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Some Molluscan Fossils from the Buried Cretaceous of Western Taiwan*

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ABSTRACT

This paper presents a result of the writers' study on the molluscan fossils from the Mesozoic rocks of the two wells, PK-2 and PK-3 of the Chinese Petroleum Corporation, drilled in the vicinity of Peikang, western Taiwan. Three species of ammonites are described by T. Matsumoto and fourteen species of other mollusca, of which three are new, by I. Hayami. The upper fossiliferous bed (at the depth of 1645.00 m in PK-2) contains *Cheloniceras* (*Epicheloniceras*) aff. *orientale*, the middle one (at the depth of 1695.20-1701.00 m in PK-2) *Cucullaea* aff. *acuticarinata* and several other bivalves, and the lower one (at the depth of 1977.65-2005.50 m in PK-2) *Costocyrena* n. sp. and *Tetoria* (*Paracorbicula*) sp. The fossiliferous part at the level of 2034.70-2065.66m in PK-3, which seems to correspond to the middle fossiliferous bed of PK-2, contains *Dufrenoyia* aff. *justinae*, *D.* aff. *discoidalis*, *Mesosaccella* (?) n. sp., *Cucullaea* aff. *acuticarinata*, *Amygdalum* aff. *ishidoense*, *Neithea* (*Neithella*) sp., *"Cardita"* n. sp., *Nemocardium* aff. *yatsushiroense*, etc. The marine faunule in the upper and middle fossiliferous layers indicates an Aptian age and the brackish-water one in the lower layer a Lower Cretaceous age. Further geological implication of these Cretaceous fossils is discussed in conclusion.

INTRODUCTION

The existence of some Mesozoic strata underneath the coastal plain of western Taiwan has been known since the discovery of an ammonite from the core samples of the well drilled by the Chinese Petroleum Corporation. The ammonite was temporarily identified by Lin (1961) with *Holcophylloceras* sp. allied to *H. mediterraneum* (Neumayr), a Middle to Upper Jurassic species.

When one of the writers (W. H.) visited Taiwan in 1964, Mr. C. Y. Meng, Chief Geologist of the Chinese Petroleum Corporation, kindly showed him other molluscan fossils from the core samples of the same and another adjacent wells,

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which were borrowed for further careful study. This paper presents a result of the writers' study. T. Matsumoto is responsible for the palaeontologic description of ammonites, I. Hayami for that of pelecypods and gastropods, and three of the writers are responsible for the introduction, stratigraphic notes, and concluding remarks.

The described specimens are now preserved in the Chinese Petroleum Corporation and the plaster casts of many of them are in the type-specimen room of the Department of Geology, Kyushu University (with symbols GK.).

Before going further the writers wish to record here a debt of gratitude to Mr. Jerome S. N. Hu, President, and Mr. C. Y. Meng, Chief Geologist, and Mr. Tunyow Huang of the Chinese Petroleum Corporation, Taipei, for their generosity of providing us the interesting specimens for study and permitting them to publish the results.

STRATIGRAPHIC NOTES

The subsurface stratigraphy of the coastal plain region of western Taiwan, as revealed by the exploration conducted by the Chinese Petroleum Corporation, was published at full length by Stach (1958). The fossiliferous core samples received came from two wells, PK-2 and PK-3, drilled in the Peikang[1] area near the western coast of Taiwan, which were regarded by Stach as representing a shelf area in the Cenozoic palaeogeography.

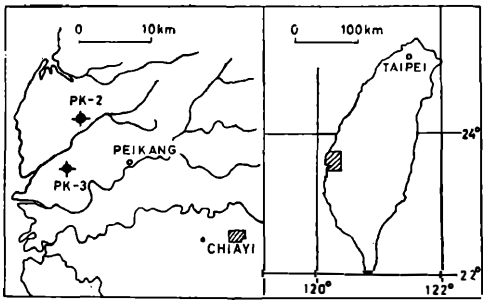

Figure 1. Index map showing the location of the wells. (adapted from Lin, 1961)

PK-2 and PK-3 wells have been drilled to the final depth of 2172.5 m and 2080 m below the surrface (approximately equal to sea-level) respectively. The base of the Miocene formation is at the depth of 1463 m in PK-2 and 1962 m in PK-3. The rocks below this level were regarded as a Mesozoic basement, forming the floor of the Tertiary sediments, the age of which was referred to Cretaceous, Jurassic, and older. According to Stach (1958, p. 69-72, pl. 3) the sequence below the base of the Miocene formation is summarized as follows:

Estimated age	Depth in m. (apparent thickness*)	Lithology
(1) "Cretaceous"	1463-1590 (127) in PK-2 1962-2015 (53) in PK-3	Tight greyish-green tuffaceous sandstone grading upward into acid tuff with some thin interbeds of red shale in the upper part

1. 北港

(2)	"Jurassic"	1590-2120 (530) in PK-2 2017-2080+ (63+) in PK-3	Indurated shale (160 m), followed below by fine-grained sandstone (360 m) and a basal conglomerate (10 m)
		A marked angular unconformity	
(3)	"Pre-Jurassic" (Triassic or older?)	2120-2172+ (dip 40°) in PK-2	Highly indurated rocks brecciated dark sandstone and shale, grading down into dark grey, partly calcareous, unfossiliferous sandstone

* Dip: less than 4° in PK-2; less than 18° in PK-3

The age determination was based on *Holcophylloceras* sp. aff. *H. mediterraneum* (described by Lin, 1961) at 1691.8 m and another ammonite compared with *Hongkongites hongkongensis* (listed only) at 1645 m in PK-2. However, the chronology of these substrata have been controversial, because *Hongkongites* itself indicates a Sinemurian age and *Holcophylloceras* actually ranges from Bathonian to Aptian. As the "Jurassic" strata are only gently inclined or nearly flat, it is hardly possible that *Hongkongites* occurs from the higher level than *Holcophylloceras* in the same well.

The core samples received, which contain the molluscan fossils described in this paper, are listed as follows:

PK-2: 1645.00, 1686.00, 1691.20, 1691.30, 1691.40, 1692.00, 1695.20, 1695.30, 1698.96, 1701.00, 1977.65, 1978.40, 2005.00-2007.00, 2005.30, 2005.40, 2005.50, 2005.55, 2005.80 (One of 2005.30 has a sample no. CPC. 460701; others have no number)

PK-3: 2034.70-2036.10 (CPC. 461101-461105), 2036.10-2039.10 (CPC. 461106, 461107), 2045.00-2046.50 (CPC. 461108-461110), 2047.00-2050.00 (CPC. 461111, 461112), 2050.00-2052.80 (CPC. 461113-461116; 461122, 461123), 2062.00-2065.66 (CPC. 461117-461121)

PALAEONTOLOGIC DESCRIPTIONS

The identified molluscan fossils are classified into three species of Ammonoidea, thirteen species of Bivalvia and one species of Gastropoda. In addition there are an indeterminable belemnoid at 1691.20 m in PK-2, and a scaphopod at 1645.00 m in PK-2. Unfortunately the ammonites identified with *Holcophylloceras* and *Hongkongites* were not found in the received samples.

AMMONOIDEA

(by Tatsuro Matsumoto)

Superfamily HOPLITACEAE

Family DESHAYESITIDAE

Genus *Dufrenoyia* (Burckhardt MS.) Kilian and Reboul, 1915

Type-species.—*Ammonites furcatus* J. de Sowerby, from the Lower Aptian of S.E. England.

Remarks.—Humphrey (1949) and then Casey (1964) gave a full account of the diagnosis, the affinities, the nomenclatural status, and the distribution of this genus.

There are in the core samples three small specimens of *Dufrenoyia*, which are classified into two species.

Dufrenoyia sp. aff. *D. justinae* (Hill)

(Pl. I, Figs. 1, 2)

Compare.—

1893. *Acanthoceras? justinae* Hill, *Biol. Soc. Washing., Proc.*, vol. 8, p. 38, pl. 7, figs. 1-3

1904. *Hoplites furcatus*, Lasswitz (*non* Sowerby), *Geol. Pal. Abh.*, N. F., vol. 6, p. 4, text-fig. 1.

1925. *Dufrenoya justinae*, Burckhardt, *Inst. Geol. Mexico, Bol.*, 40, p. 17, pl. 10 figs. 14-15.

1937. *Dufrenoya texana*, Riedel, Dept. Minas Petr., p. 48, pl. 7, figs. 15-19, pl. 14, fig. 25.

1949. *Dufrenoya justinae*, Humphrey, *Bull. Geol. Soc. Amer.*, vol. 60, p. 122.

1956. *Dufrenoya texana*, Bürgl, *Bol. Geol.* (*Bogota*), vol. 4, nos. 2-3, p. 1, pls. 1-3.

Material.—A small internal mould, No. 24, obtained in a core sample CPC 461117 and another small fragmentary external mould, No. 25, in a core sample CPC 461119. Plaster casts GK. H 9300 and GK. H 9301.

Description.—The better preserved specimen has the following dimensions (in millimeters) in a deformed condition:

Diameter = 14.3 (1), Umbilicus = 4.4 (0.31), Height = 6.0 (0.42)

The whorl is higher than broad, although the breadth is hardly estimated with accuracy. The maximum breadth seems to be in the lower part of a costal section. The venter is narrow. The whorl enlarges fairly rapidly, embracing the umbilicus of moderate size.

The ribs are gently flexuous, considerably strong and coarse, alternately long and short, and separated by somewhat narrower interspaces. About 26 or 27 ribs are counted in a whorl. The shorter ones spring in the lower part of the flank, sometimes from a point close to the umbilical margin but occasionally a little below the mid-flank. The longer ribs are gently elevated at the umbilical shoulder and somewhat asymmetric on the flank, with a steeper adaptical side. Each rib has a clavate tubercle at the ventrolateral shoulder. On the venter the ribs are somewhat weakened and flattened but still distinct.

Sutures are not clearly exposed, except for an indistinct one on the early part of this small outer whorl.

Another specimen shows a fragmentary ventral part, on which the ribs and ventrolateral clavi are apparently more narrowly spaced but otherwise very similar to the above specimen.

Affinities.—The specimens before the writer closely resemble some examples of *Dufrenoyia justinae* (Hill), from the Upper Aptian of Texas, Mexico and Colombia. This species seems to be fairly variable and the writer would agree with Humphrey (1949) in regarding *Dufrenoyia texana* Burckhardt, 1925, as identical with *Dufrenoyia justinae* (Hill, 1893). Bürgl (1956) clearly demonstrated the extent of variation in a population of what he called *Dufrenoyia texana* Burckhardt from the basal Upper Aptian of the Eastern Cordillera of Colombia. He distinguished *D. texana texana* and *D. texnna sanctorum.* According to him *D. texana sanctorum* is confined to the basal Upper Aptian, while *D. texana texana* seems to become more prominent in higher Aptian zones. The holotype of *D. justinae* (see Humphrey, 1949, pl. 6, figs. 3-4), from the Travis Peak Formation of Texas, rather belong to the subgroup of Bürgl's *D. texana texana*, which, then should be named *D. justinae justinae.* In the less numerous and coarser ribbing one of the two specimens from Taiwan may be closer to *D. justinae sanctorum*, but the ribs of the specimens from Taiwan are separated by

narrower interspaces and not so much weakened on the venter as in that subspecies. Closing of ribs seems to occur towards the end of body-chamber in *D. justinae* (see Humphrey, 1949, pl. 6, figs. 3-5; Burgl, 1956, pl. 1, fig. 1) and not in the small young stage. The Taiwan specimens may represent another subspecies of *D. justinae* or a distinct but closely allied species. The available material is insufficient for the final conclusion.

The species represented by the Taiwan specimens is somewhat similar to *Dufrenoyia notha* Casey (1964, p. 386, pl. 63, fig. 8; pl. 64, fig. 5; text-fig. 140 j) from the upper Lower Aptian (*bowerbanki* Zone) of southeastern England, in the shell-form and coarse ribs without forking. The former has distinct ventral ribbing as in typical *D. justinae*, but the latter has a smoother venter. Again the approximated ribs occur only towards the end of the body-chamber in the British species.

Occurrence.—The fossil is obtained from the dark coloured, sandy siltstone at the depth of 2062.00-2065.66 m below the surface in the well of PK-3, Peikang, western Taiwan.

Dufrenoyia sp. aff. *D. discoidalis* Casey

(Pl. I, Fig. 3)

Compare.—

1964. ***Dufrenoyia discoidalis*** Casey, ***Palaeontogr, Soc.,*** 1963, p. 393, pl. 66, figs. 7-8.

Material.— An external mould of a highly deformed specimen, No. 26, embedded obliquely to the bedding plane in a core sample CPC. 461106. Plaster cast GK.H9302.

Description.— The specimen is measured at about 40 mm. in diameter, but it is so badly deformed that its original dimensions are hardly estimated with accuracy.

The whorl is considerably involute, rapidly increasing in height, and narrowly umbilicate. It is apparently much compressed, with very gently convex flanks, subangular ventro-lateral shoulders and a narrow and flat venter.

The ribs on the flank are low, numerous, and crowded, being separated by narrow and rather shallow interspaces. They are flexuous and irregularly long and short. Longer, primary ribs occur at every second or third, and are somewhat elevated near the umbilical margin. Shorter ones are intercalated or branched, arising below or above the middle of the flank. All the ribs are flattened on the outer part of the flank and are provided with clavi of moderate intensity at the ventrolateral shoulder. Very low, flattened ribs run across the venter between the clavi.

About 18 ribs are counted on the early half of the last preserved whorl; on the late half the ribs become very faint and not exactly counted because of the incomplete preservation.

Suture is not impressed on the specimen.

Affinities.— The observable characters essentially agree with the diagnosis of *Dufrenoyia discoidalis* Casey, 1964, from the upper part of the Lower Aptian, *bowerbanki* Zone, of southeast England. A young paratype of that British species (Casey, 1964, pl. 66, fig. 8), nearly as large as the present specimen, seems to have somewhat broader and less numerous ribs, but the difference is by no

means great. On the holotype of *D. discoidalis* (Casey, 1964, pl. 66, fig. 7), however, shorter ribs seem to occur more frequently. In this respect the present specimen considerably approaches to *Dufrenoyia durangensis* Humphrey (1949, p. 127, pl. 9, figs. 3-4), from La Pena Formation of Mexico, in the holotype of which the ribs are alternately long and short and the ventrolateral clavi seem to be somewhat stronger. Accordingly the specimen from Taiwan shows apparently intermediate characters between *D. discoidalis* and *D. durangensis*.

Occurrence.— The fossil is obtained from the dark coloured, sandy siltstone at the depth of 2036.10-2039.10 m in the well of PK-3, Peikang, western coast of Taiwan. A left valve of *Neithea* (*Neithella*) sp. (No. 9) is contained in the same core sample.

Family DOUVILLEICERATIDAE

Genus *Cheloniceras* Hyatt, 1903

Subgenus *Epicheloniceras* Casey, 1954

Type-species.—Douvilleiceras tschernyschewi Sinzow, from the Upper Aptian of Mangyshlak, Russia.

Remarks.—Casey (1954, p. 113; also 1964, p. 235) gave a full account of the definition, distinction, affinities and distribution of this subgenus.

While one of the writers (I. H.) was chipping a core sample to clean a pelecypod specimen, an ammontite described below was distinguished.

Cheloniceras (*Epicheloniceras*) sp. aff.
Ch. (*E.*) *orientale* (Jacob)
(Pl. I, Fig. 4)

Compare.—

1905. ***Douvilleiceras martinii*** d'Orbigny var. ***orientalis*** Jacob, ***Bull. Soc. Géol. France,*** sér. 4, vol. 5, p. 412.

1906. ***Douvilleiceras martinii*** var. ***orientalis,*** Jacob and Tobler, ***Mém. Soc. Paléont. Suisse,*** vol. 33, no. 5, p. 13, pl. 1, figs. 1-3.

1960. ***Epicheloniceras martini orientalis,*** Druschchitz and Kudrjartseva, ***Atlas of Lower Cretaceous Fossils from North Caucasus and Crimea, Ammonoidea,*** pt. 2, p. 340, pl. 21, figs. 2, 4, text-fig. 137.

Material.—The specimen is represented by the external and internal moulds, No. 27 (a, b) in a core sample. Plaster cast GK. H 9303.

Description.—This small secondarily deformed specimen, about 15mm. in diameter, displays some characteristic features. The whorl seems to have been originally fairly depressed. The umbilicus is of moderate size and fairly deep.

The whorl is ornamented with numerous, high and sharp-headed ribs separated by deep interspaces, which are nearly as narrow as the ribs. Some of them are nearly rectiradiate; others gently flexuous. Major, stronger ribs occur at irregular intervals. Each major rib is provided with a moderate or small umbilical node, a prominent lateral tubercle and a moderate ventral swell on either side of the siphonal depression. The spinose lateral tubercle is elongated radially when the shorter rib is not branched there, but it has a clavate or obliquely elongated base when shorter one is branched. So far as

the observable part is concerned, the rib immediately behind the bifurcating major rib is fairly strong and long, being separated by a somewhat deeper, apparently constriction-like interspace. This rib is weakly elevated at the umbilical edge, at the mid-flank and also on either side of the siphonal depression. The short rib branched at the lateral tubercle from the major one likewise has a weak ventral swell. Other minor ribs are branched from the major one near the umbilical node or singly arise at a point slightly above the umbilical margin. These minor ribs all have weak swells on either side of the siphonal depression.

No suture is preserved.

Affinities.—From the observable characters the present specimen is regarded as an immature example of *Cheloniceras* (*Epicheloniceras*). Although numerous species of this subgenus have been described, there are few descriptions of early immature shells as small as the present specimen. Therefore there is some difficulty in the precise comparison. Among the previously described small examples, *Ch.* (*E.*) *orientale* (Jacob, 1905), from the Upper Aptian Luitere Zug horizon of Switzerland and the Upper Aptian of northern Caucasus, is closely allied to, if not identical with, the present specimen, especially in the development of a pair of ventral swells on every rib and in general appearance. The specimen from Taiwan shows, however, more irregularity in the configuration of major and minor ribs and shape of lateral tubercles.

Occurrence.—The fossil is obtained from the grey sandy siltstone at the depth of 1645.00 m below the surface in PK-2 well, Peikang, western Taiwan. Two specimens of Scaphopoda, *Dentalium* (?) sp., are embedded in the same core sample.

BIVALVIA

(by Itaru Hayami)

Family MALLETIIDAE

Genus *Mesosaccella* Chavan, 1947

Mesosaccella (?) *taiwanensis* sp. nov.

(Pl. I, Figs. 5-7)

Material.—The holotype (No. 1) was obtained from the core sample (1698.96 m) of PK-2 well. Two paratypes (Nos. 2, 3) from the same well are also concerned with the description below.

Description.—Shell small, not exceeding 15mm. in maximum length, inequilateral, *Saccella*-like in outline, rounded forwards, pointed at the posterior extremity, not much rostrated; antero-dorsal margin nearly straight, while postero-dorsal one is broadly concave; ventral margin gently arcuate; umbo placed slightly anteriorly from the mid-point of length; apical angle about 135 degrees; surface almost smooth except for fine concentric lines; internal characters unknown.

Measurements in mm.

specimen	Length	Height	Thickness	L/H
Holotype (No. 1) right valve	13.2	8.4	ca.2.5	1.57
Paratype (No. 2) right valve	10.2	5.4	ca.2.0	1.89
Paratype (No. 3) left valve	11.2	7.0	ca.2.0	1 60

Observations and comparisons.— The test is almost exfoliated in the three

specimens, and the surface sculpture is not recognized in detail except for the associated external mould of the paratype (No. 2). The paratype (No. 2) may be depressed obliquely, so that the ratio of length/height becomes larger than in other specimens which reveal approximately original outlines. Many denticles of a ctenodont-type are observable in the paratype (No. 3), but the existence of subumbonal chondrophore is not determinable. Therefore, it is not impossible that the present species is actually a kind of the Nuculanidae instead of the Malletiidae.

In the outline the present species is similar to *Nuculana lineata* (Sowerby, 1836) from the Upper Greensand of England (Woods, 1899), which is referable to the genus *Mesosaccella.* However, the ratio of length/height is somewhat larger in the undeformed specimens of the present species than in *M. lineata.* It is also distinguishable from *Mesosaccella insignis* (Nagao, 1934), from the Aptian of Japan (Hayami, 1965 a), in having less sharply pointed posterior extremity and much larger size. Concentric or subconcentric striae are generally developed in many species of *Mesosaccella,* but they are apparently inconspicuous in the present species.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 1698.96 m and 1701.00 m in PK-2 well, Peikang, western Taiwan.

Family NUCULIDAE

Genus *Nuculopsis* Girty, 1911

Subgenus *Palaeonucula* Quenstedt, 1930

Nuculopsis (*Palaeonucula*) sp. cf. *N.* (*P.*) *ishidoensis* (Yabe and Nagao)

(Pl. I, Fig.8)

Compare.—

1926. ***Nucula ishidoensis*** Yabe and Nagao, ***in*** Yabe, Nagao and Shimizu, ***Sci. Rep. Tohoku Imp. Univ.,*** ser. 2, vol. 9, no. 2, p. 41, pl. 13, figs. 46, 47.

1965. ***Nuculopsis (Palaeonucula) ishidoensis*** Hayami, ***Mem. Fac. Sci., Kyushu Univ.,*** ser. D, vol. 15, no. 2, p. 234.

Descriptive remarks.— Only an internal mould of right valve (No. 4) is available for the study. Judging from the nuculiform outline, apparently smooth internal margin and strongly impressed muscle scars, it is probably allied to *Nuculopsis* (*Palaeonucula*) *ishidoensis* (Yabe and Nagao, 1926) from the Upper Neocomian—Albian of Japan.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2062.00-2065.66 m in PK-3 well, Peikang, western Taiwan.

Family CUCULLAEIDAE

Genus *Cucullaea* Lamarck, 1801

Cucullaea sp. aff. *C. acuticarinata* Nagao

(Pl. I, Fig. 9)

Compare.—

1934. ***Cucullaea acuticarinata*** Nagao. ***Jour. Fac. Sci. Hokkaido Imp. Univ.,*** ser. 4, vol. 2. no. 3, p. 192, pl. 24, figs. 10-14, pl. 30, fig. 5.

1965. ***Cucullaea acuticarinata,*** Hayami, ***Mem. Fac. Sci., Kyushu Univ.,*** ser. D, vol. 15, no. 2, p. 242, pl. 27, fig. 15, pl. 28, figs. 1-10.

Descriptive remarks.— Only two poorly preserved internal moulds of right

valves (No. 5, 9.4 mm. long, 6.0 mm. high, ca. 1.6 mm. thick; No. 16, 8.2 mm. long, 5.0 mm. high, ca. 1.4 mm. thick) are available for the study. In the partly exposed hinge teeth and sharply carinated outline, the present species seems to be close to *Cucullaea acuticarinata* Nagao, 1934, from the Aptian-Albian Miyako group of Japan, but the dimensions are much smaller than the adult specimens of that species. Moreover, the ratio of length/height may be somewhat smaller in the present species than in *C. acuticarinata.*

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 1695.20 m in PK-2 well and at the depth of 2062.00-2065.66 m in PK-3 well, Peikang, western Taiwan. A somewhat similar specimen from the depth of 1691.40 m in PK-2 well.

Family PARALLELODONTIDAE

Genus *Nemodon* Conrad, 1869

Nemodon sp. indet.

(Pl. I, Fig. 10)

Descriptive remarks.— This species is represented by only an internal mould of right valve (No. 6, 14.8 mm. long, 8.4 mm. high, ca. 1.0 mm. thick). It is secondarily compressed and slightly crushed. The posteriorly alate and transversely elongated outline, presence of a weak median constriction, numerous radial riblets and apparently narrow hinge plate suggest *Nemodon* for the present species, although its specific identification is impossible at present.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2045.00-2046.50 m in PK-3 Peikang, western Taiwan.

Family PTERIIDAE

Genus *Pseudoptera* Meek, 1873

Pseudoptera sp. indet.

(Pl. I, Fig. 11)

Descriptive remarks.— Only a broken left valve (No. 7, 12.2 mm. long, 10.2 mm.+ high, ca. 3.5 mm. thick) is available for the study. The specimen shows an almost terminal umbo, undeveloped anterior wing, obscurely delimited posterior wing, comparatively large shell-obliquity, numerous radial riblets and irregularly wavy growth-lines. It probably belongs to an unnamed species of *Pseudoptera*, but a new specific name is not proposed here, because of the insufficient material.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2050.00-2052.80 m in PK-3 well, Peikang, western Taiwan.

Family MYTILIDAE

Genus *Amygdalum* Megerle von Mühlfeld, 1811

Amygdalum sp. aff. *A. ishidoense* (Yabe and Nagao)

(Pl. I, Fig. 12)

Compare.—

1926. ***Modiola? ishidoensis*** Yabe and Nagao, ***in*** Yabe, Nagao and Shimizu, ***Sci. Rep. Tohoku Imp. Univ.***, ser. 2, vol. 9, no. 2, p. 63. pl. 13, fig. 42.

1965. *Amygdalum ishidoense*, Hayami, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, vol. 15, no. 2, p. 257, pl. 30, figs. 4-10.

Descriptive remarks.— Only a poorly preserved right valve (No. 8, 19.4 mm.+ long, 7.2 mm. high, ca. 1.5mm. thick) is available for the study. In the hemicylindrical, non-carinated and posteriorly elongated outline, it resembles *Amygdalum ishidoense* (Yabe and Nagao, 1926), from the Upper Neocomian and Aptian of Japan, although the dimensions are much smaller than in the adult specimens of *A. ishidoense*. *Modiolus rectior* Wollemann, 1896, from the Neocomian of Germany, seems to be closely related to *A. ishidoense*.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2034.70-2036.10 m in PK-3 well, Peikang, western Taiwan.

Family PECTINIDAE

Genus *Neithea* Drouet, 1825

Subgenus *Neithella* Hayami, 1965

Neithea (*Neithella*) sp. indet.

(Pl. I, Fig. 13)

Descriptive remarks.—This species is represented by a left (flat) valve (No. 9, 14.0 mm. long, 14.0 mm. high), which shows the external surface. The umbonal area is slightly inflated but the remaining part is slightly concave. Six primary ribs are distinct and their interspaces are marked respectively with about a dozen of fine striae. The ventral margin is distinctly digitated in accordance with the radial ribbing. The auricular part is broken, but the anterior auricle appears to be much larger than the posterior. Judging from the above mentioned characters and also from the small size, the present species is referable to the subgenus *Neithea* (*Neithella*), which was recently defined by myself (1965, p. 291). It is somewhat similar to *Neithea* (*Neithella*) sp. cf. *N.* (*N.*) *atava* (Römer) from the Upper Neocomian and Aptian of Japan (Hayami, 1965), but the primary ribs are apparently narrower and less strongly plicated and the secondary ribs are more numerous than in the Japanese species.

Occurrence.—The fossil is obtained from the grey sandy siltstone at the depth of 2036.10-2039.10 m in PK-3 well, Peikang, western Taiwan.

Genus *Chlamys* [Röding, 1798]

Chlamys sp. indet.

(Pl. I, Fig. 14)

Descriptive remarks.—This species is represented by a right external mould (No. 10, 8.0 mm. long, 9.8 mm. high, ca. 1.0 mm. thick). The specimen shows a little opisthocline outline with a slightly concave antero-dorsal margin of disk, deeply incised byssal notch and anteriorly projected byssal auricle which is supported by a narrow fasciole area. The disk is ornamented with more than 70 fine radial riblets, and the byssal auricle with several ones. The posterior part of the disk is marked with faint oblique lines which are curved backwards and somewhat similar to *Camptonectes*-striations. In many characters the present specimen is similar to some finely ribbed species of *Chlamys*, but in the last mentioned characteristic it recalls *Camptonectes* Meek, 1864. How-

ever, the typical Jurassic and Cretaceous species of *Camptonectes* have not radial ribs, showing much larger apical angles than the present species. Such a combination of radial ribs and oblique striae is known in certain Jurassic species, for some of which Arkell (1930) proposed *Camptochlamys*. *Camptochlamys* is, however, characterized by more or less strong concentric lamellae, which are apparently very weak in the present specimen.

Occurrence.—The fossil is obtained from the grey sandy siltstone at the depth of 2045.00-2046.50 m in PK-3 well, Peikang, western Taiwan.

Family PLICATULIDAE

Genus *Plicatula* Lamarck, 1801

Plicatula sp. indet.

(Pl. II, Fig. 1)

Descriptive remarks.—This species is represented by two specimens; one is a left internal mould (No. 11, 19.6 mm. long, 23.2 mm. high), and the other is internal and external moulds of a left valve (No. 12, 9.4 mm. long, 12.2 mm. high). The larger specimen is nearly flat, revealing strong crural teeth and posteriorly located adductor scar of *Plicatula*-type. The ventral area of the two specimens are weakly plicated, but there is no trace of strong radial ornamentation on the surface. The present species is probably allied to *Plicatula hanaii* Hayami, 1965, from the Aptian of northeast Japan, but the hinge area is distinctly narrower in the present species than in *P. hanaii*. *Plicatula variata* Gabb, 1864, from the Lower Cretaceous of California (Stewart, 1930) probably has more distinct radial plications than the present species.

Occurrence.—The fossil is obtained from the grey sandy siltstone at the depth of 2036.10-2039.10 m in PK-3 well, Peikang western Taiwan.

Family CARDITIDAE

Genus *Cardita* Bruguière, 1792

"*Cardita*" *sulcataria* sp. nov.

(Pl. II, Figs. 2-4)

Material.—The holotype (No. 13) was collected from the core sample (2062.00-2065.66 m) of PK-3 well. Two paratypes (Nos. 14, 15) are also concerned with the description below.

Description.—Shell scarcely exceeding 15 mm. in length, subquadrate, longer than high, strongly inflated; test comparatively thin; antero-dorsal margin short, a little concave; postero-dorsal margin long, nearly straight; posterior margin clearly delimited, slightly opisthocline, distinctly concave, forming a right angle with the postero-dorsal margin; umbo broad, highly protruded above the hinge-margin, placed at about one-fourth or one-fifth of length from the anterior end; surface marked with regular concentric striae and numerous radial threads; ventral margin finely crenulated internally; muscle scars strongly impressed; pallial line apparently smooth, running closely along the ventral margin; hinge structure unknown in detail, although there is a somewhat elongated lateral tooth along the postero-dorsal margin.

Measurements in mm.

specimen			Length	Height	Thickness	L/H
Holotype	(No. 13)	both in. mould	13.8	13.0	10.6	1.06
Paratype	(No. 14)	right valve	12.4	11.8	ca. 5.0	1.05
Paratype	(No. 15)	left in. mould	11.4	9.4	ca. 4.5	1.21

Observations and comparisons.— The holotype is a slightly deformed internal mould of conjoined valves, on which the surface ornamentation is weakly impressed. More detailed feature of the surface sculpture is recognized from the associated broken external mould of the same individual and another specimen (No. 14). The test is well preserved in the latter specimen, which is almost free from secondary deformation. Although the hinge structure is unknown in detail, the present species should be referred to the Carditidae in view of the general external and internal characters. The musculature and the mode of marginal crenulations are especially similar to those of *"Cardita" cancellata* Woods, 1906, from the Chalk of England, but the radial ribs are much weaker than in the European species. Most distinctive feature of the present species exists in the slightly concave posterior margin and the regular concentric striae. These characters are peculiar in the Carditidae, and may suggest the requirement of a new generic name for the present species, although its proposal is deferred until better preserved material is obtained. This is, therefore, provisionally referred to *"Cardita"*.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2050.00-2052.80 m and 2062.00-2065.66 m in PK-3 well, Peikang, western Taiwan.

Family NEOMIODONTIDAE

Genus *Costocyrena* Hayami, 1965

Costocyrena peikangensis sp. nov.

(Pl. II, Figs. 5, 6)

Material.— The holotype (No. 17) was obtained from the core sample (1977.65 m) of PK-2 well. Two paratypes (Nos. 18, 19) were obtained from the same well and are also concerned with the description below.

Description.— Shell small for the genus, subovate in outline, weakly carinated posteriorly, weakly inflated; about 1.4-1.5 times as long as high; antero-dorsal margin a little concave, while postero-dorsal one broadly convex; ventral margin broadly arcuate; siphonal margin not delimited at all; umbo comparatively low, placed at about one-third of shell-length from the anterior end; lunule probably discriminated; surface ornamented with about a dozen of strong concentric lamellae which are rather regular in prominence and spacing; interspaces of lamellae marked with numerous fine radial threads; hinge structure unknown in detail, but long corbiculoid lateral teeth are developed along the antero and postero-dorsal margins.

Measurements in mm.

specimen			Length	Height	Thickness	L/H
Holotype	(No. 17)	left ex. mould	16.0	11.2	ca. 2.6	1.43
Paratype	(No. 18)	right in. mould	8.8	6.0	ca. 1.4	1.47

Observations and comparisons.— The holotype is a left external mould, the test of which was artificially solved with acid. The paratypes are right subinternal moulds, on which the surface ornamentation is clearly impressed. Besides, a few fragments are found in association.

In the general outline and the concentric sculpture this species resembles *Eomiodon* Cox, 1935, from the Jurassic and Lower Cretaceous, but the presence of weak radial threads indicates that it belongs to the genus *Costocyrena* (Matsumoto and Kanmera, 1952, MS) Hayami, 1965. If compared with *Costocyrena radiatostriata* (Yabe and Nagao, 1926) and *Costocyrena matsumotoi* Hayami, 1965, from the Aptian-Albian of Japan, the present species has weaker shell-convexity, much more delicate radial riblets, more regularly spaced concentric lamellae and less cuneiform outline. In these respects the present species appears to be intermediate between *Eomiodon* and *Costocyrena.* This fact may indicate the derivation of *Costocyrena* from *Eomiodon,* as has recently been suggested by myself (1965 b).

Occurrence.— The fossil is obtained from the grey carbonaceous sandy siltstone at the depth of 1977.65 m and 2005.30 m in PK-2 well, Peikang, western Taiwan.

Family CARDIIDAE

Genus *Nemocardium* Meek, 1876

Nemocardium sp. aff. *N. yatsushiroense* Hayami

(Pl. II, Fig. 8)

Compare.—

1965. ***Nemocardium yatsushiroense*** Hayami, ***Mem. Fac. Sci., Kyushu Univ.***, ser. D, vol. 17, no. 2, p. 120, pl 17, figs. 1-7.

Descriptive remarks.— This species is represented by a right valve (No. 20, 36.6 mm.+ long, 39.4 mm. high, ca. 12.6 mm. thick) and a fragmentary specimen (No. 21). The posterior part of the right valve is broken, and the test has been replaced by certain carbonaceous substance. The surface is marked with numerous fine radial riblets, and the ventral margin is finely crenulated internally in accordance with the radial riblets. Although the ornamentation on the posterior part is unknown, the present species probably belongs to *Nemocardium,* because concentric sculpture is almost indiscernible. It resembles especially *Nemocardium yatsushiroense* Hayami, 1965, from the Albian of west Japan, but the antero-dorsal part appears to be more strongly angulated and the test may be thinner than in the Japanese species.

Occurrence.— The fossil is obtained from the grey sandy siltstone at the depth of 2047.00-2050.00 m and 2050.00-2052.80 m in PK-3 well, Peikang, western Taiwan.

Family CORBICULIDAE

Genus *Tetoria* Kobayashi and Suzuki, 1937

Subgenus *Paracorbicula* Kobayashi and Suzuki, 1939

Tetoria (*Paracorbicula*) sp. indet.

(Pl. II, Fig. 7)

Descriptive remarks.—Only a bivalved internal mould (No. 22, right in.

mould, 26.4 mm. long, 17.4 mm. high, ca. 6.0 mm. thick; left in. mould, 26.4 mm. long, 18.6 mm. high, ca. 7.4 mm. thick). It is more or less deformed secondarily, and the ratio of length/height may be larger than that of the original outline. The shell is subovate or suborbicular, inequilateral, provided with an anteriorly placed umbo. The test is comparatively thin. The dentition, as formulated: AIII AI 3a 1 3b PI (PIII)/AII 2a 2b 4b PII, is characterized by the completely developed cardinal teeth of a cyrenoid type plus much elongated corbiculoid lateral teeth. The trace of pallial sinus is weakly impressed on the internal surface. In every internal character the present specimen agrees well with the subgenus *Tetoria* (*Paracorbicula*), which was recently redefined by Ota (1965). The present species is certainly allied to *Tetoria* (*Paracorbicula*) *sanchuensis* (Yabe and Nagao, 1926) and *Tetoria* (*Paracorbicula*) *yoshimoensis* Ota, 1965, from the Neocomian of Japan. In the more anteriorly placed umbo and the stronger curvature of the posterior margin, however, the present species is distinguishable from the two Japanese species. In some respects it is more similar to an undescribed species of *Paracorbicula* from the Miyakoan (Aptian-Albian) formations of Southwest Japan.

Occurrence.—The fossil is obtained from the grey carbonaceous siltstone at the depth of 2005.50 m in PK-2 well, Peikang, western Taiwan.

GASTROPODA

(by Itaru Hayami)

Family APORRHAIDAE

Genus *Aporrhais* Da Costa, 1778

Subgenus *Cuphosolenus* Piette, 1876

Aporrhais (*Cuphosolenus?*) sp. indet.

(Pl. II, Fig. 9)

Descriptive remarks.—Only an incomplete specimen (No. 23, 26.4 mm. wide, 24.8 mm.+high) is available for the study. It reveals the dorsal surface of the last whorl and digitated apertural wing. The greater part of the spire and the probable projection attached to it are lacked. Because of the very incomplete material, much cannot be said as to the specific characters. This species seems, however, to be characterized by the two, not much curved, spiny projections of similar strength, which are produced from the flattened wing and form an angle of about 80 degrees with each other. The upper projection is reinforced by a slightly nodose keel, which runs spirally on the upper part of the whorl. The siphonal canal is spiny and nearly straight. The surface is wholly marked with numerous faint spiral striae. The not much curved upper projection and fairly strong lower projection, which is as long as the upper one, indicate that the present species belongs to *Aporrhais* instead of *Drepanocheilus*. The weakness of the lower keel and the numerous fine spiral striae especially recall the subgenus *Cuphosolenus*, although the spiny projections are not so long as in the type-species.

Occurrence.—The fossil is obtained from the grey sandy siltstone at the depth of 2050.00-2052.80 m in PK-3 well, Peikang, western Taiwan.

CONCLUDING REMARKS

(by Tatsuro Matsumoto, Itaru Hayami and Wataru Hashimoto)

The molluscan fossils described in this paper are summarized in the following list:

Ammonoidea (identified by T. Matsumoto)	
Dufrenoyia sp. aff. *D. justinae* (Hill)	PK-3, 2062.00-2065.66 m
Dufrenoyia sp. aff. *D. discoidalis* Casey	PK-3, 2036.10-2039.10 m
Cheloniceras (*Epicheloniceras*) sp. aff. *Ch.* (*E.*) *orientale* (Jacob)	PK-2, 1645.00 m
Bivalvia (identified by I. Hayami)	
Mesosaccella (*?*) *taiwanensis* sp. nov.	PK-2, 1698.96 m, 1701.00 m
Nuculopsis (*Palaeonucula*) sp. cf. *N.* (*P.*) *ishidoensis* (Yabe and Nagao)	PK-3, 2062.00-2065.66 m
Cucullaea sp. aff. *C. acuticarinata* Nagao	PK-2, 1695.20 m; PK-3, 2062.00-2065.66 m
Nemodon sp. indet.	PK-3, 2045.00-2046.50 m
Pseudoptera sp. indet.	PK-3, 2050.00-2052.80 m
Amygdalum sp. aff. *A. ishidoense* (Yabe and Nagao)	PK-3, 2034.70-2036.10 m
Neithea (*Neithella*) sp. indet.	PK-3, 2036.10-2039.10 m
Chlamys sp. indet.	PK-3, 2045.00-2046.50 m
Plicatula sp. indet.	PK-3, 2036.10-2039.10 m
"Cardita" sulcataria sp. nov.	PK-3, 2050.00-2052.80 m, 2062.00-2065.66 m
Costocyrena peikangensis sp. nov.	PK-2, 1977.65 m, 2005.30 m
Nemocardium sp. aff. *N. yatsushiroense* Hayami	PK-3, 2047.00-2050.00 m, 2050.00-2052.80 m
Tetoria (*Paracorbicula*) sp.	PK-2, 2005.30 m
Gastropoda (identified by I. Hayami)	
Aporrhais (*Cuphosolenus?*) sp. indet.	PK-3, 2050.00-2052.80 m

Let us consider at first the stratigraphic positions of the examined molluscan fossils. In PK-2 well the fossiliferous samples may be divided into the following three layers:

(a) upper layer, represented by a core sample at 1645.00 m.

(b) middle layer, represented by samples from 1695.20 m to 1701.00 m, with an apparent thickness of about 6 m.

(c) lower layer, represented by samples from 1977.65 m to 2005.50 m, with an apparent thickness of 28 m.

The interval between (a) and (b) is about 50 m and that between (b) and (c) is about 277 m in vertical distance (Fig. 2). Layer (a) contains an ammonite, *Cheloniceras* (*Epicheloniceras*) sp. aff. *Ch.* (*E.*) *orientale* and an indeterminable scaphopod. Layer (b) has several marine bivalves in which *Cucullaea* sp. aff. *C. acuticarinata* seems to be characteristic. Layer (c) is dominated by some brackish-water bivalves such as *Costocyrena peikangensis* and *Tetoria* (*Paracorbicula*) sp. and lithologically somewhat different from (a) and (b), being more sandy, more micaceous and more carbonaceous. PK-3 well has yielded more samples of fossils which, however, are concentrated in a fossiliferous part ranging from 2034.70 m to 2065.66 m, with an apparent thickness of about 30 m. The fossil contents of this layer in PK-3 are marine molluscs, including *Cucullaea* sp. aff. *C. acuticarinata* at 2062.00-2065.66 m. On

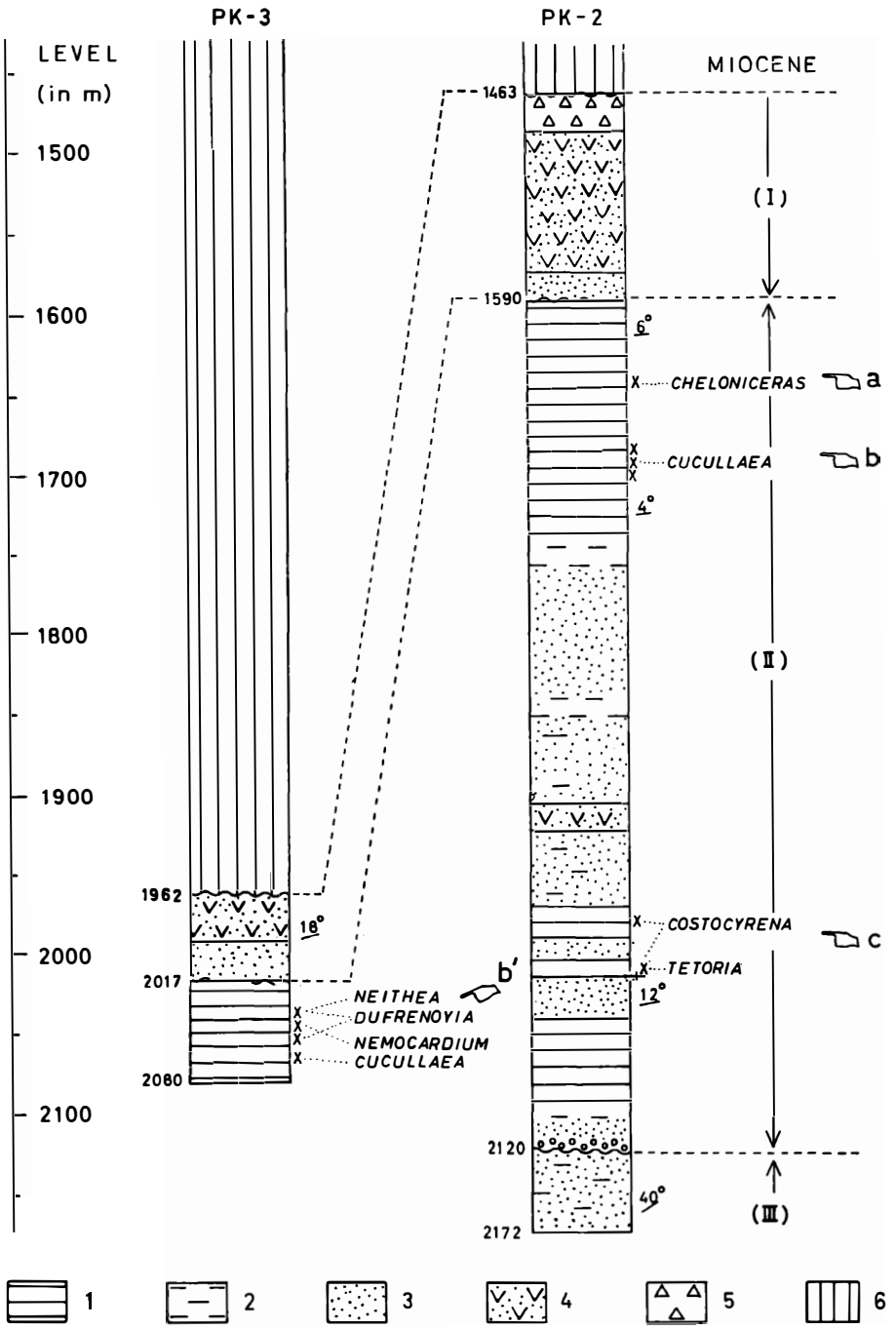

Figure 2. Well sections of PK-2 and PK-3, showing the stratigraphic position of fossil beds (adapted from Stach, 1958). The detailed lithology of the Neogene is omitted. Legend 1: shale, 2: sandy shale, 3: sandstone, 4: tuffaceous sandstone, 5: agglomerate, 6: Miocene strata (mainly shale), I: Cretaceous or Palaeogene volcanic series, II: Aptian and (?) Neocomian sediments, III: Folded basement strata of unknown age.

account of the similarity both in lithology and fossil content, the fossiliferous layer in PK-3 can be correlated to the middle layer (b) in PK-2.

Next comes the problem of age determination. Although the specimens are incompletely preserved, the ammonoids belonging to the Hoplitaceae are most important for the correlation. *Cheloniceras* (*Epicheloniceras*) is a world wide subgenus in the Upper Aptian. The specimen from the layer (a) is allied to, if not identical with, *Ch.* (*E.*) *orientale* (Jacob) from the Upper Aptian of the northern Swiss-Alps and northern Caucasus. Accordingly it probably indicates an Upper Aptian age. From the fossiliferous layer of PK-3, which is possibly referable to the layer (b), came two species of *Dufrenoyia,* one allied to *D. justinae,* from the Upper Aptian of Texas, Mexico and Colombia, or to *D. notha* Casey, from the upper Lower Aptian *bowerbanki* zone of southeast England, and the other allied to *D. discoidalis* Casey, from the same zone of England or to *D. durangensis* Humphrey, from the Upper Aptian of Mexico. As has been pointed out by Casey (1964, p. 377), *Dufrenoyia* has an interesting distribution in space and time, with its maximum abundance in upper Lower Aptian in England and Russia, in basal Upper Aptian in south of France, and in Upper Aptian of Mexico and Colombia. Taking consideration of this fact and the affinity of the Taiwan species with British ones on one hand and to those of the province of Texas-Mexico-Colombia on the other, we are inclined to conclude that the two species of *Dufrenoyia* from Taiwan may indicate the lower part of Upper Aptian rather than upper Lower Aptian. Anyhow, they certainly indicate an Aptian age, probably earlier than the age of *Cheloniceras* (*Epicheloniceras*) sp. aff. *Ch.* (*E.*) *orientale.*

The bivalvian species from the layer (b) of PK-2 well and the corresponding layer of PK-3 are allied to some of the hitherto known species from the Lower Cretaceous, especially abundantly from the Aptian, of Japan and Europe. *Neithea* (*Neithella*) sp. from the fossiliferous layer of PK-3 also indicates a Lower Cretaceous age, because the genus is almost confined to the Upper Neocomian, Aptian and Albian in the Pacific region. They, thus, support the age determination by the above discussed ammonites.

The brackish-water bivalvian species, *Costocyrena peikangensis* sp. nov. and *Tetoria* (*Paracorbicula*) sp., from the layer (c) of PK-2 well, have affinities with those from the Neocomian-Albian of Japan. *Costocyrena* ranges in Japan from the Upper Neocomian to Albian, and this new species from Taiwan is rather primitive, approaching ancestral *Eomiodon,* which prospered mainly in the Jurassic and Neocomian. If we take consideration of this palaeontologic fact and also the stratigraphic position, we may arrive at the conclusion that the fossiliferous layer (c) is referable to Neocomian, if not Lower Aptian.

The above conclusion is not congruent with the previous opinion of correlation. All the fossiliferous layers discussed herein belong to the sequence which was assigned to Jurassic by Stach (1958) and Lin (1961). The ammonite which was stated as comparable with *Hongkongites hongkongensis* came from the depth of 1645.00 m in PK-2 well, which is the same level as the above discussed *Cheloniceras* (*Epicheloniceras*) sp. aff. *Ch.* (*E.*) *orientale.* Another ammonite, *Holcophylloceras* sp., which was said to be allied to *H. mediterraneum,* came from the depth of 1691.80 m in the same well, its stratigraphic position being slightly higher than the layer (b) of the above discussion. Inasmuch as the

specimen is poorly preserved, as illustrated by Lin (1961), the specific identification was by no means certain. Genus *Holcophylloceras* itself has a long range from Middle Jurassic to Aptian. These two previously identified ammonites are, thus, open for careful reexamination.

A result of the present study may be concerned with the palaeogeography and the tectonic history. This new confirmation of probably shallow sea Aptian fauna in western Taiwan may permit us to draw a coastal line of an Aptian age somewhere off the west coast of Taiwan. A palaeogeographic map drawn by one of the writers (Matsumoto, 1954, p. 224) must be somewhat modified so as to include west Taiwan in a marine area. Broadly speaking the Lower Cretaceous fauna of west Taiwan have affinities with those of Japan, but the faunal elements are not specifically quite identical between the two provinces. Certain species are particular to Taiwan. This statement can be applied to both the Aptian marine fauna and the Neocomian-Aptian brackish-water one. The second unit (underlying the pyroclastic rocks), previously referred to Jurassic, has now proved to be Lower Cretaceous. The angular unconformity which was reported at the base of this unit (2120 m in PK-2), will accordingly turn to be the base of the Lower Cretaceous sequence. This stratigraphic break may mark one of the phases in the late Mesozoic orogeny (see Fig. 2). The Cretaceous non-marine facies and faunas, which seem to be particular to Eastern Asia, may be intimately related to these and related tectonic movements.

The first unit immediately below the base of Miocene, previously ascribed to Cretaceous, may be either upper Cretaceous or lower Tertiary. Since this unit contains much tuffaceous matter, a volcanic activity is indicated. This activity may approximately correspond with that in the Outer Volcanic Zone of northeast Siberia and that in some parts of Northeast Japan and also in the Inner Zone of Southwest Japan. It may be intimately related to the magmatism in the region of Southeast China-South Korea.

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Explanation of Plate I

page

Dufrenoyia sp. aff. *D. justinae* (Hill) 4

Fig. 1. Internal mould, No. 24 (CPC 461117) from the level of 2062.00-2065.66 m of PK-3. x 2.

Fig. 2. Rubber cast from a fragmentary external mould, No. 25 (CPC 461119) from the level of 2062.00-2065.66 m of PK-3, x 2.

Dufrenoyia sp. aff. *D. discoidalis* Casey 5

Fig. 3. Plaster cast from a deformed external mould, No. 26 (CPC 461106) from the level of 2036.10-2039.10 m of PK-3, x 2.

Cheloniceras (*Epicheloniceras*) sp. aff. *Ch.* (*E.*) *orientale* (Jacob) 6

Fig. 4. Rubber cast from a fragmentary external mould, No. 27, from the level of 1645.00 m of PK-2, x 2.

Mesosaccella (?) *taiwanensis* sp. nov. 7

Fig. 5. Right valve, holotype, No. 1, from the level of 1698.96 m of PK-2, x 2.

Fig. 6. Right valve, paratype, No. 2, from the same level, x 2.

Fig. 7. Left valve, paratype, No. 3, from the same level, x 2.

Nuculopsis (*Palaeonucula*) sp. cf. *N.* (*P.*) *ishidoensis* (Yabe and Nagao) 8

Fig. 8. Right internal mould, No. 4, from the level of 2062.00-2065.66 m of PK-3, x 3.

Cucullaea sp. aff. *C. acuticarinata* Nagao 8

Fig. 9. Right internal mould, No. 5, from the level of 2062.00-2065.66 m of PK-3, x 2.

Nemodon sp. indet 9

Fig. 10. Right internal mould, No. 6, from the level of 2045.00-2046.50 m of PK-3, x 2.

Pseudoptera sp. indet. 9

Fig. 11. Left valve, No. 7, from the level of 2050.00-2052.80 m of PK-3, x 2.

Amygdalum sp. aff. *A. ishidoense* (Yabe and Nagao) 9

Fig. 12. Right valve, No. 8, from the level of 2034.70-2036.10 m of PK-3, x 2.

Neithea (*Neithella*) sp. indet. 10

Fig. 13. Left valve, No. 9, from the level of 2036.10-2039.10 m of PK-3, x 2.

Chlamys sp. indet. 10

Fig. 14. Rubber cast from a right external mould, No. 10, from the level of 2045.00-2046.50 m of PK-3, x 2.

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W. HASHIMOTO, PLATE I

PETROLEUM GEOLOGY OF TAIWAN, NUMBER 4

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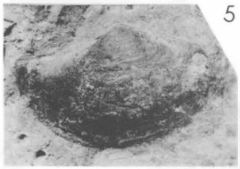
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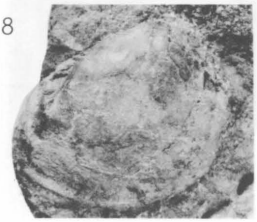
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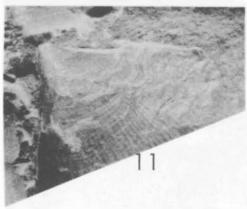
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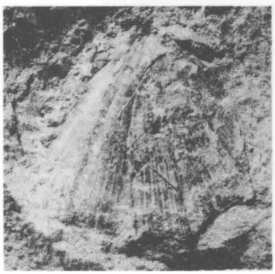
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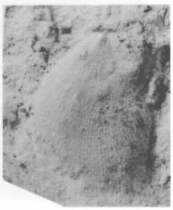
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Explanation of Plate II

page

Plicatula sp. indet. 11

Fig. 1. Left internal mould, No. 11, from the level of 2036.10-2039.10 m of PK-3, x 2.

"Cardita" sulcataria sp. nov. 11

Fig. 2. Right valve, paratype, No. 14, from the level of 2062.00-2065.66 m of PK-3, x 2.

Fig. 3. Left internal mould, paratype No. 15, from the level of 2050.00-2052.80 m of PK-3, x 2.

Fig. 4. Internal mould of closed valves, holotype, No. 13, from the level of 2062.00-2065.66 m of PK-3, x 2.

Costocyrena peikangensis sp. nov. 12

Fig. 5. Right internal mould (5 a) and rubber cast from the same external mould (5 b), paratype, No. 18, from the level of 2005.30 m of PK-2, x 2.

Fig. 6. Rubber cast from a left external mould, holotype, No. 17, from the level of 1977.65 m of PK-2, x 2.

Tetoria (*Paracorbicula*) sp. indet. 13

Fig. 7. Internal mould of two valves, No. 22, from the level of 2005.50 m of PK-2, x 1.5.

Nemocardium sp. aff. *N. yatsushiroense* Hayami 13

Fig. 8. Right valve, No. 20, from the level of 2050.00-2052.80 m of PK-3, x 1.5.

Aporrhais (*Cuphosolenus?*) sp. indet. 14

Fig. 9. Specimen revealing the dorsal surface of the last whorl and apertural wing, No. 23, from the level of 2050.00-2052.80 m of PK-3, x 1.5.

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Petroleum Ggeology of Taiwan, Number 4 Plate II

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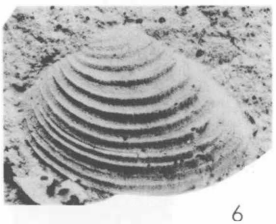

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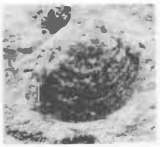

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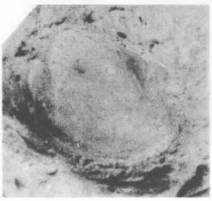

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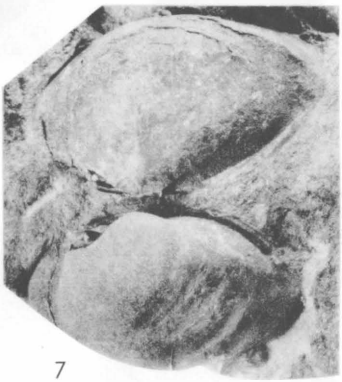

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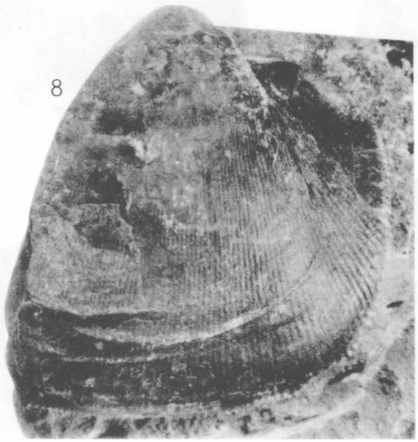

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