ON SOME ORDOVICIAN FOSSILS FROM NORTHERN MALAYA AND HER ADJACENCE

By

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With Plates XXIV–XXVII.

Lately I have described several Ordovician fossils collected from the Thailand-Malayan borderland by Mr. Saman BURAVAS, chief geologist of the Royal Department of Mines, Bangkok, Thailand (1958). Subsequently another collection was sent from the Geological Survey, Federation of Malaya, at Ipoh and this is the result of study.

According to Mr. Olive R. JONES, geologist of the survey, who made the collection, the fossiliferous formation of the Langkawi islands and the neighbourhood which he called "Setul formation" is tentatively divided into five parts in descending order as follows:

S_5. Upper bedded gray limestone, richly fossiliferous.....1,000′ thick.
S_4. Bedded limestone with shale lenses containing graptolites.....1,500′ thick.
S_3. Thickly bedded grey limestone with occasional fossiliferous horizons containing cephalopods and gastropods .....3,000′ thick.

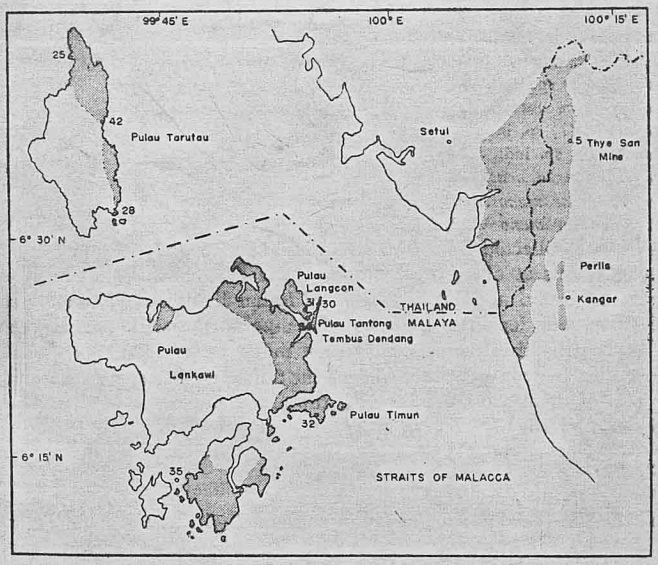

Figure 1. Map showing fossil localities (small circls) and Distribution of the Setul formation (shade).

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S_2. Massive white unfossiliferous limestone .....2,000′ thick.
S_1. Light coloured bedded limestone with brachiopods and some other fossils...100-200′ thick.

The Setul formation may be 7,500 to 8,000 feet or 2,300 to 2,500 meters in total thickness. It is underlain conformably by quartzites and shales which yield Upper Cambrian fossils at Tarutau island as I have described in a recent paper (1957). The fossils described in this paper were mostly collected from the middle limestone or the division S_3 at some localities on the Langkawi islands, Tarutau island and Perlis on the peninsula. (See Text-figure 1). They are shown in the table 1.

Armenoceras chediforme was first described from the Thung Song limestone at Ron Phibon near Thung Song in Peninsular Thailand. Three specimens of this species were procured at loc. 5, Thye San mine, northwest of Perlis. There they are accompanied by *Ormoceras* sp. indt. and *Lytospira rectangularis* which the last is closely allied to *L. norvegica* from the Llandeilian *Ogygiaschiefer* of Oslo, Norway. However, I have seen no *Armenoceras* in Eastern Asia which is older than Toufangian, or the Machiakou limestone in North China and the Tsuibon limestone in South Korea. In North America the genus most flourished in the Red River formation (FLOWER, 1957). The age of this faunule is probably Black River or younger.

The gastropod limestone of the Langkawi islands yields a copious fauna comprising the following fossils:

Hormotoma (?) spp. indt.
Helicotoma jonesi
Helicotoma (?) *costata*
Palaeomphalus giganteus
Lesueurilla zonata
Lesueurilla (?) sp. indt.
Malayaspira rugosa
Malayaspira (?) sp. indt.
Endoceras (?) sp. indt.
Ormoceras langkawiense
Discoceras (*Hardmanoceras*?) *chrysanthimum*
Discoceras (*Hardmanoceras*?) *laeviventrum*

They were collected from four localities (Locs. 30, 31, 32 and 34). *Malayaspira rugosa* occurs at all of these localities and *Helicotoma jonesi* and *Hormotoma* (?) sp. indt. are found at locs. 31 and 34 of Lulau Langgon. Therefore the fossil beds of these four localities must be contemporaneous with one another. It is further noteworthy that these beds are not much apart from the fossil bed at Kangar, Perlis, in geological age, whence the following four species were procured, because two of them are common with the above fauna.

Malayaspira rugosa
Ormoceras langkawiense
Actinoceras perlisense
Actinoceras sp. indt.

Thus the Langkawi gastropod fauna combined with the Kangar faunule consists of 9 species of gastropods and 6 of nautiloids beside an indeterminable form.

Helicotoma jonesi is a common gastropod which is intermediate between *H. sinensis* and *H. louderbacki*, if the sunken spires of these Chinese species are ignored. *H. sinensis* is a common membr of the early Neichiashan fauna the age of which is Llandeilian. *Helicotoma* (?) *costata* is allied to *H. ichimurai* from the Shorin formation in North Korea which is considered late Lower Ordovician, but distinct

ribs on the basal side of the whorl represent a remarkable characteristic of *costata*. In the Eastern Asiatic faunas the nearest to *Palaeomphalus giganteus* is *P. keizanensis* from the Tsuibon limestone of South Korea which is considered Caradocian in age.

None of the Asiatic gastropods appears to be close to *Lesueurilla zonata*, but it bears similarities to *Lecanospira* which suggests its possible derivation from this late Canadian genus. Among the Baltic gastropods, however, *L. helix* and *L. dilatata* from the *Vaginatenkalk* reveal resemblances with *zonata*, although *zonata* has zonal sculptures in the lower part of the whorl which are quite strange for *Lesueurilla* as well as *Lecanospira*. It is further a remarkable fact that *Palaeomphalus giganteus* agrees with "*Raphistoma*" *qualterium* and "*R.*" *scalitoides* both from the *Vaginatenkalk* in one or the other character. The resemblance of *H. jonesi* with "*R.*" *schmidti* from the *Orthocerenkalk* of the Oslo district, Norwey can hardly be overlooked.

In Central China *Helicotoma sinensis* is often found associated with *Discoceras eurasiaticum* in the Neichiashan formation. Likewise, *H. jonesi* is found together with two species of *Discoceras* at loc. 31. These nautiloids, however, bear similarities with *Hardmanoceras* which is so far endemic to Northwestern Australia in the late Canadian. The Malayan forms of *Discoceras* are, however, apparently more advanced than *Hardmanoceras lobatum* in the effacement of the radial ribs. Therefore it is reasonable to consider that the Australian form is a little older than the Malayan one.

According to FLOWER (1957) the oldest *Ormoceras* appears in the Chazyan in North America. In Eastern Asia *Actinoceras* occurs in the Toufangian, but most of the so-called *Actinoceras* in the Toufangian are better placed in *Armenoceras* or *Ormoceras*.

If emphasis is laid on the inclusion of the two species of *Actinoceras* in the Kangar faunule, its age may not be older than the Toufangian or Black River of North America. *Actinoceras* is, however, as yet unknown from the gastropod limestone of Langkawi and the majority of gastropods suggests Llandeilian or Chazyan for the age of its fauna.

Sinuitopsis cfr. *kochiriensis* is a solitary gastropod found at loc. 42, Wanderer bay, L. Tarutau. *S. kochiriensis* is a member of the Chikunsan fauna in South Korea whose age is Llandeilian.

Endoceroid, gen. and sp. indt. from loc. 28 on the south coast of L. Tarutau is too fragmentary to discuss the chronology.

In summarizing the above discussion, it is concluded that

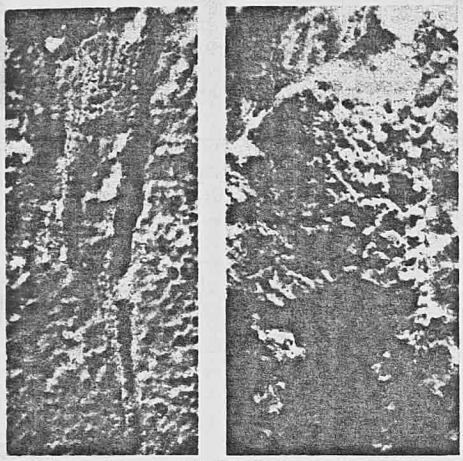
1. The gastropod limestone of Langkawi is probably correlated to the Neichiashan formation of Central China and the *Vaginatenkalk* of the Baltic region.
2. *Sinuitopsis* cfr. *kochiriensis* bearing horizon of L. Tarutau may be Llandeilian and close to the preceding.
3. The *Actinoceras* limestone of Kangar, Perlis, is probably a little younger than the gastropod limestone of Langkawi.
4. The *Armenoceras* limestone at Roh Phibon and Thye San mine is not older than Toufangian and most probably coeval with the Mohawkian or Black River-Trenton in North America.

The present collection contains an Obolid and Orthid brachipod (Nos. 40 and 41) and a sponge (No. 29) from the basal limestone or S_1 division of Pulau Jong (loc. 35). The sponge is, like *Archaeoscyphia*, conical, but much longer and slender and not annulated. Unfortunately they are all imperfect to carry

out a presise determination. The limestone is, however, most probably Lower Ordovician because the quartzite and shale formation which lies beneath the

Number in brackets: Locality Number / Number without brackets: Specimen number in JONES' collection / Diagonal cross: Specimen in BURAVAS' collection	Malaya					Thailand		
	Perlis	Langkawi islands				Bulau Terutau		
	Kangar Thye San Mine (loc. 5)	Pulau	Langgon	P. Tangong Tembus Dendang		Wanderer Bay (42)	South coast (28)	Ron Phibon
		East coast (31)	South end (34)	Northern part (30)	Pulau Timun (32)			
Hormotoma (?) spp. indt.		22	19, 20, 21					
Sinuitopsis cf. *kochiriensis*						11		
Helicotoma jonesi		7, 10	18	6				
Helicotoma (?) *costata*				9				
Palaeomphalus giganteus			14, 16, 17					
Lesueurilla zonata		7						
Lesueurilla (?) sp. indt.			13					
Malayaspira rugosa	×	8	2, 15	4, 6	5			
Malayaspira (?) sp. indt.			13					
Lytospira rectangularis	37							
Endoceras (?) sp. indt.		28						
Endoceroid, gen. et sp. indt.							27	
Ormoceras langskawiense	×			25				
Ormoceras sp. indt.	24							
Armenoceras chediforme	30, 31, 32							×
Actinoceras perlisense	×							
Actinoceras sp. indt.	×							
Discoceras (*Hardmanoceras* ?) *chrysanthimum*		3						
D. (H.?) *laeviventrum*		12						

Table 1. List or Ordovician fossils from the Thung Song limestone or/and the Middle limestone of the Setul formation.



(*a*) PP 2353 (*b*)

Fig. 2. Two indeterminable Sponges.
a. *Archaeoscyphia*-like sponge from loc. 35, (Specimen 29), ×2
b. Same specimen. (No. 29), ×5

P/2353

P,389

limestone is correlated to the fossiliferous Upper Cambrian of Tarutau island.

On Palau Langgon and Palau Tanjong Tembus Dendang graptolite shales are inserted in the Setul formation. Graptolites from the latter island are not well preserved, but BULMAN noted that there are

1. *Glyptograptus* or *Orthograptus* of *calcaratus* type suggesting high Ordovician for its age, and
2. *Monograptus* resembling *concinnus* or *regularis* of the Llandovery.

BALL and STRACHAN indentified a well preserved graptolites from the former island with *Monograptus clingani* of the middle Llandovery. On the basis of these finds JONES (1957) considered that the S_4 zone of the Setul formation is in a range from Caradocian to middle Llandovery.

The fossiliferous limestone of S_5 must be younger, but I cannot express any opinion for its chronology, because the collection comprises none from this division.

For the time being it is reasonable to consider that the Setul formation belongs wholly to the Silurian of the sense by MURCHISON. Its major part is, however, Ordovician and the boundary between the Ordovician and Gotlandian or Silurian of the narrow sense by LAPWORTH must be somewhere in the S_4 division.

Returning to the gastropods from the Langkawi limestone, it is a remarkable fact that the radial sculptures are sometimes unusually strong on the basal side but become weak or completely obsolete on the other side, as examplified by *Malayaspira rugosa*, *Lesueurilla zonata* and *Helicotoma* (?) *costata*. This mode of ornamentation is so rare in *Lesueurilla* and *Helicotoma* that I deem that these species may be segregated from these genera in future when a rich material can be examined.

Not only the affinity of *Helicotoma jonesi* with *R.* cfr. *sinensis* by GORTANI (1934), but the occurrence of endoceroids also suggest some alliance of the Langkawi fauna to the Llandeilian limestone fauna in Caracorum. There the gastropod limestone with *Raphistoma qualterium*, *R.* cfr. *sinensis*, *Lesueurilla de-filippi* and others lies on the cephalopod limestone containing *Vaginoceras* and *Orthoceras*.

It is certain that the Himalayan geosyncline was the main route of migration through Eurasia, but the route to the west of Caracorum is obscure. Gastropods and cephalopods are apparently uncommon in the Ordovician formations in

Central Asia and the Ural mountains, although *Endoceras* is reported to occur in these regions and *Lophospira*, *Cyclonema* and *Orthoceras* is known from Kazakstan (BELIAEVSKY et al., 1958). Incidentally, *Lophospira* is not restricted to the Arcto-American-East Asiatic provinces. Many KOKEN's species of *Worthenia* from the Baltic Ordovician were transferred by TEICHERT (1932) to this genus. *Lophospira* and *Pagodispira* or *Donaldiella* are known from the Lower Ordovician of Smóla island Norway, the Durness limestone of Scotland and the Middle Ordovician and later rocks in the Girvan and other districts of Britain (STRAND, 1932, DONALD, 1902, '06).

As noted on the previous occasion (1958), the occurrence of *Actinoceras*, *Armenoceras* and *Ormoceras* in the Thailand-Malayan border is a remarkable fact, because the cephalopods from South China, Burma and the Himalaya which were placed in these genera or *Gonioceras* are found to be erraneous references. The presence of actinoceroids in these regions is now a question. In Korea and North China on the other hand the actinoceroids are well represented in the Ordovician fauna. It is known now that the Toufangian fauna of Eastern Asia was connected with the related ones of North America and Arctic regions through Siberia as proven by the followings (BELIAEVSKY et al., 1958):

1. *Actinoceras bigshyi* in the Llandeilian Krivolutsk formation of the Siberian platform.
2. *Armenoceras holtedahli* from the Siberian platform.
3. *Armenoceras* cfr. *holtedahli* from the Upper Ordovician of Kotelny island, New Siberia.

Armenoceras holtedahli was originally described by STRAND (1933) from the gastropod limestone of the Oslo region, Norway, but as pointed out by TEICHERT (1930) and STRAND, the Upper Ordovician cephalopods of the Baltic region are intimate to those of the Arcto-American ones. The actinoceroids of the Thailand-Malayan border are connecting links in the distribution of the Toufangian terrain of Eastern Asia to Australasia where they are known from Central Australia and Tasmania.

Finally, it is a great interest to see that *Discoceras* which was thrived in the Baltic region in the Middle and Late Ordovician period (STRAND, 1930, SWEET, 1958) is fairly common in Central China. There are some in Yunnan, Burma and the Himalaya which are suggestive of the Himalayan geosyncline for the route of migration of *Discoceras*. Two Malayan species of *Discoceras* are each represented only by a single specimen. Nevertheless, they show the alliance to *Hardmanoceras lobatum* TEICHERT and GLENISTER (1952, 54) from the Upper Canadian of the Desert basin, Australia, or probably a step advanced from that species. It is further noteworthy that *Trocholitoceras idaense* TEICHERT and GLENISTER (1953) from the Upper Canadian of Tasmania bears some characters of *Trocholitoceras* as well as *Discoceras*. Though the material so far obtained are fragmental, the Western Pacific may be the cradle of *Discoceras*, *Hardmanoceras* and *Trocholitoceras*.

Now it is found that Northern Malaya and Peninsular Thailand are located at a cross road in the Ordovician palaeogeography. The JONES' collection which I studied is not a big one, but allowed me to grasp some significant aspects. When I received it, many of them looked poorly preserved, but fortunately their silicification admitted me to isolate them from mother limestone. This painstaking work was taken up and carried out very carefully by my assistant, Mr. Takeo ICHIKAWA to whom I am very much obliged for his service. I am happy to have the opportunity to study this valuable collection and wish to thank most cordially to Director J. B. ALEXANDER, Messrs E. F. BRADFORD and C. R. JONES of the Geological Survey, Federation of Malaya.

Description of Fossils, Gastropoda

Family Sinuitidae KOKEN

Genus *Sinuitopsis* PERNER, 1903

Sinuitopsis cfr. *kochiriensis* KOBAYASHI, 1943

Plate XXIV, Figures 4 a–b

1933. cfr. *Sinuitopsis kochiriensis* KOBAYASHI, *Jour. Fac. Sci. Imp. Univ. Tokyo, Sect. 2, Vol. 3, Ft. 8*, p. 360, pl. 5, figs. 1–4.

Shell planispiral, composed of about 4 volutions, gradually expanding; umbilicus wide open; whorl subovate or roundly subpentagonal in cross section, depressed, subangulate on lateral sides at about one-fourth from suture where it is broadest; dorsal wall somewhat roof-shaped, but well rounded on top; surface marked by fairly strong radial ribs which are swinging back from the angulation to form V-shaped sinuation on periphery; slit-band absent.

A solitary specimen (No. 11) is 9.5 mm. in diameter where the last whorl is 5.3 mm. high and 4.2 mm. broad.

This species cannot be included in *Owenella*, because the whorl is much broader, umbilicus narrower and radial striae are fine and numerous in that genus. In the typical forms of *Sinuitopis* the whorl is more compressed laterally. *S. neglecta* PERNER, 1903, from the Ordovician of Bohemia is the type species of *Sinuitopsis*. It differs from this species in the well rounded whorl and very fine ornamentation. *S. nodosa* PERNER, 1903, is another Bohemian species to which these distinctions are also applicable. In addition, it has constrictions which are unusual for the genus. *S. congruens* REED, 1918, from the Balclatchie of Girvan, Scotland, is different from this species in the rounded umbilical edge, U-shaped sinus and more slender surface ornements.

In my opinion this species is most closely related to *S. kochiriensis* from the Chikunsan shale of South Korea, although the specific identification is hesitated. The lateral angulation is found in that species closer to the periphery. As the result the dorsal wall looks nearly flat, instead of roof-shaped in this species. Beside the ribs it has fine threads, but such fine sculptures are absent in this species, if not unpreserved on the specimen. A better material, when uncovered, will enable one to erect a new species for the Malayan form.

Occurrence :—Loc. 42 (Specimen No. 11).

Family Pleurotomaridae D'ORBIGNY

Genus *Hormotoma* SALTER

Hormotoma spp. indt.

Plate XXV, Figures 6, 7a–b

There are some imperfect specimens which are tentatively referred to *Hormotoma*. One No. 22 has an obtuse angulation near the midheight of the whorl. The shoulder plane above it is flat or slightly concave, while the wall is subvertical and rounded below the angulation.

The specimen No. 21, on the contrary, has no angulation, but the whorl surface consists of a broad nearly flat upper part and a narrow rounded lower part. The former is longer than twice the latter part. Compared to the preceding form, this spire appears to be composed of more numerous volutions.

The specimens Nos. 19 and 20 are more similar to the specimen No. 21 than the one No. 22 in the lack of angulation, but these whorls are well rounded and

most expanded near the middle height. No aperture is preserved in these specimens.

Occurrence :—Loc. 34 (Specimens 19–21) and Loc. 31 (Specimen 22).

Family Euomphalidae DE KONINCK

Genus *Helicotoma* SALTER, 1859

Helicotoma jonesi KOBAYARHI, new species

Plate XXIV, Figure 5; Plate XXVI, Figures 5 a–b; Plate XXVII, Figures 9 a–c; Text-figs. 3 b, e.

Description :—Shell discoidal; spire composed of 4 or 5 volutions, slightly sunken below the level of the carina of the last whorl and expanding fairly rapidly; whorl subquadrate in cross section; upper wall gently inclined inward from shoulder but becomes steep just before contact with the preceding whorl; suture running one-third to a half of height of inner whorl below the shoulder; outer wall moderately convex and meets with well rounded basal wall without angulation; carina increases its prominence through growth; umbilicus broad, open and deep.

Observation :—The specimen No. 10 is 17 mm. in diameter where the last whorl is about one-third as wide as the diameter, but its upper wall inclusive of the carina is no more than one-third of the diameter. The specimen No. 18 which is the holotype is about the same as the preceding in size. This shows the section of the whorl. The surface sculptures are obscure in these specimens, but by cross light growth lines appear to form V-shaped sinus and a little notched at the carina.

The specimen No. 7 which is 5 mm. in diameter was procured from the same locality with the specimen No. 10 and is considered probably an immature form of this species. The last whorl occupies one-third the diameter in the apical view, but broader in the basal view. The spire is scarcely sunken. The whorl section is subquadrate, but well rounded on the basal side. The umbilicus is a little narrower than one-third the diameter of the shell and very deep.

The specimen No. 6 which is laterally compressed is 16.3 mm. in diameter where the last whorl is 6 mm. Its spire consists of more than 3 volutions.

Comparison :—This species is closely allied to *Raphistoma sinensis* FRECH, 1895, which is widely distributed in the middle and lower Yangtze valley, Central China. It was first described from Lunshan near Nangking, Prov. Kiangsu, but found later more common in Prov. Hupeh as repeatedly described by FRECH (1911), YABE and HAYASAKA (1920) and GRABAU (1922). Since the last author placed it in *Eccyliopterus*, this reference is generally accepted by Chinese geologists and it is known to be a leading member of the Neichiashan fauna.

R. sinensis has never been described in detail. However, insofar as can be judged from their illustrations, it is distinct from *Helicotoma jonesi*, because the spire is more depressed, the upper wall of the whorl has greater inclination and the last whorl is usually narrower than one-third the diameter of the shell. The whorl section is best shown by GRABAU's specimen which is not so triangular as supposed by FRECH and more similar to the section of this species.

Eccyliopterus louderbacki ENDO, 1932, from the Hanchung basin, Central China, is another ally to this species, but has the spire more roundly expanding. In the rate of expansion *jonesi* is intermediate between *sinensis* and *louderbacki*. The upper wall of the whorl is more steeply slant in *louderbacki* than in *jonesi*.

The whorl of *louderbacki* is trigonally ovate and its spire well sunken as in *sinensis*. *Eccyliopterus shirakii* KOBAYASHI, 1934, from the Tsuibon limestone of South Korea is less similar to this species, because not only these distinctions apply to *shirakii*, but also because there is an angulation on the basal wall of *shirakii*.

The spire is scarcely sunken and the whorl more quadrate in *R.* cfr. *sinensis* by GORTANI, (1934) from Caracorum. *Raphistoma schmidti* KOKEN (in KOKEN-PERNER, 1925) from the *Orthocerenkalk* of Norway is similar to this species, but this shell again has the flat apical side.

None of the above species indicates loose coiling of the spire as diagnostic of *Eccyliopterus* RÉMELÉ, 1888, which is synonymized with *Ecculiomphalus* PORTLOCK, 1843, by KNIGHT (in SHIMER and SHROCK 1949).

The present species has the sunken spire, but the sinking is very slight. The whorl looks quadrate rather than trigonal in section and has a marginal carina. Though rather indistinct, growth lines appear to make a weak selenizone on the carina. Although the spire is commonly a little protruded, such a form as *jonesi* is plausible to place in *Helicotoma* rather than *Eccyliopterus*.

Occurrence :— Loc. 30 (Specimen No. 6), Loc. 31 (Specimens Nos. 7 and 10) and Loc. 34 (Specimen No. 18).

Helicotoma (?) *costata* KOBAYASHI, new species

PM2331 Plate XXV, Figures 1 a–c; Text-fig. 3 d.

Description :—Shell discoidal with spire in a level and slowly enlarging; whorl subquadrate in section; upper wall a little convex and limited by an obtuse angulation on each side; inner wall steeply slant from the angulation; peripheral band on upper wall indistinct and narrow, if present; outer and lower walls well rounded and marked by relatively coarse, numerous ridges which are swinging back on outer wall as they ascend; umbilicus broad and open.

Comparison :— Specimen No. 9 is, though imperfect, quite distinct from *H. jonesi* in the slow coiling and other features. Unfortunately, however, growth lines are ill-preserved and the peripheral band or selenizone is obscure on the upper wall. Nevertheless, this species is similar to *Helicotoma ichimurai* KOBAYASHI, 1931, from the Shorin formation of North Korea, although the rate of expansion of the whorl is a little greater and the umbilicus relatively small in that species. The coarse ridges on the outer and basal walls represent a feature very rare in *Helicotoma*.

This species is allied also to *Raphistoma* cfr. *sinensis* by GORTANI (1934), but his form is coiling more rapidly and the top is literally horizontal.

The specimen is 30 mm. in diameter where the last whorl is 8 mm. broad.

Occurrence :—Loc. 30 (Specimen No. 9).

PM2332-25-2
PM2333-25-3
PM2334-26-3

Genus *Palaeomphalus* KOKEN, 1925

Palaeomphalus giganteus KOBAYASHI, new species

Plate XXV, Figures 2 a–c, 3 a–c; Plate XXVI, Figures 3 a–c; Text-fig. 3 a.

Description :—Shell somewhat lenticular with apical angle of about 120 degrees; spire composed of 7 or 8 volutions which are expanding gradually; shoulder increasing its prominence through growth to form terraces; cross section of whorl subquadrate; upper wall gently slant and forms an acute angle with lateral wall, but the inclination of the former decreases till at length the wall of the

last whorl becomes horizontal; lateral and basal walls well rounded and gradually bent up into umbilical side; umbilicus half as wide as shell-diameter and largely open; suture running shortly below shoulder; growth lines deeply sinuate and protruded into shallow slit which yields a narrow band along periphery of upper wall; stout ribs appear on basal side of last whorl.

Observation:—This species is represented by three specimens. The largest one, No. 14, which is the holotype is, if complete, more than 65 mm. in diameter and probably as high as 35 mm. The shoulder angle of the last whorl is distinctly produced in the grown stage. Rugose ribs are well marked on this whorl from the lower half of the outer wall to its umbilical wall. There is no angulation on the basal side of this whorl, but the umbilical angulation is known to be distinct in the ealier whorls. The umbilicus is open as far as it is embraced by last four volutions.

A small specimen No. 18 is compressed laterally, its major diameter being 28 mm. and its minor one 24 mm., if complete. The spire is composed of 6 volutions. The umbilical angle is very distinct; the umbilicus a little narrower than a half of the shell-diameter and its apical part closed. Some revolving ribs are seen on the basal wall of last whorl near the umbilicus. Thus these specimens are fairly different in the basal view and the spire appears to coil more slowly in the second than the first specimen.

The third specimen is imperfect, but it is important to see its being an intermediate form between the above two specimens. Namely, in the mode of coiling and other features in the apical and lateral views it agrees with the first specimen, although the umbilical angulation is as strong as that of the second specimen.

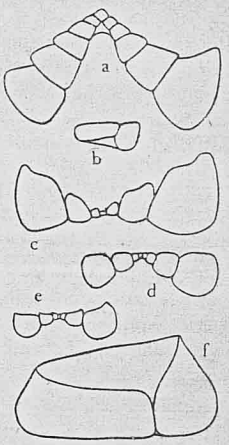


Fig. 3. Diagrammatic sections and side views of some gastropods.
a. *Palaeomphalus giganteus*, (×0.5)
b. *Helicotoma jonesi*, immature, (×2).
c. *Malayaspira rugosa*, (×1).
d. *Helicotoma* (?) *costata*, (×3/4).
e. *Helicotoma jonesi*, mature, (×1).
f. *Lesueurilla zonata*, (×3/4).

Comparison:—An immature form like the second specimen looks similar to *Ophileta* in the apical view, but the spire is higher and the umbilicus much broader in *Ophileta*, because of the slow revolving of the spire. As the general outline is lenticular and the spire coils with moderate rate of expansion, this species somewhat resembles *Liospira*, but in this species the spire is stepping down through distinct shoulders and the calcareous deposit is not well developed in the umbilicus.

Among the Baltic gastropods *Raphistoma scalitoides* KOKEN and *R. qualterium* WAHLENBERG, both from the *Vaginatenkalk* (KOKEN-PERNER, 1925) reveal some similarities with this species, but *R. scalitoides* has the taller whorl and narrower umbilicus and *R. qualterium* possesses the spire lower and non-terraced.

Palaeomphalus keizanensis (KOBAYASHI), 1958, from the Tsuibon limestone of South Korea is the nearest in the Asiatic fauna, but it can be easily distinguished from this species by the more rapid growth of the whorl, greater developement of the shoulder and the smaller umbilicus. KNIGHT (in SHIMER and SHROCK,

1949) is of opinion that *Palaeomphalus* is congeneric with *Helicotoma* SALTER, but there are some differences in the peripheral carination and other features. The peripheral band of this species is flat except for the final stage when the shoulder angle becomes a salient keel as typically seen in *Helicotoma*. The rugose sculpture in this stage is a very distinctive characteristic of this species.

Occurrence :—Loc. 34 (Specimens Nos. 14, 16, 17).

Genus *Lesueurilla* KOKEN, 1898

Lesueurilla zonata KOBAYASHI, new species

Plate XXIV, Figures 6 a–d; Text-fig. 3 f.

Description :—Shell discoidal, with horizontal base; spire composed of some 4 volutions, profoundly depressed; whorl rapidly expanding; its section much higher than broad, subtrigonal and somewhat protruded up, forming a salient keel which is sharply truncated and flat on top; inner wall steeply slant from keel with distinct concavity and in contact with the preceding whorl at two-thirds of its height; outer wall similarly inclined as the inner wall, but straight or more or less convex and gradually rounded toward flat base; elevated and depressed bands of unequal breadth alternating on outer wall, sharply edged or even ridged and ornamentated with fine lines parallel to the bands; these lines and bands arcuate and most protruded forward at about one-third of whorl height; inner wall marked with very fine diagonal lines of growth which are receding as much as they ascend; thus they form Vs with growth lines on outer wall, apparently in addition to shallow sinuation on the carina.

Comparison :—This species is represented by a specimen No. 7 which is 44 mm. in diameter. The last whorl is 15 mm. broad and 21 mm. high.

In the general outline it resembles *Maclurites*, but can easily be distinguished from that genus by the presence of carination. Insofar as I am aware, *Maclurea helix* EICHWALD and *M. dilatata* KOKEN from the *Vaginatenkalk* which were later referred to *Lesueurilla* by PERNER (1925), agree best with this species in the flat base of the spire, its rate of expansion, tall whorl and most other features, but their inner wall does not show such remarkable concavity, as seen in this species. *Maclurea infundibulum* KOKEN from the *Unterer grauer Orthocerenkalk* (KOKEN-PERNER, 1925) which is the type of *Lesueurilla*, and many other species of the genus have the cancave umbilicus. Their whorls are sometimes tending to be detached from one another, although *Lesueurilla* is not so far advanced as *Eccyliomphalus* or *Ecculiopterus* along the trend of loose coiling.

Lecanospira biconcava ULRICH and BRIDGE (in BRIDGE, 1930) has the umbilicus slightly concave. The concavity of the umbilicus is stronger, while the spire is scarcely sunken from the level of the last whorl in *Ophileta alturensis* SARDESON, 1896, which was referred to *Lecanospira* by ULRICH and BRIDGE. In the typical forms of *Lecanospira*, however, the spire is depressed, the base flat and the whorl subtrigonal in cross section and keeled on the top. *Ophileta compacta* SALTER (in KNIGHT, 1941) which is the type of the genus is especially allied to this species in the subtriangular whorl section with the concave inner wall. In *Lecanospira*, however, the spire consists of more numerous volutions which are very slowly expanding. In my opinion it is probable that such a form as *L. zonata* can be derived from *Lecanospira*, but the banded structure on the outer wall of the last whorl is the speciality of this species which I could not find either in *Lecanospira* or in *Lesueurilla*.

Occurrence :—Loc. 31 (Specimen No. 7).

Lesueurilla (?) sp. indt.

Plate XXVI, Figures 6 a–b

PM2336

This species looks to be allied to the preceding in the descendant spire, high subtrigonal whorl section and distinctly concave inner wall. The whorl is higher in this than that species and angulated on the top but scarcely protruded. The basal wall is well rounded; basal umbilicus concave to some degrees. The spire is composed of about 5 volutions. Ribs on the outer wall are narrower than their interspaces and running diagonally on the outer wall.

This species resembles *Maclurites niuhsintaiensis* (KOBAYASHI), 1930, or *M. nitida* by ENDO, 1932, from the Toufangian of South Manchuria, in the high whorl and strong angulation, but the whorl is enlarging more rapidly, its base flat, the inner wall convex and the apical umbilicus much narrower in *niuhsintaiensis*.

The specimen No. 13 is 32 mm. across and about 23 mm. high. Although it is poorly preserved to make a precise comparison, it is very similar to the preceding species in many characteristics. The whorl is, however, not distinctly carinated in this species.

Occurrence :—Loc. 34 (Specimen No. 13).

Genus *Malayaspira* KOBAYASHI, 1958

1958. *Malayaspira* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 29*, p. 226.

Diagnosis :—Shell discoidal with flat base; umbilicus wide open; spire sunken as far as basal walls of whorls become almost in the same plane; whorl expanding gradually; its cross section subquadrate; top wall narrow, flat or concave and carinate along periphery; three other walls more or less convex; growth striae rugose, sinuated on top and produced behind into shallow notches at carina.

Type-species :—*Malayaspira rugosa* KOBAYASHI, 1958.

Remark :—This genus resembles *Lecanospira* in the depressed spire and flat base, but *Lecanospira* can easily be distinguished from this genus by the subtrigonal whorl section with an acute crest and more numerous whorls. In the rate of expansion and cross section of the whorl this genus is closer to *Helicotoma* than *Lecanospira*. In *Helicotoma*, however, the spire is often elevated and never so much depressed as in this genus. The upper wall is broad and in contact with the outer wall of the preceding whorl and the peripheral carination is more prominent in *Helicotoma* than in this genus. In this genus the top wall is very narrow and the inner wall which is slightly convex is contact with the outer wall of the preceding whorl at about its middle height.

It is remarkable that surface sculptures are stronger on the outer and basal walls than on the others in the type-species. In the angulation between the upper and inner walls, this resembles *Ophiletina*, but the whorl section is hexagonal, the outer wall bisected by a median carina and the last whorl becomes out of contact in the typical forms of *Ophiletina*.

Distribution :—Ordovician; Southeastern Asia.

PM2337-24-1
PM2335-24-2
PM2339-24-3

Malayaspira rugosa KOBAYASHI, 1958

Plate XXIV, Figures 1 a–c, 2, 3 a–c; Text-fig. 3 c.

1958. *Malayaspira rugosa* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 29*, p. 227, pl. 18, figs. 1a–c.

Four specimens of this species are contained in JONES' collection. The largest (No. 8) of them measures about 41 mm. in diameter. It is composed of 5 volutions and the last whorl 15.2 mm. broad, but the original breadth may be a little different because the whorl is destructed.

The specimen No. 4 is better preserved, but a little smaller than the preceding. Its inner whorls are unpreserved, but the ultimate and penultimate ones show the rapid descendance of the spire, the gradual expansion of the whorl and other features.

The whorl is subquadrate in cross section, higher than wide and somewhat narrowing upward. Growth lines bear rugose appearance on the outer and basal sides, slightly convex to the adapical side on the basal wall, and subvertical in the lower half of the outer wall, but swinging back in the upper half, they form V-shaped sinuation on the summit carina where they appear slightly notched behind and strengthened in form of a chain of nodes. The upper wall is gently slant inward with weak concavity and meet with the subvertical inner wall by an obtuse angulation. The growth lines become less oblique on the inner than the upper wall.

The specimen No. 2 is somewhat compressed laterally and the spire less depressed than the others, but otherwise it is diagnostic and the surface sculptures are especially well preserved and somewhat depressed in basal view.

Specimen No. 5 is a small, ill-preserved specimen which is laterally compressed. The sunken spire suggests that the specimen No. 15 is probably a poor specimen of this species.

Occurrence :— Loc. 30 (Specimens Nos. 4 and 6), Loc. 31 (Specimen No. 8), Loc. 32 (Specimen No. 5) and Loc. 34 (Specimens Nos. 2 and 15).

Malayaspira (?) sp. indt.

PM2340

Plate XXV, Figure 4.

This form is represented by an incomplete shell which appears to be the basal wall similar to that of *Malayaspira rugosa*, but more convex. The inner whorls are distinctly depressed below the outer and their suture is profound. Surface sculptures are much finer than those of *rugosa*. The shell is 45 mm. in diameter; last whorl as wide as 14 mm.

Occurrence :—Loc. 34 (Specimen No. 13).

Genus *Lytospira* KOKEN, 1890

Lytospira rectangularis KOBAYASHI, new species

PM2341

Plate XXV, Figures 5 a–c

Description :—Shell horn-shaped with no plane of symmetry. In lateral view, however, the horn looks to be composed of a transverse and longitudinal part which are disposed almost rectangularly, although the former part transmits into the latter gradually without forming an angle; shell expanding more rapidly in the former than in the latter part; cross section trigonally ovate; convex side a little narrower than flanks, sharply defined by angulation and bipartate by a low obtuse median ridge. Apertural margin appears profoundly sinuated on this side. Nucleus unpreserved.

Comparison :—This species is very similar to *Lytospira norvegica* KOKEN from the *Ogygiaschiefer* of Oslo (KOKEN-PERNER, 1925). It is, however, very unlikely that this shell is sinuated on the upper edge as seen in *Euomphalus angelini*

LINDSTRÖM, 1884, which is the type-species of *Lytospira* KOKEN.

Occurrence :—Loc. 5 (Specimen No. 37).

Nautiloidea

Family Endoceratidae HYATT, 1883

Genus *Endoceras* HALL, 1844

Endoceras (?) sp. indt.

Plate XXVI, Figures 4 a–b

PM2342

A siphuncle 98 mm. long, longiconic, gradually tapering with the rate of 1 mm. in 7 to 8 mm and very slightly arcuate; its cross section subcircular, but a little depressed dorso-ventrally and somewhat flattened on convex side; endocone subcentral, longiconic and subcircular, but more or less flattened on the convex side of the siphuncle; endosiphuncle crescentic in section with convexity on concave side of the siphuncle and located a little close to this side, its breadth being narrower than one third as wide as the siphuncle; surface annulated; annulations and constrictions seemingly straight, equally weak and about same in length and running apparently all around the siphuncle; 4 annuli and 3 intervals distributed in the length of 12 to 14 mm.

The flattening of the endocone and the convexity of the endosiphuncular section suggest that the siphuncle is exogastric. If this orientation is correct, it must be a member of the Basslerocerati dae, instead of the Endoceratidae or Cyrtendoceratidae, and there is no species known from Eastern Asia which is comparable to this species. The curvature of the siphuncle is, however, neither strong nor quite regular. It is probably due to the twisting of the siphuncle at least to some degrees, which must be the secondary modification. The flattening of the siphuncle does not match with its curvature exactly and it suggests that the siphuncle was possibly located marginally. The surface of the siphuncle is not well preserved and it is indeterminable either holo- or ortho-choanitic.

The dorso-ventral diameter of the siphuncle is 6.5 mm. at the adapical end, but enlarges to 16.5 mm. in the length of 7.5 cm. From this siphuncle it is inferred that the conch is fairly large and rapidly expanding and has numerous short camerae. In view of the large siphuncle, its rapid expansion and developed internal structure, it looks to be more likely an endoceroid rather than an *Avaoceras* or any other genus of the Basslerocerati dae.

Occurrence :—Loc. 31 (Specimen No. 28).

Endoceroid, gen. and sp. indt.

Plate XXVII, Figures 2 a–b

PM2343

A fragmentary siphuncle, about 30 mm. long, elliptical in cross section which is 12.5 mm. by 10.5 mm. at the adapical end whereas the longer or lateral diameter is 16.5 mm. at the other end. The endosiphuncle is subcentral, crescentic in cross section, a little broader than one third the lateral diameter at the narrow end; surface ill-preserved, but apparently non-annulated.

This siphuncle resembles the preceding in the rate of expansion and the section of the siphuncle, but its preservation is too poor to say their relationship.

Occurrence :—Loc. 28 (Specimen No. 27).

Family Ormoceratidae SAEMANN, 1852

PM2344-27-3
PM2345-27-4
PM2346-27-5

Genus *Ormoceras* STOKES, 1852

Ormoceras langkawiense KOBAYASHI, new species

Plate XXVII, Figures 3 a–b. 4 a–b and 5 a–b

1958. *Stereoplasmoceras* (?) sp. indt. KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 29*, p. 227.

Specimen No. 25 is the holotype of this species. It is 20 mm. in length in which 10 camerae are distributed. On the polished section through the siphuncle it is seen that the siphuncle is subcentral and 3 mm broad in the adoral part where the conch is 17 mm. broad. The diameter of the siphuncle is nearly the same at the other end of the specimen. The septum is gently convex to the adapical side as much as a septal interval and recurving at the neck to describe a small loop. There the siphuncle is contracted to one-third the diameter of the nummulus. The neck ring is small and nearly circular in longitudinal section. The episeptal deposit is thickened proximally.

In BURAVAS' collection there were two specimens which are thought to belong to this species. On the previous occasion it was suggested to be an ormoceroid, but it was called *Stereoplasmoceras* (?) sp. because no siphuncular structure was known. The larger one of the two specimens was already described in some detail. The smaller one is about 30 mm. long. Its diameter is 7.5 mm. at the adaptical end where it is circular. The siphuncle is located near the center and about one fifth as wide as the conch. Eight septa and seven camerae are distributed in the length of 8 mm. in the middle part of the specimen.

Occurrence :—Loc. 30 (Specimen No. 25); Kangar, Perlis (BURAVAS collection).

Ormoceras sp. indt.

PM2347

Plate XXVII, Figures 1 a–b

Specimen No. 24 is a phragmacone of 37 mm. in length in which 8 camerae are countable. The conch is apparently cylindrical and nearly circular; siphuncle narrow and central. In the polished longitudinal section the former is 30 mm. in diameter where the latter is 8 mm at the middle of the siphuncular segment and 3.3 mm. at the septal neck. It is seen on the section that the septal depth corresponds to about twice the septal interval, the septum is regularly convex and describes a small semi-ellipse at the neck; connecting ring semi-circular in section; neck ring small; episeptal and hyposeptal deposit well developed and meeting each other in early camerae, forming a pseudoseptum.

Occurrence :—Loc. 5 (Specimen No. 24).

Family Armenoceratidae FOERSTE and TEICHERT, 1930

PM2348-27-6
PM2349-27-7
PM2350-27-8

Genus *Armenoceras* FOERSTE, 1924

Armenoceras chediforme KOBAYASHI, 1958

Plate XXVII, Figures 6, 7 a–b and 8

1958. *Armenoceras chediforme* KOBAYASHI, *Japan. Jour. Geol. Geogr. Vol. 29*, pp. 229, pl. 19, figs. 2 a–b, text-fig. 3.

There are three specimens of *Armenoceras* from loc. 5 which are thought to belong to this species. Specimen No. 23 is a part of a conch of about 7 cm. in length on which 9 camerae are countable in the length of 44 mm. The siphuncle appears about half as wide as the conch and to be located probably near the

center, although the excentricity cannot be exactly determined. In the polished section it is measured that the breadth of the siphuncle is 12.5 mm. and 23.5 mm. respectively at a septal neck and segment. There the central canal is 5.5 mm. broad. The septal interval is about 5 mm. on an average and the septal depth corresponds roughly to two intervals. The septum is inserted between two nummuli. The septal neck of about 2 mm. is adnated to the septum proper. The episeptal deposit is fairly well developed.

The specimen No. 30 is a siphuncle of 34 mm. in length in which 6 and a half nummuli are distributed. The expanded part of the siphuncle is eroded out, but the original breadth is estimated about 25 mm. The septal adnation is quite similar to that of the preceding specimen. The central canal is excentric, subcylindrical and about 5 mm. in diameter; radial canals nearly horizontal on the dosral side, but commonly bent back to some extent on the other side.

The specimen No. 31 is a siphuncle about 28 mm. in breadth and 37 mm. in length in which 7 nummuli are countable. Its central canal appears more excentric than the preceding and located at about one-third from the dorsal side. The high excentricity of the canal suggests its being the dorso-ventral section. The septum forms an obtuse angle at its adnate portion. Though less significant, such angulation is seen also at a few septa of the specimen No. 30.

The two siphuncles are similar to that of the first specimen in the size of the siphuncle and septal distance which is 4.5 to 5 mm. Their septa are similarly adnated at the necks; radial canals all nearly horizontal. These features are also seen in the holotype from Thung Song, Thailand. The specimen No. 23 shows fairly good agreement with the type specimen in the relative size and position of the siphuncle to the conch. Because the outline of the siphuncle and the curvature of the septa are irregular in the type specimen, it is highly probable that its siphuncle was curved by secondery deformation.

Occurrence: —Loc. 5 (Specimens Nos. 30, 31 and 32) and Thung Song, Thailand.

Family Trocholitidae CHAPMAN, 1857

This family includes *Trocholites* CONRAD, 1838, *Discoceras* BARRANDE, 1867, *Litoceras* HYATT, 1883, *Trocholitoceras* HYATT, 1894, *Curtoceras*, *Arkoceras*, *Jasperoceras* and *Wichitoceras* by ULRICH, FOERSTE, MILLER and FURNISH, 1942 and *Hardmanoceras* TEICHERT and GLENISTER, 1952, all from the Ordovician and a Gotlandian *Graftoceras* FOERSTE, 1925. *Cyclolituites* RÉMELÉ, 1886, was referred to this family by ULRICH et al. (1942), but now in the Lituitidae NOETLING (FLOWER and KUMMEL, 1950). STRAND (1933) pointed out that *Schroedoceras* HYATT, 1894, is congeneric with *Discoceras*, the opinion being now generally accepted. SHIMIZU and OBATA (1935) proposed *Eurasiatoceras* for *Discoceras eurasiaticum* FRECH. According to them "This genus is quite distinct from *Discoceras* by having much narrower, more crowded ribs which are covered by concentric striae on some part of the shell." This distinction is, however, neither very significant nor important enough to discriminate *Eurasiatoceras* from *Discoceras*, although the name may serve in future for segregation of certain oriental or Pacific forms from *Discoceras* s. l.

Genus *Discoceras* BARRANDE, 1867

Type-species: *Clymenia antiquissima* EICHWALD, 1840

As shown by STRAND (1930), SWEET (1958) and others, the genus most flour-

ished in the Baltic region in the Middle and Late Ordovician period. Beside the type-species there occur some 15 species and 1 subspecies, namely, *annulatus* SAEMAN, 1852, *rarospira* EICHWALD, 1860, *arcuatus* LOSSEN, 1860, *seamanni* HYATT, 1894, *tubulatum* HYATT, 1894, *hyatti* STRAND, 1930, *roemeri* STRAND, 1930, *gubkovense* BALASCHOV, 1953, *ievesense* BALASCHOV, 1953, *tammikuense* BALASCHOV, 1953, *vasalemmense* BALASCHOV, 1953, *wesenbergense* BALASCHOV, 1953, *boreale* SWEET, 1953, *boreale amplicameratum* SWEET, 1958, *depressum* SWEET, 1958, and *fleischeri* SWEET, 1958.

Discoceras canadense WHITEAVES, 1897, and allied forms are reported to occur in the Upper Ordovician of Lake Winnipeg, Canada, Baffin island and Sutton island of the Canadian Arctic archipelago (TEICHERT, 1937, MILLER and YOUNGQUIST, 1947, MILLER et al. 1954), among which *Discoceras* (?) sp. by MILLER et al. from Silliman's Fossil Mount, Baffin island is excluded from the genus by SWEET.

SHIMIZU and OBATA (1935) has once suggested *Discoceras* for *Plectoceras ohtakai* ENDO, 1932, from South Manchuria. It is represented by an external mould which is characterised by the gradually enlarging spire, large umbilical perforation, well defined rib-like folds and the remarkable dorso-lateral angulation of whorls. SHIMIZU and OBATA emphasized the last two features for the points of disagreement with *Plectoceras*, but such angulation of whorls and strong oblique folds are present in *Nautilus jason* BILLINGS which is the type-species of *Plectoceras*. Because the whorl section is imperfectly known and the siphuncular position unknown, it is indeterminable whether it belongs to the Trocholitidae, or whether does it to the Plectoceratidae, but it is not the less probable to be a *Plectoceras* than a *Discoceras*.

Discoceras is not rare in Prov. Hupeh, Central China. FRECH (1911) has described two species, *Discoceras eurasiaticum* (Taf. 1, Fig. 1 a–b, non 2 a–b) and *D. verbeeki*. The whorl section is more quadrate in the former, but more rounded in the latter. The ribs in these species are similarly bent back to form Vs on the venter, but they are finer and more numerous and become weaker in the latter than in the former. The siphuncle is narrow and marginal on the dorsal side in these species. Beside *D. eurasiaticum*, YABE and HAYASAKA (1920) described *Discoceras* sp. whose whorls are, like *D. verbeeki*, broad and fairly rounded in cross section and the siphuncle is again marginal (pl, 27, fig. 6). It is said to disagree with the two species in the relatively wide umbilicus. YABE and HAYASAKA's specimen of *eurasiaticum* clearly shows that the ribs appear narrow ridges, not imbricated and separated from one another by broader intervals than the ribs. YÜ (1930) illustrated two specimens of *eurasiaticum* which were procured from the upper part of the Middle Ordovician Neichiashan formation. In the exfoliated part of his specimen in fig. 5, pl. 9 it is recognizable that the septal sutures intercross the ribs. Thus there are three species of *Discoceras* in Central China. It can, however, hardly be overlooked that the siphuncle is usually marginal or almost marginal in the Hupeh forms, instead of submarginal in the typical *Discoceras*. Their ribs are never imbricated.

When I described *Trocholites ammonoides* from South Korea (1934), I noticed that *Trocholites juliformis* SALTER in REED (1921) from the Himalaya, *T.* cfr. *remelei* SCHROEDER by REED (1906) from Burma, *T. yunnanesis* REED and *T.* cfr. *macromphalus* SCHROEDER by REED (1917) from Yunnan in South China look similar to *Discoceras* than *Trocholites*. Lately SWEET (1958) expressed the opinion

that the first and the third species of them may properly referred to *Discoceras*. *T. yunnanensis* having a marginal siphuncle is a close relative to *eurasiaticum*. It is noted further that SHIMIZU and OBATA (1936) suggested the possibility of REED's *Tarphyceras* (?) sp. from Yunnan to be a *Schroedoceras*, i. e. a *Discoceras*, but its whorl is too much compressed laterally for *Discoceras*. These specimens from South and Southeastern Asia are unfortunately not well preserved. Nevertheless, it is of great interest that they reveal important links in the chain of distribution of the genus between the Baltic region and Eastern Asia.

Finally, *Discoceras* (?) sp. from the Lower Ordovician of Bendigo, Victoria, Australia (THOMAS and TEICHERT, 1947) is the oldest of the genus, if correctly referred to it, but it needs a further confirmation with a better material. *Trocholitoceras idaense* TEICHERT and GLENISTER (1953) from Tasmania is according to the authors, allied to *Trocholitoceras* as well as *Discoceras*. The authors instituted *Hardmanoceras* on their *H. lobatum* from Desert basin, Western Australia. This genus agrees with *Discoceras* in the subrectangular whorl section, subdorsal position of the siphuncle and some other characters. It is the monotypic species which is especially interesting to see the agreement with the Malayan forms of *Discoceras* in "Ribs prominent on the flanks, becoming faint as they cross the venter forming a deep V-shaped lobe." The effacement of the ribs on the venter is more advanced in the Malayan than the Australian species.

In looking through these occurrences it is found that the Western Pacific must have been a center of distribution of *Discoceras* and its close allies. On the Australian side they are found in the Lower and Middle Ordovician rocks. They flourished more on the Asiatic side in the Middle Ordovician period. It is probable that the Himalayan geosyncline was the Eurasiatic route of migration for *Discoceras*. In Northern Europe *Discoceras* attained its zenith in the Middle and Late Ordovician period when its distribution was expanded as far as the Arctic seas.

Discoceras (*Hardmanoceras* ?) *chrysanthimum* KOBAYASHI, new species

Plate XXVI, Figures 1 a–b

PM2351

Description :—Shell discoidal, composed of about 5 volutions, slowly expanding; whorl subquadrate in cross section and slightly impressed on dorsal side; outer wall a little inflated. subangulated on the borders with gently and regularly convex flanks; siphuncle subdorsal at least in last whorl; body whorl occupies more than a half volution; flanks marked with strong radial ribs which are somewhat thickened distally and a little bent forward near the ventral wall; they form rectangular sinuses with their counters on ventral wall, but they are not so prominent there as on flanks.

Measurement and observation :—The type specimen No. 3 is composed of 5 volutions and 41 mm. in diameter. The aperture is unpreserved, but it is certain that at least a little more than a half of the ultimate whorl belongs to the body chamber. The last septum is seen at the point marked by s in figs. a–b. There the whorl is 8.5 mm. high and 12 mm. wide. The septum is strongly concave, its concavity corresponding to about a half of the whorl height. Although the septal suture is not exposed on the specimen, it is evident that the suture intercrosses the radial rib.

The penultimate whorl, the third and fourth whorl counted inwardly measure 24.5 mm., 15 mm. and 8.5 mm. in diameter respectively. The radial ribs

are countable 16 and 14 on a half of the second and third whorl respectively. On the natural section the location of the siphuncle can be recognized to be very close to the dorsal margin of the last whorl, although there is no sagittal section through the siphuncle. The camerate portion is largely recrystallized, while the body chamber is mostly filled with calcareous dirt.

Comparison :—Although the internal structure is not well known, it is certain that this form belongs to *Discoceras* s. l. because of the slow coiling of the conch, subquadrate whorl section, subdorsal siphuncle and mode of ornamentation. In the typical *Discoceras* it is said that "Shell surface marked by adapically imbricate lamella." The periodic annulations or ribs are, however, noted to appear in the advanced forms in the Baltic region.

This species agrees better with *Hardmanoceras* than typical *Discoceras*, with regard to the prominent ribs on the flanks which become weak on the venter where they are V-shaped. In *Hardmanoceras* the body whorl is extraordinarily long, occupying one and a quarter of a volution. The body whorl of this species is also possibly very long, because the outer wall of the last whorl near s point suggests the attachment of the still outer whorl.

H. lobatum Teichert and Glenister (1952) is the monotypic species of *Hardmanoceras* whose whorls look more slowly expanding. It is known on the hypotype of the species that the coiling tends to be released at the last quarter of a volution (Teichert and Glenister, 1954), but all whorls are in contact not only in this species but also in the succeeding species whose spire is enlarging more rapidly. Although there are some differences, the Malayan forms of *Discoceras*, s. l. are intimate to *H. lobatum* from the upper Canadian of Australia. At the same time it is noted that the distinction of *Hardmanoceras* from *Discoceras* is not quite sharp.

Occurrence :—Loc. 31 (Specimen No. 3).

Discoceras (*Hardmanoceras*?) *laeviventrum* Kobayashi, new species

PM2352 Plate XXVI, Figures 2 a–b

This is represented by a phragmacone, 32.5 mm. in diameter. It is composed of 4 volutions which are expanding a little more rapidly than in the preceding species. If the umbilicus is open, it must be a very small perforation. At the adoral end of the specimen the whorl is 9.5 mm. high and 12 mm. wide. It is subquadrate in cross section, but comparatively more rounded than the section of the preceding species. The dorsal impression of the whorl is shallow. The body chamber is unpreserved. The second and third whorl counted inwardly, are respectively 16.5 mm. and 9 mm. in diameter and possess 14 and 9 ribs on a half volution. They are as strong as those of the preceding species, but become very weak on the last whorl on the venter of which they are completely obsolete. Like the preceding, the siphuncle is located near the dorsal margin at least on the last two whorls of this specimen.

This species is distinguishable from the preceding by the more rapid growth, more rounded whorl section and especially by the evanescence of the ribs which is quite significant, if they are compared in the grown stage. This species is somewhat similar to *Trocholitoceras idaense* Teichert and Glenister, 1953, from Tasmania, but can easily be distinguished by the more rounded whorl section and the more dorsal position of the siphuncle.

Occurrence :—Loc. 31 (Specimen No. 12).

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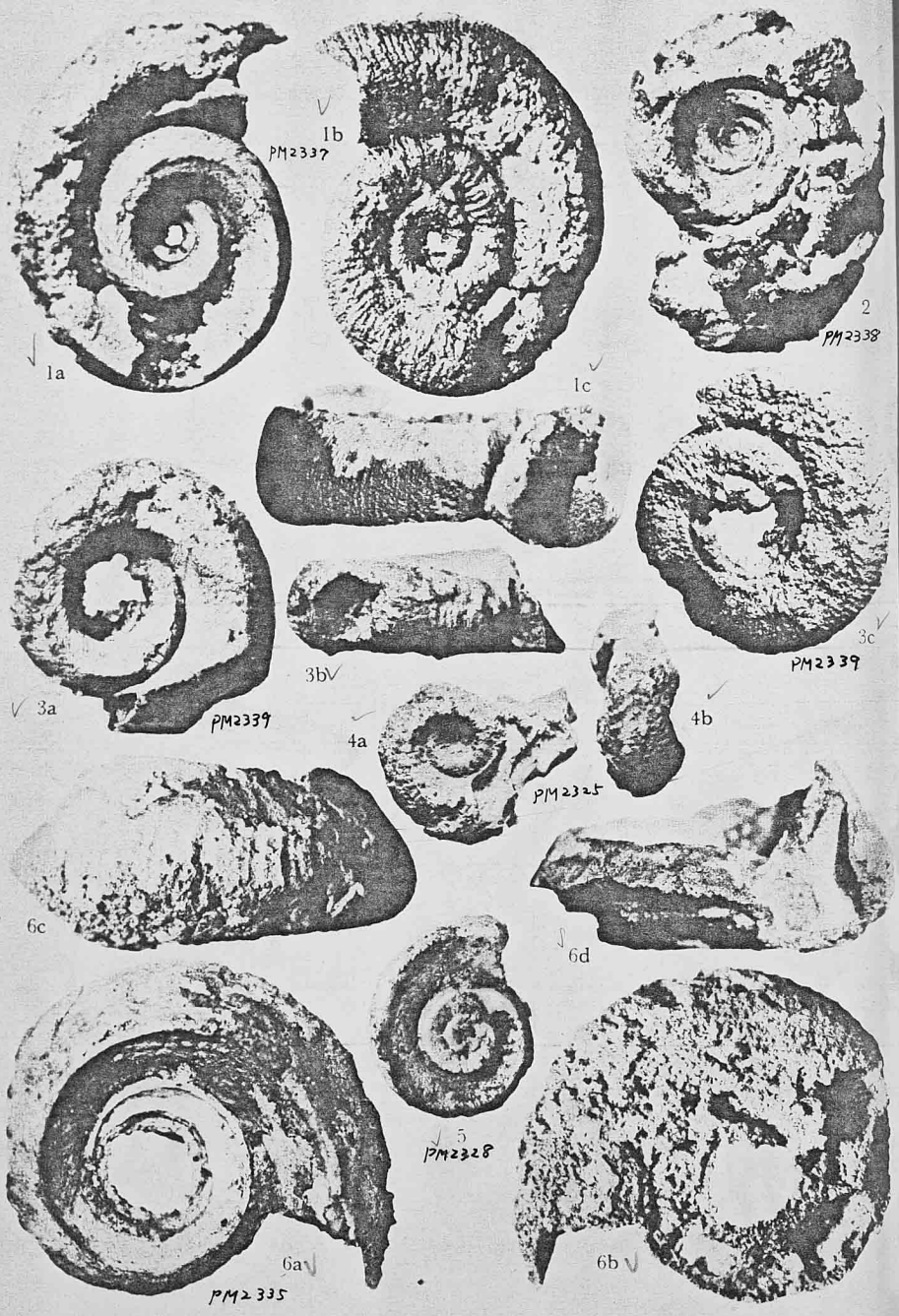
Explanation of Plate XXIV

Malayaspira rugosa KOBAYASHI ..... p. 398 PM2337
Figures 1a–c. Apical, basal and lateral views of Specimen No. 2. ×2. Loc. 34. PM2338
Figure 2, Apical view of Specimen No. 8. ×1.5 Loc. 31. PM2339
Figures 3a–c. Apical, lateral and basal views of Specimen No. 4. ×1.5 Loc. 30.
PM2325 *Sinuitopsis* cfr. *kochiriensis* KOBAYASHI ..... p. 393
Figures 4a–b. Lateral and dorsal views of Specimen No. 11. ×3 Loc. 42.
Helicotoma jonesi KOBAYASHI, new species ..... p. 394 PM2328
Figures 5. Apical view of Specimen No. 10. ×2 Loc. 31.
Lesueurilla zonata KOBAYASHI, new species ..... p. 397
Figures 6a–d. Apical, basal and two lateral views of Specimen No. 7. ×1.5 Loc. 31. PM2335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Explanation of Plate XXV

Helicotoma (?) *costata* KOBAYASHI, new species ..... p. 395 PM2331

Figures 1a–c. Apical, lateral and basal views of Specimen No. 9. ×1.5 Loc. 30.

Palaeomphalus giganteus KOBAYASHI, new species ..... p. 395 PM2332

Figures 2a–c. Apical, lateral and basal views of Specimen No. 16. ×1.5 Loc. 34. PM2333

Figures 3a–c. Lateral, apical and basal views of Specimen No. 14. ×1. Loc. 34.

Malayaspira (?) sp. indt. ..... p. 399 PM2340

Figure 4. Basal view of Specimen No. 13. ×1. Loc. 34.

Lytospira rectangularis KOBAYASHI, new species..... p. 399 PM2341

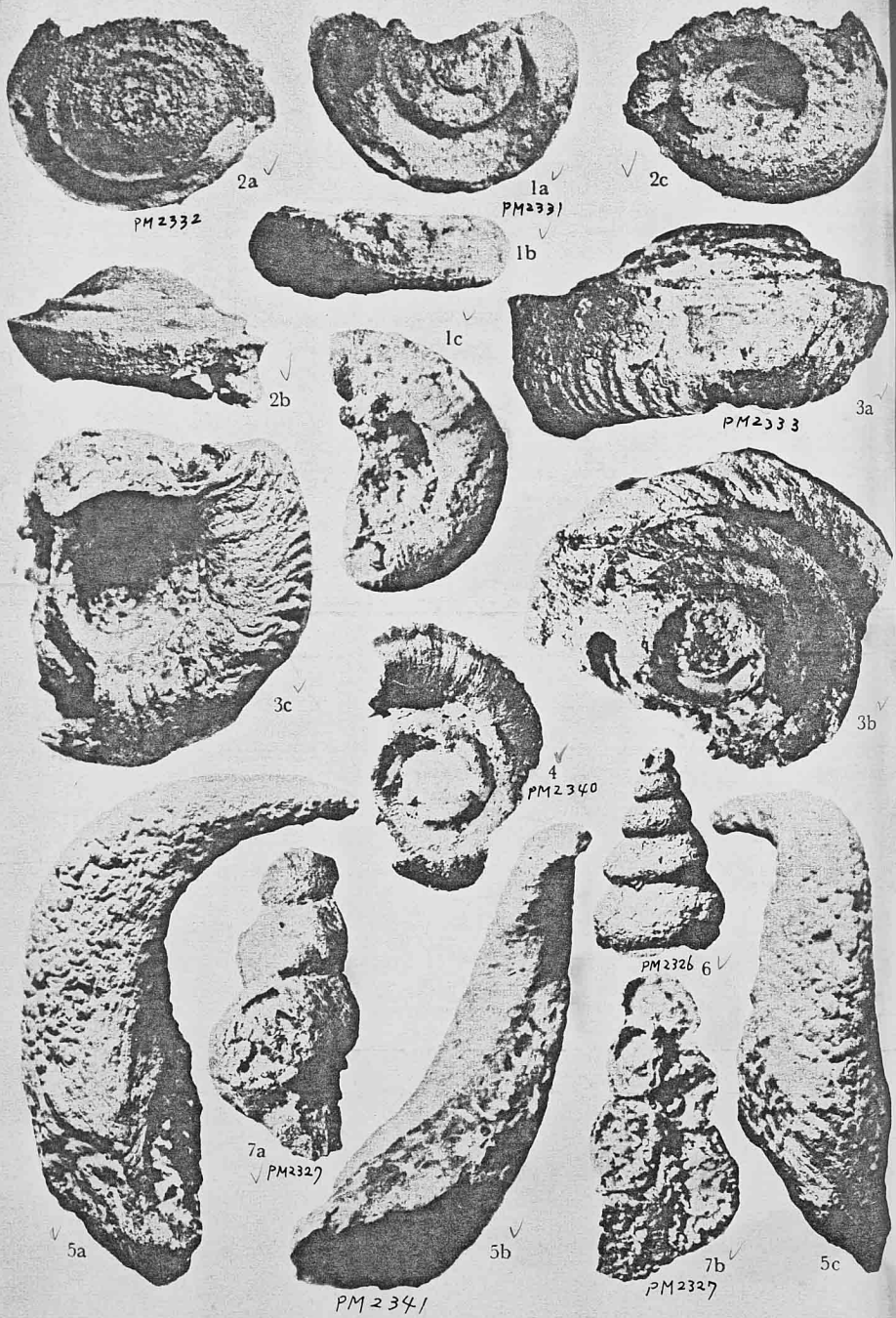
Figures 5a–c. Lateral views of Specimen No. 37. ×1.5 Loc. 5.

Hormotoma a sp. ..... p. 393 PM2326

Figure 6. Lateral view of Specimen No. 21. ×1. Loc. 34.

Hormotoma b sp..... p. 393 PM2327

Figures 7a–b. Lateral view and natural longitudinal section of Specimen No. 22. ×1. Loc. 34.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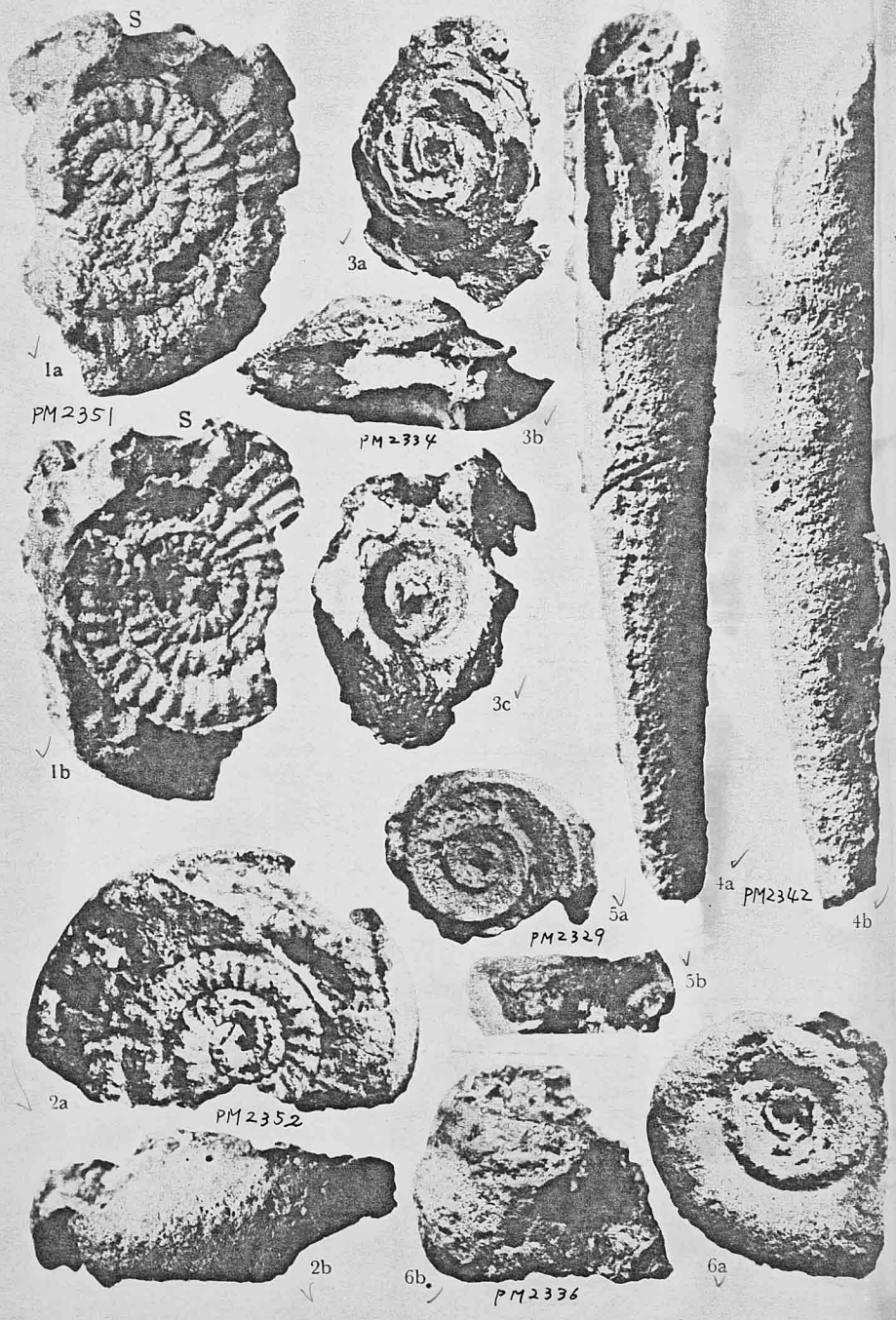
Explanation of Plate XXVI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Explanation of Plate XXVII

Ormoceras sp. indt. ..... p. 401 PM2347

Figure 1a. Eroded surface of Specimen No. 20. ×1. Loc. 5.

Figure 1b. Longitudinal section of the same specimen, ×1.5

Endoceroid, Gen. and Sp. indt. ..... p. 400 PM2343

Figure 2a. Lateral view of a siphuncle. Specimen No. 27. ×1.5. Loc. 28.

Figure 2b. Cross section of the same siphuncle. ×2.

Oromoceras langkawiense KOBAYASHI, new species ..... p. 401

Figure 3a. Eroded surface of Specimen No. 25. Holotype. ×1.5. Loc. 30. PM2344 PM2345

Figure 3b. Same phragmacone. ×2.

Figures 4a–b. Natural longitudinal and cross sections of a specimen from Kangar, near Perlis. ×1.5. PM2346

Figures 5a–b. Another specimen from Kangar, Perlis. ×2.

Armenoceras chediforme KOBAYASHI ..... p. 401 PM2348

Figure 6. Longitudinal section of Specimen No. 31. ×1.5. Loc. 5.

Figures 7a–b. Eroded surface and longitudinal section of Specimen No. 30. ×1.5 PM2349 Loc. 5. PM2350 (R)

Figure 8. Longitudinal section of Specimen No. 23. ×1.5. Loc.5.

Helicotoma jonesi KOBAYASHI, new species ..... p. 394 PM2330

Figure 9a–c. Lateral, apical and basal views of Specimen No. 7. ×4. Loc. 31.