Jurassic in Mindoro Island would offer a very important key to the problem.

Conclusions

1. The stratigraphical sequence of the Jurassic Mansalay formation is given, but due to the structural complexity, unclassified parts still remain.
2. The age of the Jurassic formation is from Middle Callovian to Oxfordian, so far as the fossiliferous part is concerned.
3. The relation between the Jurassic and metamorphic basement is assumed to be unconformable. The Jurassic, in turn, is unconformably covered by an Eocene formation.
4. The Jurassic formation is judged to have been deposited after metamorphism was completed. The deformation of the Jurassic formation occurred after the Oxfordian. Therefore two deformational phases are hypothesized in the southern part of Mindoro Island.

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1a



1b



2a



2b



3



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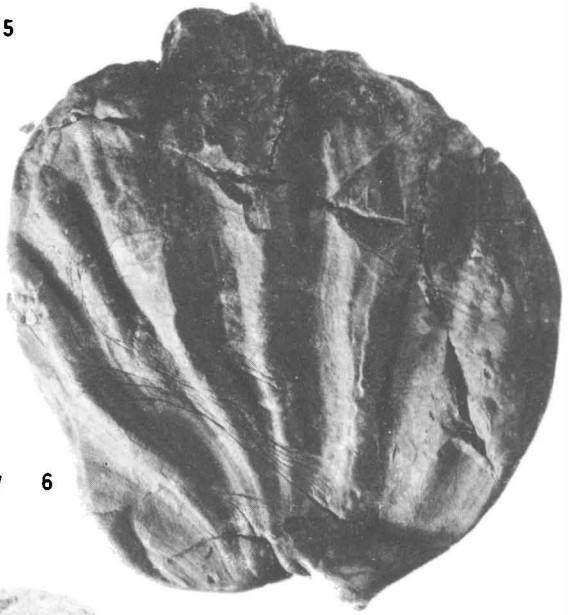
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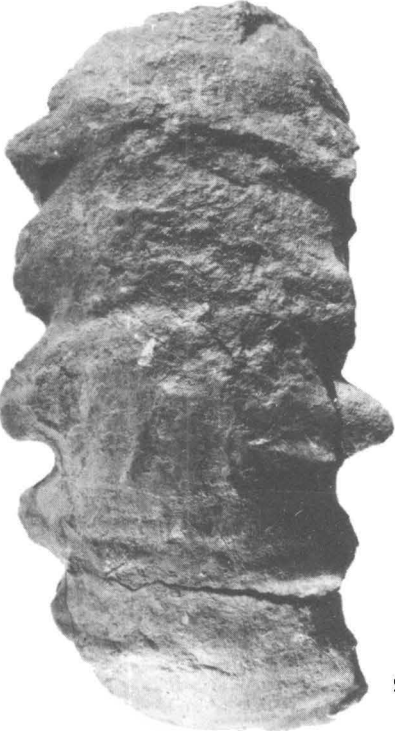
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7



6



9b



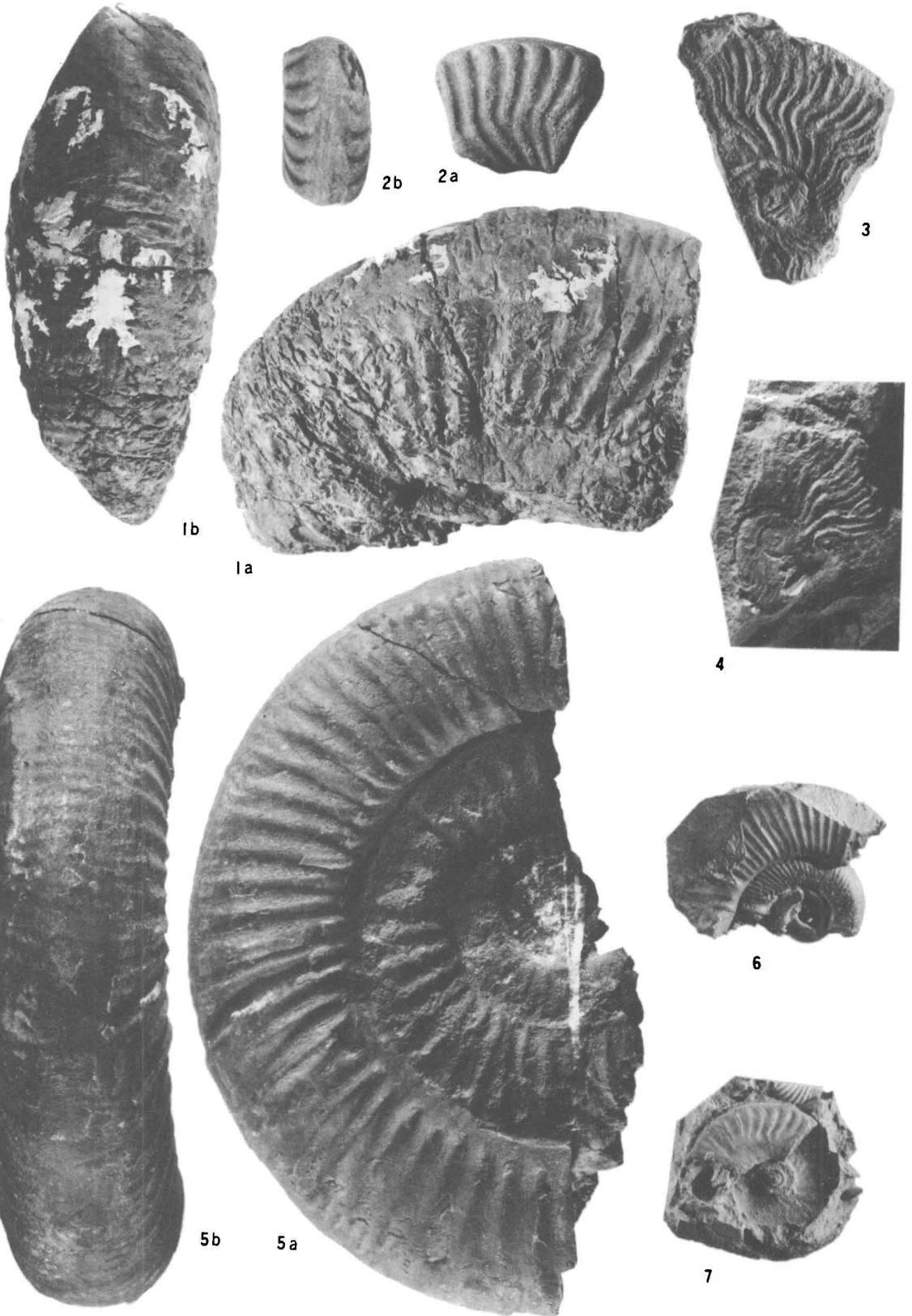
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